

Chapter 15

Singapore Country Report

Loi Tian Sheng Allan

Energy Studies Institute (ESI), National University of Singapore (NUS), Singapore

Jaqueline Tao Yujia

Energy Studies Institute (ESI), National University of Singapore (NUS), Singapore

Yuen Kah Hung

National University of Singapore (NUS), Singapore

September 2015

This chapter should be cited as

Loi Tian Sheng Allan, Jacqueline Tao Yujia and Yuen Kah Hung (2015), 'Singapore Country Report', in Kimura, S. and H. Phoumin (eds.), *Energy Outlook and Energy Saving Potential in East Asia*. ERIA Research Project Report 2014-33, Jakarta: ERIA, pp.223-237.

CHAPTER 15

Singapore Country Report*

LOI TIAN SHENG ALLAN, JACQUELINE TAO YUJIA, AND YUEN KAH HUNG

Energy Studies Institute (ESI), National University of Singapore (NUS), Singapore

1. Background

Singapore is a small island-state in Southeast Asia, located along the Straits of Malacca between Malaysia and Indonesia. It is the most urbanised and industrialised country in the Association of Southeast Asian Nations (ASEAN), with an annual gross domestic product (GDP) per capita of S\$ 71,318 in 2014¹ and is fully electrified. It has a national policy framework to maintain a balance amongst the policy objectives of economic competitiveness, energy security, and environmental sustainability.² Singapore has a national target of reducing energy intensity by 20 percent by 2020 and 35 percent by 2030 compared with 2005³. It also has a voluntary target of reducing carbon dioxide (CO₂) emissions by 7–11 percent below business-as-usual levels in 2020,⁴ which will be increased to 16 percent if there is a global agreement on climate change.

1.1. Singapore's Policy Initiatives

An inter-agency Energy Efficiency Programme Office (EEPO), led by the National Environment Agency (NEA) and the Energy Market Authority (EMA), was established in May 2007 to help promote and facilitate the adoption of energy efficiency in Singapore.⁵

1.1.1. Households

Households account for about one-sixth of electricity consumed in Singapore⁶ and thus is a key sector for energy efficiency policies. The Mandatory Energy Labelling Scheme (MELS), introduced in 2008, imposes compulsory display of energy labels on relevant household appliances. Initially only levied on all registrable air-conditioners and refrigerators, the requirement has progressively expanded over the years to include television sets and clothes dryers. The MELS serves to inform consumers and helps them identify, and thereby purchase, more energy efficient appliances. The Minimum Energy

* Special thanks to two former interns in the Energy Studies Institute, Carissa Tan Rou Xing and Jazreel Low Kai Jun, for their quantitative contributions in this study.

¹ Singapore Department of Statistics (2015), *National Accounts*, from <http://www.singstat.gov.sg/statistics/browse-by-theme/national-accounts>

² Ministry of Trade and Industry of Singapore (2007). National Energy Policy Report–Energy for Growth, from <http://app.mti.gov.sg/data/pages/2546/doc/NEPR.pdf>

³ Singapore Government (2009). The Sustainable Development Blueprint 2009, from http://app.mewr.gov.sg/data/lmgCont/1292/sustainableblueprint_forweb.pdf; Singapore Government (2014). The Sustainable Development Blueprint, from <http://www.mewr.gov.sg/ssb/files/ssb2015.pdf>

⁴ National Climate Change Secretariat (2012). Speech on Climate Change by Mr Teo Chee Hean, Deputy Prime Minister, Coordinating Minister for National Security and Minister for Home Affairs, at the Committee of Supply Debate, from http://app.nccs.gov.sg/news_details.aspx?nid=642&pageid=97

⁵ Energy Efficiency Programme Office (2013), http://app.e2singapore.gov.sg/About_Esup2/supPO/Objective_and_Members.aspx

⁶ <https://www.nccs.gov.sg/climate-change-and-singapore/domestic-actions/reducing-emissions/households>

Performance Standards (MEPS) is a supply-side policy that complements the MELS by prohibiting 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 bring more energy-efficient appliances to the market as technology improves.

Both the MELS and MEPS are constantly evaluated and revised to ensure policy efficacy and efficiency. Although both policies are limited in coverage at the existing stage, it is expected that these initiatives will be extended to include other energy intensive appliances, through a continuing assessment process. In particular, general lighting, such as incandescent lamps, CFL, and LED lamps, will be covered under the scheme from July 2015. Given that the efficacy of existing labelling standards in facilitating energy conservation and efficiency improvements will depend on how responsive end-users are to these initiatives, the MELS is constantly evaluated. In September 2014, new ratings systems and designs of the MELS were introduced to improve consumer readability and understanding. The revised label also included a component on estimated annual energy cost aimed at helping consumers better understand how the energy performance of the appliance they buy will translate into cost savings.

In addition to the initiatives targeting the purchase of electrical appliances, NEA also aims to affect energy consumption behaviour through the '10 Percent Energy Challenge' national campaign. Launched in 2008, the campaign aims to increase consumer understanding of residential energy consumption by providing energy savings tips and incentivising households to reduce energy consumption. In conjunction with the campaign, NEA has launched various interactive mobile communication applications, such as Life Cycle Calculator and Home Energy Auditor mobile application. Currently, NEA is also looking at rolling out additional public messaging initiatives in 2015 and the possibility of utilising smart home technologies, such as the Home Energy Management Systems (HEMS), to reduce residential energy consumption.

For the transport sector, the Vehicle Quota System (VQS) regulates the growth of the vehicle population in Singapore. Under the VQS, anyone who wishes to register or buy a new vehicle in Singapore must first obtain a Certificate of Entitlement (COE), which represents a right to vehicle ownership for 10 years.⁷ In view of the land constraints on road expansion, the annual vehicle population growth rate has been reduced from 3 percent in 1990 to 1.5 percent in 2009, to 1 percent in August 2012, to 0.5 percent in 2013, and 0.25 percent since 2015.⁸ The Fuel Economy Labelling Scheme (FELS) has mandated fuel economy labels to be affixed to vehicles at the point of sale since 2012.⁹ This is complemented by the Carbon Emissions-based Vehicle Scheme (CEVS), which was introduced in 2013. The CEVS will be revised in July 2015 to reflect improvements in emission standards. Rebates and surcharges will also be increased for very low- and high-carbon emission vehicles, respectively, to further encourage vehicle buyers to shift to low-

⁷ Land Transport Authority (2014), 'Overview of Vehicle Quota System', <http://www.lta.gov.sg/content/ltaweb/en/roads-and-motoring/owning-a-vehicle/vehicle-quota-system/overview-of-vehicle-quota-system.html>

⁸ Land Transport Authority (2015), 'Vehicle Quota System', <http://www.lta.gov.sg/content/ltaweb/en/roads-and-motoring/owning-a-vehicle/vehicle-quota-system.html>

⁹ Land Transport Authority (n.d.), 'Fuel Economy Labeling Scheme (FELS)', http://www.onemotoring.com.sg/publish/onemotoring/en/lta_information_guidelines/buy_a_new_vehicle/fuel_economy.html

carbon emission models. All new cars and imported used cars with low carbon emissions of less than 136g carbon emissions per kilometre (CO₂/km) will qualify for vehicle tax rebates of between S\$5,000 and S\$30,000. Cars with high carbon emissions more than 185g CO₂/km, will incur a corresponding registration surcharge between S\$5,000 and S\$20,000. Cars with carbon emissions between 136 and 185g CO₂/km receive neither a rebate nor will they have to pay a surcharge. To encourage taxi companies to adopt lower emission models for their fleet, the CEVS rebate and registration surcharge for taxis is set 50 percent higher than for cars – between S\$7,500 and S\$30,000.¹⁰

1.1.2. Buildings

The Building and Construction Authority (BCA) of Singapore launched the BCA Green Mark Scheme in January 2005 to promote environmental sustainability in the construction and real estate sectors. 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 National Climate Change Secretariat (NCCS) and the National Research Foundation (NRF) in 2014, evaluates existing energy efficiency technologies for building providing technical expertise in the area. A variety of financial support mechanisms, such as the Green Mark Incentive Scheme for Existing Buildings and Premises (GMIS–EBP) and the Building Retrofit Energy Efficiency Financing (BREEF) scheme are available to provide co-financing for retrofitting and energy efficiency upgrades. The target is for at least 80 percent of the buildings in Singapore to achieve BCA Green Mark Certified rating by 2030.¹¹

In its recently launched Third Green Building Masterplan, BCA announced its intention to engage building tenants and occupants with a view to inducing energy consumption behavioural change.

Since a 2012 survey by Development Authority of Singapore (IDA) 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, which was in line with estimates from the 2012 survey, which posits that there is an energy efficiency potential of 20 percent. IDA also launched a new Green Data Centre Innovation Programme (GDCIP) aimed at promoting innovative technological approaches to improving data centre energy efficiency.

¹⁰ Land Transport Authority (2015), 'Revised Carbon Emissions-based Vehicle Scheme (CEVS) from 1 July 2015', *Press Release*, 23 February, <http://www.lta.gov.sg/apps/news/page.aspx?c=2&id=8aa03b88-409f-4852-b2df-09077e101468>

¹¹ Building Construction Authority (2013), 'R&D Framework', *Build Green Magazine*, Issue 02/13 <https://www.bca.gov.sg/greenmark/others/BGreen2013.pdf>

1.1.3. Industry

The industry-focused Energy Efficiency National Partnership (EENP) 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 (ECA). Energy intensive companies consuming more than 15GWh (electricity) or 54TJ (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.¹² Besides legislation enforcing mandatory energy management practices, policies were also introduced to incentivise energy efficiency investments. A recent document released by NCCS made references to the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC), which includes forecasts that the deployment of best-available technology could reduce energy intensity from current levels by 25 percent across the industrial sector. Incentives and grants, such as the Design for Efficiency Scheme (DfE), Energy Efficiency Improvement Assistance Scheme (EASe), and the Grant for Energy Efficiency Technologies (GREET), were put in place as co-financing schemes to reduce initial costs of energy efficiency upgrades. Knowledge sharing is also promoted through industry-focused seminars and provision of energy management training and resources.

The industry-focused Energy Efficiency National Partnership (EENP) is a voluntary programme that started in 2010 and 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 (ECA). Energy intensive companies consuming more than 15GWh (electricity) or 54TJ (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.¹³ In the same year, the SME (small and medium enterprise) Energy Efficiency Initiative was conceptualised with the goal of helping 300 SMEs achieve at least 10 percent savings over three years. The government has set aside S\$17 million for this initiative and four areas of support were emphasised – Energy Audit, Energy Monitoring System, Energy Efficiency Project Implementation, and Energy Efficiency Thought Leadership.¹⁴

2. Modelling Assumptions

Five scenarios were developed to assess the energy saving potential of the energy efficiency and conservations policies in Singapore. The ‘Business As Usual’ (BAU) scenario forecasts energy demand and CO₂ emissions by incorporating energy policies implemented up until the end of 2013. Three Alternative Policy Scenarios (APS) project energy use and CO₂ emissions with higher uptakes of energy efficiency and conservation

¹² National Environment Agency, (2014), http://app.e2singapore.gov.sg/Programmes/Energy_Efficiency_National_Partnership.aspx

¹³ National Environment Agency, (2014), http://app.e2singapore.gov.sg/Programmes/Energy_Efficiency_National_Partnership.aspx

¹⁴ SPRING Singapore (2013), ‘Government Sets Aside \$17 Million to Boost Energy Efficiency in SMEs’, *Press Release*, 10 July. <http://www.spring.gov.sg/NewsEvents/PR/Pages/Government-Sets-Aside-17-million-to-Boost-Energy-Efficiency-in-SMEs-20130710.aspx>

policies – lower end-user energy demand, more efficient power generation, and increased share of renewable in the energy mix for APS1, APS2, and APS3, respectively. Unlike some other ASEAN countries, Singapore does not have a nuclear policy and hence APS4 is not considered. Finally, APS5 aggregates the effects of all three APS.

2.1. Power Generation Sector

In 2012, the overall efficiency of gas-fired power plants in Singapore was 51 percent and it was 39 percent for thermal plants. According to the International Energy Agency (IEA), the average thermal efficiency of combined cycle gas turbine (CCGT) generators was 57.0 percent and that of conventional power plants was 41.1 percent.¹⁵ By 2035 under BAU, it is assumed that the efficiency of gas power plants will attain 55 percent efficiency and thermal power plants will attain an efficiency of 41 percent. The share of electricity contributed by solar power reaches 6 percent by 2035. The government aims to boost the adoption of solar power in Singapore's system to 350 megawatt-peak (MWp) by 2020, which is about 5 percent of peak electricity demand in 2020, a significant increase from Singapore's existing 15 MWp of solar power capacity.¹⁶

APS2 projects higher efficiencies and a larger share of solar power. It is assumed under APS2 that by 2035 gas-fired turbines will attain 61.0 percent efficiency and that thermal power plants will attain an efficiency of approximately 45.0 percent. The share of electricity contributed by solar power reaches 10 percent by 2035 under APS3. According to an estimate provided by the Sustainable Energy Association of Singapore (SEAS) in its White Paper, Singapore has enough space to accommodate 6GWp of solar PV, which can generate 7.2 TWh of electricity each year, or approximately 17 percent of Singapore's current electricity demand.¹⁷ However, this projection could be too optimistic in view of the government's announcement to nearly double the cap for power generation from renewable sources to 600MW from 350MW. These and other measures are expected to help enable renewable energy sources (without the aid of government subsidies) meet 8 percent of Singapore's electricity needs by 2025, up from less than 1 percent now.¹⁸

2.2. Transport Sector

For the transport sector in all scenarios, both gasoline and diesel demand are linked to assumptions in the annual vehicle population growth rate. Following the caps on annual vehicle population growth rate announced by the government, the vehicle population is projected to grow by 1.5 percent from 2011, reducing to 0.5 percent from 2013 and to 0.25 percent from 2015 and assumed as such thereafter. Fuel efficiency improvements are also expected to further reduce fuel demand in APS1, which is fed into the model as an equivalent of 0.1 percent less vehicle growth in 2013, and 0.05 percent less vehicle growth in 2015.

¹⁵ International Energy Agency (2010), *Projected costs of generation electricity*, p 102.

¹⁶ Chia, Y.M. (2014), 'Boost for electricity retail market and solar power use', *The Straits Times*, 7 March.

¹⁷ Sustainable Energy Association of Singapore (2014), 'A case for sustainability: Accelerating the adoption of Renewable Energy in Singapore', White Paper.

¹⁸ Leong, G. (2013). 'Electricity market revolution on the way', *Business Times*, 23 November.

2.3. Residential Sector

It is assumed that energy efficiency measures targeted at the residential sector, such as energy labelling, minimum energy efficiency standards, and educational campaigns (e.g. '10 Percent Energy Challenge'), will reduce residential energy demand by 5 percent under the BAU scenario, and by 7.5 percent in APS1 by 2035.

2.4. Commercial Sector

A joint study conducted by the Building and Construction Authority (BCA) and the National University of Singapore (NUS) demonstrated that retrofitting to achieve the standard BCA Green Mark certification can result in a 17.0 percent reduction in energy demand.¹⁹ If measured by the area of the buildings where owners are responsible for paying for the utilities, the average savings are even higher at nearly 30.0 percent. In 2005, the total number of buildings awarded the Green Mark Scheme was 17. By September 2014, there were more than 2,200 Green Mark building projects in Singapore.²⁰ At this pace, Singapore should be on track to achieve its target of having 80.0 percent of its existing and future buildings Green-Mark-certified by 2030.²¹ Given our understanding of the vintage of building stock in Singapore and building stock replacement rates, a 10.0 percent reduction in electricity demand by the commercial sector is assumed for BAU and a 20.0 percent reduction in APS1.

2.5. Industry/Petrochemicals Sector

With reference to the IEA's Energy Technology Transitions for Industry 2009, the application of Best Available Technology (BAT) could reduce energy use in the industry sector by 13–29 percent.²² Hence, the energy saving potential in the industry sector by 2030 is assumed to be 5.0 percent in the BAU scenario and 10.0 percent in APS1.

Singapore has a long-term aim of expanding ethylene production to a range of 6–8 million tonnes per year by 2020.²³ Over the last few years, its naphtha has doubled to 4 million tonnes per annum²⁴. Singapore's petrochemical complex primarily uses liquefied petroleum gas (LPG) and naphtha to produce olefins, ethylene, and propylene. Most ethylene plants in Singapore are naphtha-based; therefore, capacity additions in the petrochemical sector will affect naphtha demand. In 2010, naphtha accounted for 99.0 percent of the petrochemical feedstock in Singapore and LPG 1.0 percent.²⁵ In December

¹⁹ Yu, S.M., Y. Tu, C.X. Luo, (2011), 'Green Retrofitting Costs and Benefits: A New Research Agenda, Institute of Real Estate Studies 2011-022', available at:

<http://www.ires.nus.edu.sg/workingpapers/IRES2011-022.pdf>

²⁰ Building and Construction Authority Singapore (2015), 'Green Mark Projects', available at:

http://www.bca.gov.sg/greenmark/green_mark_projects.html

²¹ Building and Construction Authority Singapore (2009), '2nd Green Building Masterplan', available at

<http://www.bca.gov.sg/GreenMark/others/gbmp2.pdf>

²² International Energy Agency (2009), *Energy Technology Transitions for Industry*, p 31.

²³ Economic Development Board (2007), 'ExxonMobil's second steam cracker brings chemical industry to the next lap', available at

http://www.edb.gov.sg/edb/sg/en_uk/index/news/articles/exxonmobil_s_second.html

²⁴ Lim, R. (2013), 'Petrochem-refining sector in 'digesting' phase', *Business Times*, 19 December.

²⁵ International Energy Agency (2012), *Energy Balances of Non-OECD Countries*.

2012, a new 220 megawatt petrochemical co-generation plant was added to ExxonMobil's existing petrochemical operations, adding 2.6 million tonnes per year to its finished product capacity.²⁶ According to the IEA, 155.0 GJ of naphtha is required to produce one tonne of ethylene. If the share of naphtha in the production of ethylene increases to 100.0 percent by 2020 and the above conversion factor is used, the production of 6.0 million tonnes of ethylene implies the demand of 22.2 Mtoe of naphtha in the non-energy sector.

There are also plans for the sharing of excess heat and steam for greater efficiency in the petrochemical plants on Jurong Island.²⁷ The carbon emissions reduction from these measures could be expected to go up to 13 percent by 2025, which is assumed to be about half of what IEA had assumed (24 percent) if current best practices are adopted.²⁸

3. Outlook Results

3.1. Business-as-Usual (BAU)

3.1.1. Total Final Energy Demand

Singapore's total final energy demand grew at an annual rate of 5.4 percent from 5.0 Mtoe in 1990 to 16.0 Mtoe in 2012. During the same period, oil was the dominant energy source, with 3.8 Mtoe and 11.1 Mtoe consumed in 1990 and 2012 respectively. More than 37.0 percent of the country's final energy is consumed for non-energy uses, particularly as feedstock for petrochemical production. In 1990, 27.1 percent of total final energy demand was used in the transport sector, although its share in total final energy demand declined by more than 40 percent, reaching around 15.7 percent in 2012.

Under the BAU scenario, total final energy demand is projected to grow by an average 4.2 percent per year between 2012 and 2035. The fastest growth is expected to occur in the petrochemical sector, at 6 percent per year. This is followed by the industry sector, which is projected to grow by an average annual 3.6 percent (Figure 15-1). The transport sector is projected to grow by 0.9 percent per year and the 'others' (residential and commercial) sector by 1.7 percent.

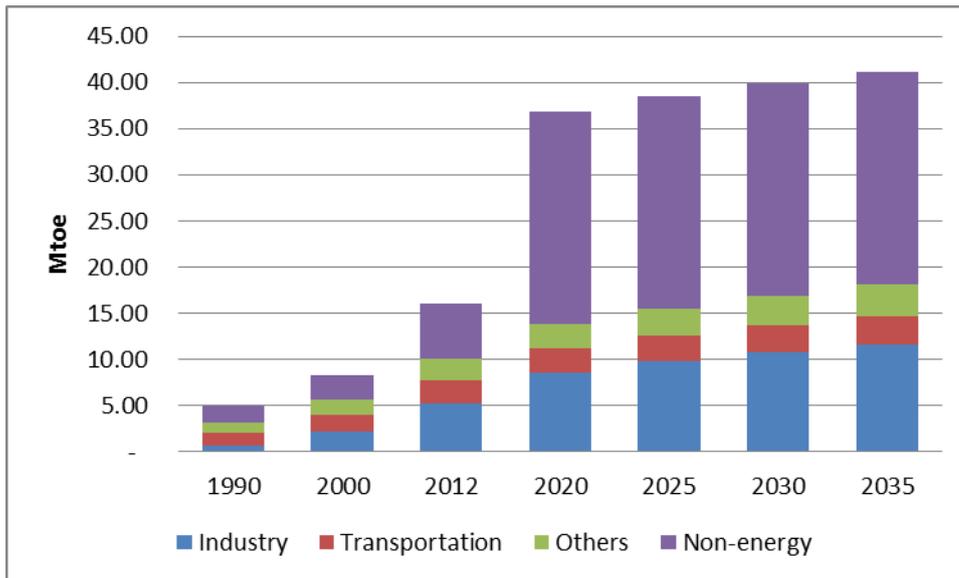
Under the BAU scenario, non-energy consumption will still comprise the highest share in total final energy demand, followed by the industrial sector. By the end of 2020, non-energy use will exceed 60.0 percent of Singapore's total final energy demand, before declining slightly, to 56.1 percent, in 2035. The industrial sector's share will also fall, from a 32.3 percent share in 2012 to around 28.1 percent in 2035.

²⁶ ExxonMobil Chemical (2012), 'ExxonMobil Commissions Singapore Petrochemical Plant Expansion', available at: <http://news.exxonmobilchemical.com/pressrelease/english/exxonmobil-commissions-singapore-petrochemical-plantexpansion>

²⁷ Lim, R. (2013), 'In the pipeline: Heat exchange on Jurong Island: Plans for plants to share excess heat, steam for efficiency'. *The Straits Times*, 19 December.

²⁸ International Energy Agency (2014), 'Energy Technology Perspectives 2014 – Harnessing Electricity's Potential'.

Figure 15-1. Final Energy Demand by Sector, BAU

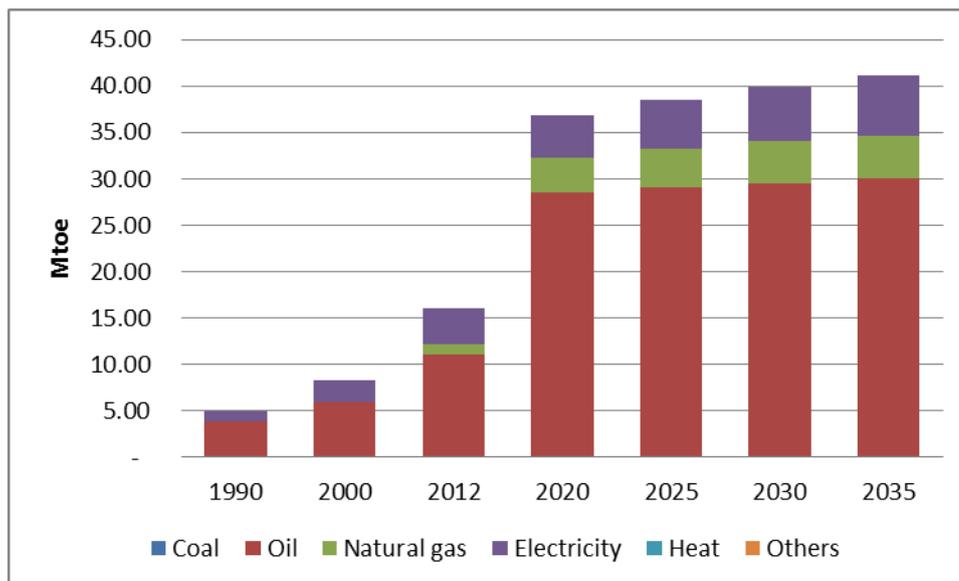


BAU = Business-as-Usual.
Source: Author’s calculation.

The transport sector’s share in total final energy demand from 2012 to 2035 is expected to decrease to 7.5 percent from its 27.1 percent share in 1990. The decrease is due to the country’s active promotion of more efficient automobile technology and the increased use of mass transit for personal transport. Moreover, COE quotas are also expected to remain effective in curbing vehicle growth.

By fuel type, natural gas saw the fastest growth from 1990 to 2012, increasing at an average annual rate of 14.1 percent.

Figure 15.2. Final Energy Demand by Fuel, BAU



BAU = Business-as-Usual.
Source: Author’s calculation.

The rapid growth of natural gas was due to the increasing demand in its use mainly in the rapidly expanding industry sector. From 1990 to 2012, demand for electricity grew at an average annual rate of 5.7 percent.

Under the BAU scenario, demand for natural gas is expected to continue to expand, but at a slower average growth rate of 6.3 percent per year. Electricity demand is projected to grow at an average annual rate of only 2.3 percent per year.

Oil is expected to continue to play a major role in Singapore's final energy demand. From 1990 to 2012, the share of oil fell from 76.1 percent to 69.1 percent. Under the BAU scenario, oil's share in total final energy demand is projected to rise to 77 percent in 2020 before falling to 73 percent in 2035. Natural gas usage will increase from its share of 7.1 percent in 2012 to 11.1 percent in 2035. And the share of electricity in final energy demand will decrease to around 12.4 percent in 2020 and rise to 15.8 percent in 2035. Figure 15-2 shows final energy demand by fuel type.

3.1.2. Total Primary Energy Consumption

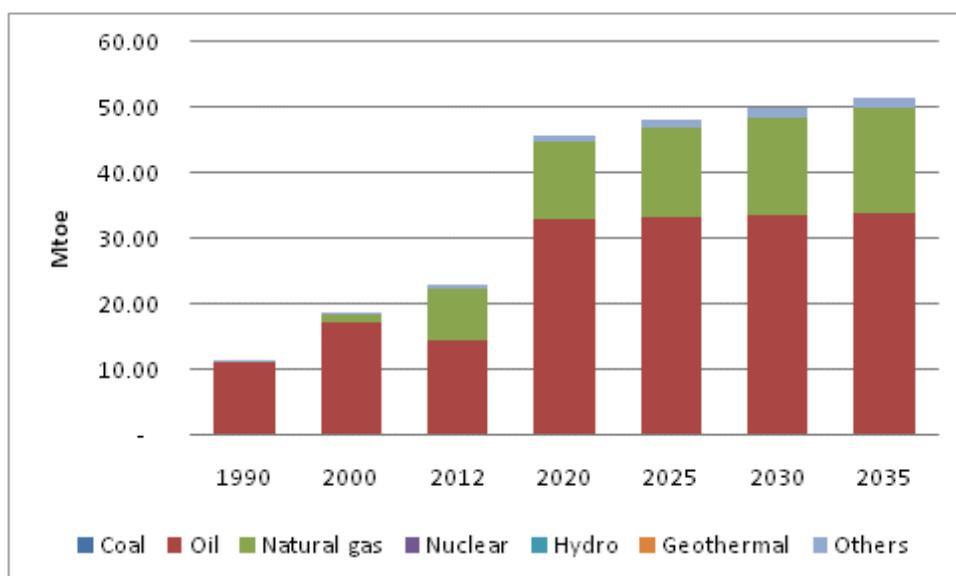
Total primary energy consumption grew by 3.2 percent per year, from 11.53 Mtoe in 1990 to 22.91 Mtoe in 2012. Singapore's dominant source of energy in 1990 was oil, of which consumption increased by an average annual 3.2 percent, from 11.4 Mtoe in 1990 to 14.43 Mtoe in 2012. Following the construction 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 increased. Natural gas consumption increased rapidly from 0.4 Mtoe in 1992 to 7.87 Mtoe in 2012. To expand the country's import capability and sourcing options, Singapore has commenced commercial operations with its newly constructed LNG terminal in May 2013, which currently has a throughput capacity of 6.0 million tonnes per year,²⁹ and an expected 9 million metric tonnes per year in 2017, with a fourth storage tank to be constructed.³⁰

Primary energy demand in the BAU scenario is projected to grow by 3.6 percent per year between 2012 and 2035 (Figure 15-3). Amongst the energy sources, solar energy is expected to grow fastest, at 32.3 percent a year, followed by oil at 3.8 percent. Natural gas demand is expected to grow in line with the expansion of gas-fired power plants.

²⁹ Boon (2013).

³⁰ *ChannelNewsAsia, Singapore Opens First LNG Terminal, Plans for Second Terminal, 25 February 2014.*

Figure 15-3. Total Primary Energy Consumption, BAU



BAU = Business-as-Usual.
 Source: Author’s calculation.

Over the next few years, Singapore’s net generation capacity will increase by more than 2,000 MW or about 20.0 percent of current installed capacity and will consist of more efficient Combined Cycle Gas Turbines (CCGTs)³¹. Nevertheless, oil is expected to remain the primary energy source, accounting for 66 percent of primary energy demand in 2035, followed by natural gas at 30.7 percent.

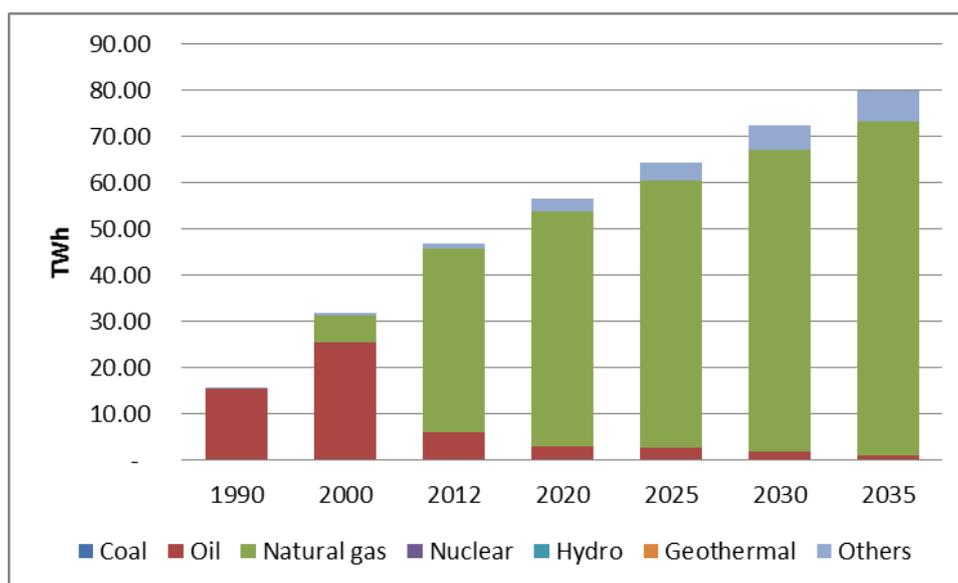
3.1.3. Power Generation

Electricity generation grew by 5.1 percent per year, from 15.7 TWh to 46.9 TWh, from 1990 to 2012. The electricity generation mix has changed significantly over the past decade. Natural gas, which accounted for 28 percent of electricity generation in Singapore in 2001, grew rapidly to supply 84.3 percent of Singapore’s electricity in 2012. Fuel oil use for thermal power generation was around 13 percent³² in 2012 and serves as a ‘balancing’ alternative to a total dependence on natural gas. Biomass takes up a small proportion of the mix, at around 2.7 percent.

In the BAU scenario, power generation is projected to increase at a slower rate of 2.3 percent per year, reaching 79.96 TWh in 2035. By type of fuel, generation from ‘Others’ will see the fastest growth, at an average rate of almost 7.7 percent per year. ‘Others’ power generation is expected to increase its share from a minimal share of 2.7 percent in 2012 to 8.6 percent in 2035.

³¹ Ministry of Trade and Industry (2012).

³² Energy Market Authority (2012).

Figure 15-4. Electricity Generation, BAU

BAU = Business-as-Usual.
Source: Author's calculation.

By the end of 2013 and the years thereafter, at least 90.0 percent of the country's power generation mix will be made up of natural gas under the BAU scenario, whereas the share of oil will decline to 1.4 percent over the same period.

The average thermal efficiency of fossil power plants was around 30.3 percent in 1990 and improved to 48.7 percent in 2012, as natural gas-fired power plants came into operation. In the BAU scenario, thermal efficiency of fossil plants is expected to improve further, to around 55 percent in 2035.

By fuel, natural gas plants' thermal efficiency is projected to be 55.0 percent in 2035 and that of oil 41.0 percent.

3.1.4. Energy Indicators

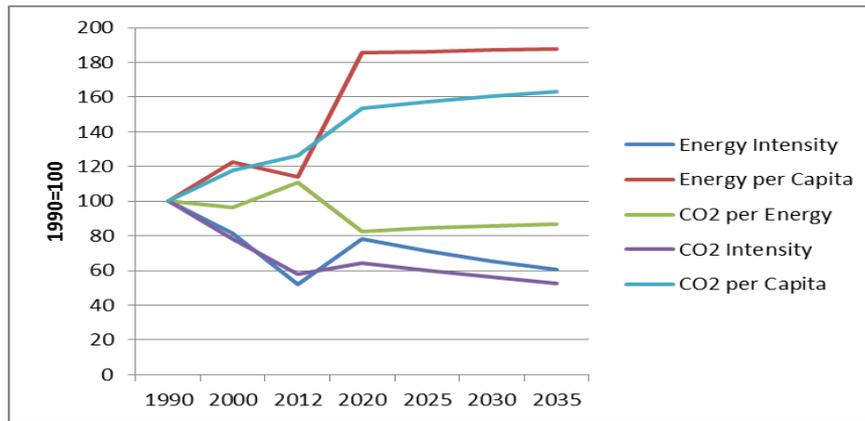
Total primary energy intensity, which is computed as the ratio of total primary energy demand over GDP is expected to increase over the projection period. Energy intensity continues to increase as Singapore's population will experience slower growth in the future.

3.2. Energy Saving and CO₂ Reduction Potential

3.2.1. Total Final Energy Demand

Final energy demand under APS1 is projected to increase by an annual average 4.1 percent from 2012 to 2035. Similar to the BAU case, the non-energy sector is expected to lead growth, at 6 percent per year, followed by the industry sector at 3.3 percent, and the other (residential and commercial) sector at 1.3 percent. APS2 and APS3 do not include energy conservation policies for end demand and hence are similar to the BAU scenario. APS5, as combination of all APS, will have the same final energy demand as APS1.

Figure 15-5. Energy Indicators, BAU

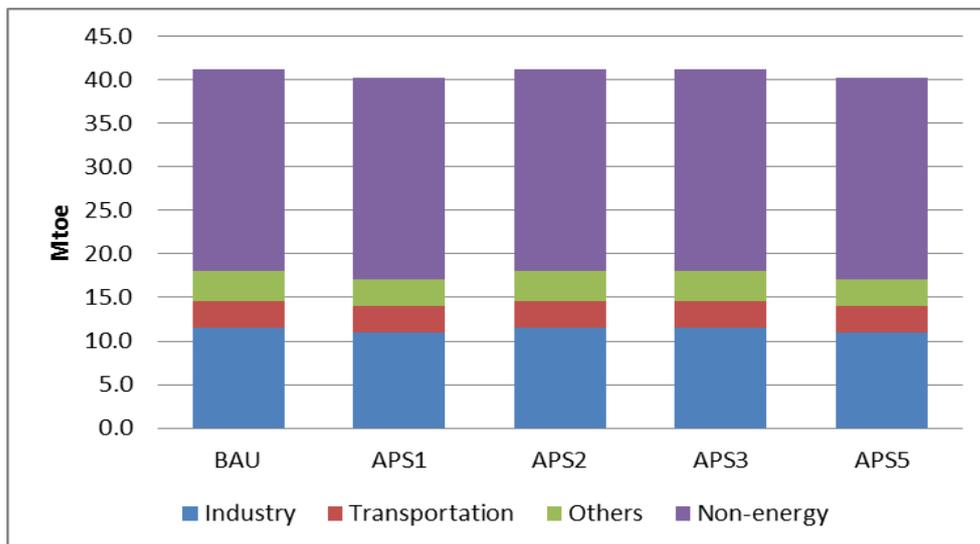


BAU = Business-as-Usual.
Source: Author's calculation.

3.2.2. Total Primary Energy Consumption

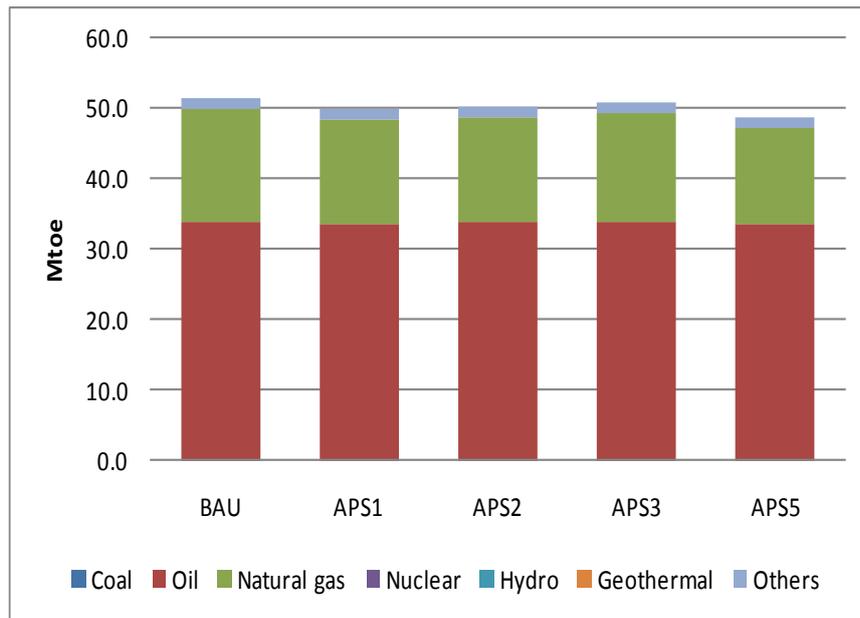
Results from APS1 show that primary energy demand from 2012 to 2035 will increase at an average annual rate of 3.4 percent, a marginal decrease from BAU (Figure 15-7). This translates to a reduction of 1.6 Mtoe from end-user energy efficiency policies. APS2 and APS3 will help to lower primary energy consumption by 1.4 Mtoe and 543 ktoe, respectively. This illustrates that solar policies play only a secondary role to end-user energy efficiency policies in reducing primary energy demand, whereas power generation can help provide sizeable consumption reductions.

Figure 15-6. Total Final Energy Demand by Sector, BAU and APS1–5



BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

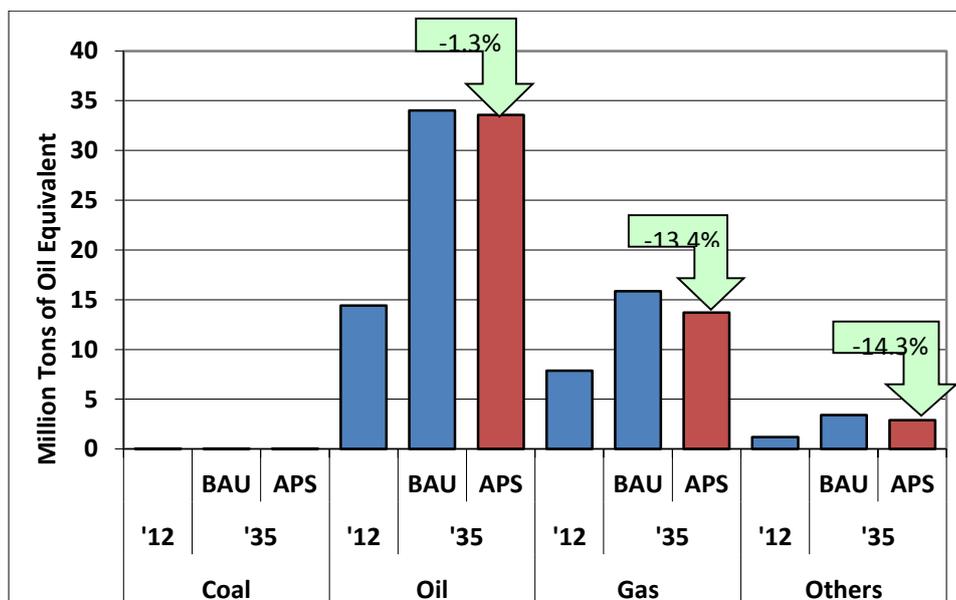
Figure 15-7. Total Primary Energy Consumption by Fuel, BAU and APS1–5



BAU = Business-as-Usual; APS = Alternative Policy Scenario
 Source: Author’s calculation.

Most of the reduction in primary energy consumption will come from natural gas, at 2.13 MTOE, which is a drop of 13.4 percent from BAU. Oil only falls by 1.3 percent as it is limited by the already declining BAU consumption for power generation, as well as the large consumption in petrochemical non-energy use. Biomass’ consumption will remain relatively constant.

Figure 15-8. Total Primary Energy Consumption by Fuel, BAU and APS5

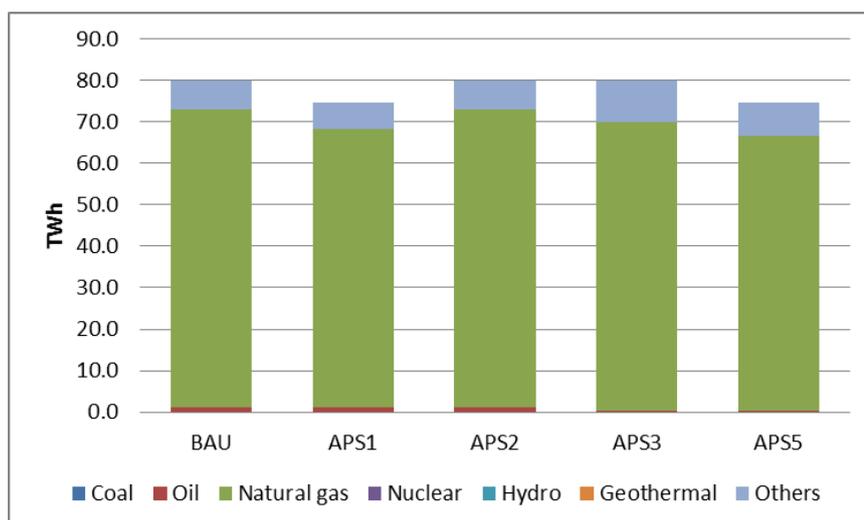


BAU = Business-as-Usual; APS = Alternative Policy Scenario.
 Source: Author’s calculation.

3.2.3. Power Generation

Results from APS1 and APS5 show a decrease in electricity generation, with a projected decrease of 5.38 TWh or 6.7 percent from BAU. APS2 and APS3 assume the same generation as BAU, since final energy demand does not decrease under these two scenarios.

Figure 15-9. Electricity Generation, TWh

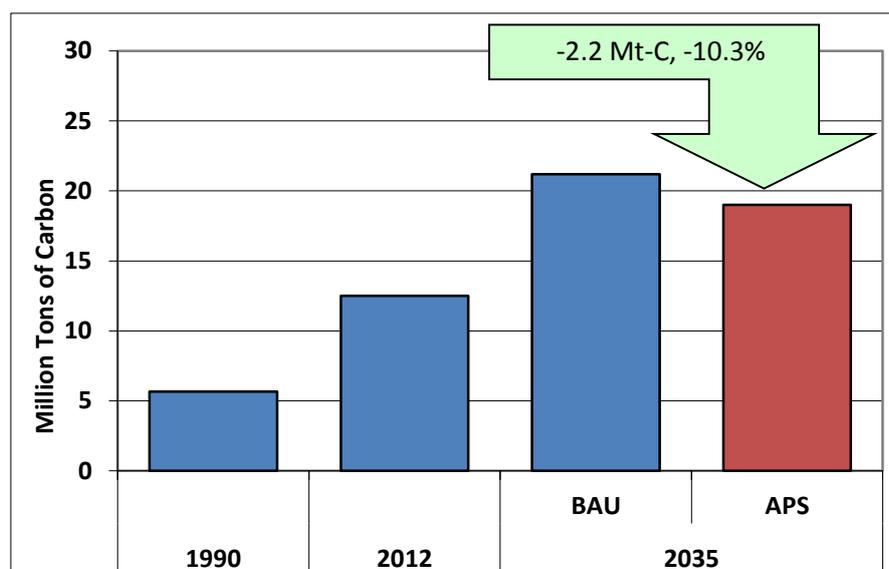


Source: Author's calculation.

3.2.4. CO₂ Reduction Potential

Carbon dioxide (CO₂) emissions from energy demand are projected to increase at an average annual rate of 2.3 percent, from 12.5 Mt-C in 2012 to around 21.2 Mt-C in 2035 (Figure 15-10).

The CO₂ emissions reduction potential comes mainly from power generation (APS2), with savings of 1.24 Mt-C in 2035, equivalent to a 5.8 percent decrease from BAU. This shows that further switching of power generation to cleaner sources greatly reduces emissions. Educational policies and incentives that target behavioural changes in end-consumers of energy are also very beneficial, with a projected emissions reduction of 0.832 Mt-C (3.9 percent) under APS1. Utilisation of solar power and biomass accounts for the remainder of the carbon emissions, at 0.36 (1.7 percent) Mt-C. In total, all the energy efficiency policies (APS5) will contribute to reducing CO₂ to 2.29 Mt-C, which is a decrease of 10.3 percent from the BAU case from 2012 to 2035. This effectively translates to an annual average decrease of 1.8 percent.

Figure 15-10. CO₂ Emissions from Energy Consumption, BAU and APS5

BAU = Business-as-Usual; APS = Alternative Policy Scenario.

Source: Author's calculation.

4. Implications and Policy Recommendations

The impetus for a reduction in energy use and emissions is provided by the host of programmes instituted by the government that seek to incentivise the use of less carbon-intensive fuels and to improve energy efficiency. These programmes includes a number of funding schemes, including the Clean Development Mechanism and the Documentation Grant that help provide companies with financial assistance for the engagement of carbon consultancy services, and the Grant for Energy Efficient Technologies (GREET) to help encourage industry investments in energy efficient equipment or technologies.³³ Zero-Capex (Capital Expenditure) or similar commercial contracts can also be actively promoted to increase the involvement of energy service companies (ESCOs) to help conserve energy. There is also an initiative to improve the petrochemical industry's energy efficiency and competitiveness by way of a 'heat-integration' plan.³⁴ Despite certain limitations due to Singapore's 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.

³³ Energy Efficiency Programme Office (2013), 'Incentives' available at: http://www.ema.gov.sg/info_directory/id:162/

³⁴ Lim Ronnie (2013), 'In The Pipeline: Heat Exchange on Jurong Island', *Business Times*, 19 December.