

STATEMENT OF OPPORTUNITIES

for the energy industry 2009

CONTENTS

Overview of Singapore's Energy Industry	03
Oil and Gas Industry	07
Electricity Industry	15
Clean Energy and Research & Development	27
Test-bed Projects	37
Summary of Opportunities	45
Appendix	53

OVERVIEW OF SINGAPORE'S ENERGY INDUSTRY





chapter 1

OVERVIEW OF SINGAPORE'S ENERGY INDUSTRY

Singapore has done well to establish itself as one of Asia's major energy hubs. Despite our limited natural resources, Singapore is one of the top three oil-refining centres in the world, accounting for 68 million tonnes of oil exports in 2007. This is a remarkable feat considering that Singapore does not produce any oil itself. Leveraging on its position at the centre of Asian trading routes, Singapore has established itself as the world's busiest marine bunkering centre, accounting for around 32 million tonnes of bunkers in 2007. Singapore is also the largest oil trading hub in Asia, and the third largest in the world. We are home to more than 800 professional oil traders with a trading volume of US\$375 billion in oil contracts annually.

All this activity takes place on the back of a world-class electricity transmission network. Singapore's transmission network is acknowledged as a world leader in terms of sophistication and reliability. In 2007, Singapore recorded just 0.01 interruptions in electricity supply per customer, far ahead of the second lowest city, London, which recorded 0.33 interruptions per customer.

DEVELOPING SINGAPORE'S ENERGY INDUSTRY

Without indigenous resources, Singapore is a price taker when it comes to energy. Approximately 80 per cent of Singapore's electricity is produced from piped natural gas imported from Malaysia and Indonesia. Singapore also imports all of its crude oil. With our energy needs being so import-dependent, the continued growth of our economy can be undermined by rising energy prices and externalities such as geopolitical conflicts, natural

disasters and terrorism. This is the key consideration behind Singapore's decision to build a liquefied natural gas terminal to diversify our sources of natural gas.

At the same time, the issue of climate change has risen to prominence in the international community. This, together with recent technological advances, has sparked interest in a variety of industries including clean and renewable energy, energy efficiency and electric vehicles. These factors have served as strong motivators for Singapore's recent focus on the energy sector as a key growth area as well as an essential enabler for our economic development. This is why the Government has developed a National Energy Policy Framework to maintain a balance between the policy objectives of economic competitiveness, energy security and environmental sustainability.

With the many new opportunities emerging in the energy industry, it is timely that the Energy Market Authority (EMA) has evolved from its traditional role as regulator for the electricity and gas industry to take on the additional roles of planner, promoter and developer for the energy sector. The EMA has set up the S\$25 million Energy Research and Development Fund to give impetus to research, development and demonstration initiatives that can help grow the energy industry and improve Singapore's energy security. To take advantage of the growing interest in clean and renewable energy solutions, the EMA is also developing Singapore as a 'living laboratory' where new energy concepts can be tested in a real-world environment, implemented in Singapore and exported beyond our shores. We have set aside S\$20 million for the electric vehicle test bed launched in May 2009 and there are plans to use Pulau Ubin as a testing ground for sustainable energy solutions. We have also set up the S\$5 million Market Development Fund to promote the use of renewable energy solutions.

To reflect the EMA's expanded mandate, the current edition of the Statement of Opportunities for Singapore's energy industry has been expanded to encompass opportunities beyond the electricity industry, to include the oil and gas sector, renewable energy sector, research and development and Singapore's test-bedding projects. The EMA is committed to forging a progressive and sustainable energy landscape, spearheading various energy-sector initiatives and working closely with all stakeholders to develop Singapore as a leading hub for the global energy industry.



OIL AND GAS INDUSTRY

OIL AND GAS INDUSTRY

The oil industry is an integral part of Singapore's economy. With our strong foundations in refining, logistics and trading, the oil industry contributes close to 5 per cent of our Gross Domestic Product (GDP). Today, Singapore remains a leading oil hub in Asia and is recognised as one of the world's top three export refining centres.

Moving beyond oil, we are also developing new strengths in the gas industry. Given the region's long-term demands for energy, Singapore's location in the heart of Asia puts us in a good position to play a critical role in meeting the region's energy needs. As we continue to diversify our energy sources, exciting economic opportunities will emerge for companies looking to grow their businesses from Singapore.

OIL: SOLUTIONS TO ENHANCE REFINING CAPACITY, EFFICIENCY AND STORAGE

“Singapore's goal is to further our role as Asia's undisputed oil hub through expanding refining capacity, advancing our technology base and developing innovative logistics solutions.”

Singapore aims to raise its refining capacity from the current 1.3 million barrels per day by expanding existing refineries, and increasing complexity and efficiency. Growing our refining capacity will at the same time, put Singapore in good stead to grow our oil trading activities.

Improving technology is another prong in our strategy to enhance the competitiveness of the oil industry. Through investments in research and development, Singapore hopes to optimise refinery operations and raise their productivity levels. In addition, we are committed to establish and promote research and development activities in the areas of high-value products, process optimisation and catalyst development.

Finally, Singapore is developing innovative logistics solutions in response to land constraint challenges. We currently offer extensive oil storage facilities on Jurong Island, where more than 95 leading petroleum, petrochemical, speciality chemicals and supporting companies have their operations. To supplement this, we are developing underground storage. The Jurong Rock Cavern is a massive underground facility that, when fully completed in 2014, will hold 1.47 million m³ of crude oil and condensates.

These initiatives are vital to driving the oil industry in Singapore and will help position Singapore competitively in the global energy landscape. We welcome companies with the relevant resources and capabilities to partner us in this endeavour.

JURONG ISLAND

Jurong Island is the heart of Singapore's energy and chemical industry. The island, made by amalgamating seven smaller islands, lies off Singapore's southern coast and is home to more than 95 leading petroleum, petrochemical, speciality chemicals and supporting companies. They include global companies such as Air Products, Akzo Nobel, Asahi Kasei, Celanese, Chevron Philips, Eastman Chemical, ExxonMobil, Huntsman Corp, Mitsui Chemicals, Shell, Sumitomo Chemicals and Teijin. The energy and chemical industry generated S\$97 billion worth of manufacturing output in 2008, making it the largest contributor to Singapore's overall manufacturing output (Fig. 2.1).

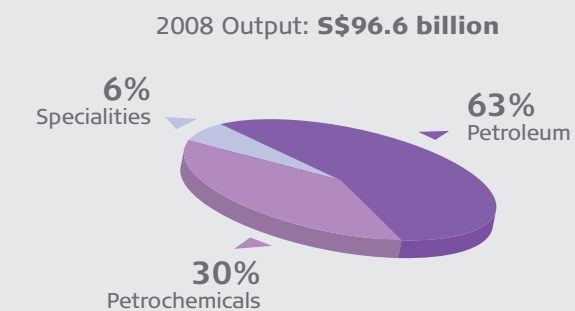


Fig. 2.1 Breakdown of Singapore's energy and chemical sector

What makes Jurong Island attractive to investors is its plug-and-play infrastructure (Fig. 2.2). It offers the infrastructural support for companies to quickly site and ramp up their operations on the island. This unique feature has helped to bring in investments, ranging from upstream to downstream companies.



Fig. 2.2 Jurong Island's plug-and-play concept



JURONG ROCK CAVERN

Jurong Rock Cavern is an underground oil storage facility undergoing construction under the Banyan Basin at more than 100 metres below the seabed.

The construction of the multi-million-dollar facility will be completed in two phases. The first phase will be ready by 2013 with two caverns having a combined storage capacity of 480,000 m³. The second phase would be ready by 2014 with additional three caverns, increasing the total storage capacity to 1.47 million m³.



Fig 2.3 Jurong Rock Cavern start-up gallery

GAS: LNG TRADING IS THE FUTURE

“As a small country without energy resources of our own, ensuring energy security is a priority for Singapore. To enhance our energy security, Singapore has decided to diversify our fuel sources by importing liquefied natural gas (LNG). To this end, Singapore is building our first LNG terminal. This would also pave the way for Singapore to become an LNG trading hub.”

Currently, about 80 per cent of Singapore’s electricity is produced from piped natural gas, delivered over long gas pipelines from Malaysia and Indonesia. As our economy grows, we expect that gas consumption will increase to meet the rising demand for electricity.

Liquefying natural gas reduces its volume, making it practical to store and transport. The ability to transport LNG over long distances when pipeline transportation is not feasible expands our pool of possible natural gas suppliers and enables us to diversify our sources of natural gas. With these considerations in mind, Singapore is embarking on the construction of an LNG terminal located on a 30-hectare site on Jurong Island. This terminal will initially have two storage tanks with a capacity of 3 million tonnes per annum (mtpa), and will be able to accommodate two additional tanks.

BG Asia Pacific Pte Ltd has been appointed as the LNG aggregator, and will have the exclusive rights to import LNG and sell regasified LNG to end users in Singapore for up to 3 mtpa. There are possibilities for other LNG suppliers to provide LNG to the Singapore market when the LNG demand goes beyond 3 mtpa.

When completed in 2013, the terminal will be an important part of Singapore’s energy security strategy and serves as the centrepiece in Singapore’s ambitions to be an LNG trading hub. Singapore’s strategic location and excellent port facilities, together with our wealth of experience in oil trading, will stand us in good stead to be a centre for LNG trading (Fig. 2.4). To this end, the terminal has been deliberately built with additional capacity from the beginning. This will enable traders to lease capacity for the temporary storage of LNG while waiting to re-export it to other markets around the world. There are also provisions in the terminal’s design for LNG reloading.

The Singapore government has put in place specific programmes to grow the LNG trading industry. Under the Global Traders Programme, we have introduced a special corporate tax of 5 per cent on LNG trading income to encourage existing energy players to expand into LNG trading. We hope to open new opportunities in this sector and work towards developing Singapore as an LNG trading hub.

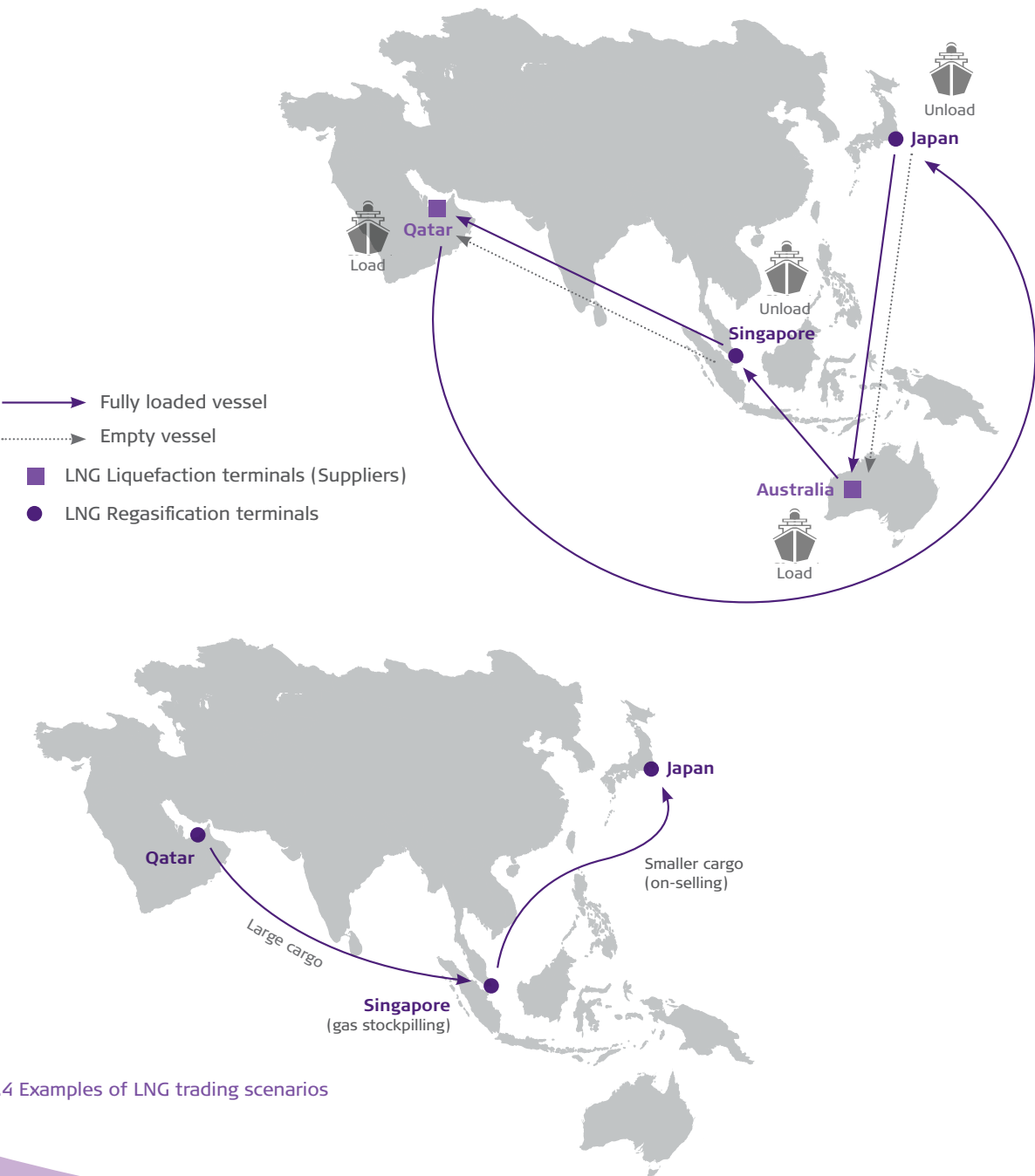


Fig. 2.4 Examples of LNG trading scenarios

THE LNG TERMINAL

The LNG terminal is located on the southwest corner of Jurong Island, on a 30-ha reclaimed plot of land. It will have a capacity of 3 mtpa, with provision for expansion to 6 mtpa, accommodating up to 4 LNG storage tanks.

The terminal project was originally envisaged as a commercial project. However, with the global economic downturn, it was difficult for the project to proceed on a commercial basis. Hence in June 2009, the Singapore government decided to take over the development and ownership of the LNG terminal to ensure its timely completion.

In line with this decision, the EMA has formed a new company, Singapore LNG Corporation, to build, own and operate the LNG terminal. The EMA expects to award a contract for engineering, procurement and construction of the LNG terminal by end 2009, and for the LNG terminal to be ready for commercial operation by 2013.

Once the economy recovers, it is expected that demand for LNG will pick up and stabilise at a commercially viable level. The EMA will leave open the option of divesting its stake in the terminal at an opportune time.

ELECTRICITY INDUSTRY



ELECTRICITY INDUSTRY

Over the years, Singapore's generation capacity has grown at an average annual growth rate of around 3 per cent from 2003 to 2008 to meet our expanding demand for electricity from industry, as well as our growing population. Currently, approximately 70 per cent of Singapore's generation capacity is located in the western part of Singapore. To meet the rising demand for electricity, especially by industries developing in the eastern part of Singapore, land has been set aside for a new generation plant to be built in the northeast region. Potential investors are encouraged to explore opportunities in this area.

SINGAPORE'S ELECTRICITY MARKET

In January 2003, Singapore liberalised its electricity market. The National Electricity Market of Singapore (NEMS) was formed and real time trading between electricity generators and electricity retailers began.

The Energy Market Authority (EMA) is the electricity regulator and the power system operator. It controls the dispatch of generation facilities in NEMS to safeguard the security of electricity supply to consumers. The EMA aims to maintain competitive, secure and reliable electricity supply to consumers, which has been divided into two segments, contestable and non-contestable.

In Singapore, the price of electricity is set every half-hour in a real-time electricity trading pool. Generation companies compete to generate and sell electricity by offering their capacity (specifying price/quantity pairs) in the spot market. The Energy Market Company (EMC), the market operator, operates the Market Clearing Engine and the Market Settlement System, which will determine the least-cost dispatch quantities, the reserve and regulation capacity required to be maintained by each generator, the corresponding wholesale spot market prices for energy, reserve and regulation, and settle the payments and receipts for the electricity traded.

The price received by each generator is the nodal price, which may vary according to their location on the network. Nodal prices are higher in areas where higher transmission losses are incurred in getting the electricity generated to the load facilities.

The electricity that retailers sell to contestable consumers has to be purchased from NEMS. Retailers pay for their electricity purchases at the Uniform Singapore Energy Price. This is a weighted average of nodal prices, and is determined every half-hour in NEMS.

The liberalisation of the retail market has been implemented in phases starting with the largest consumers. Currently, industrial and commercial users who consume more than 10,000 kWh a month are defined as contestable consumers and they are allowed to buy electricity from different retailers. They can also buy electricity directly from NEMS, or indirectly from NEMS through Singapore Power (SP) Services, which acts as the Market Support Services Licensee. Non-contestable customers are those who use less than 10,000 kWh of electricity a month. These consumers, mainly households, buy electricity from SP Services at regulated tariffs.

To allow for better capacity management, contestable consumers may offer their load to be available for disruption in times of supply shortage. They can either participate directly in the NEMS to offer their interruptible load, or engage the services of a licensed retailer or interruptible load service provider.

Electricity Industry Structure from Jan 2003

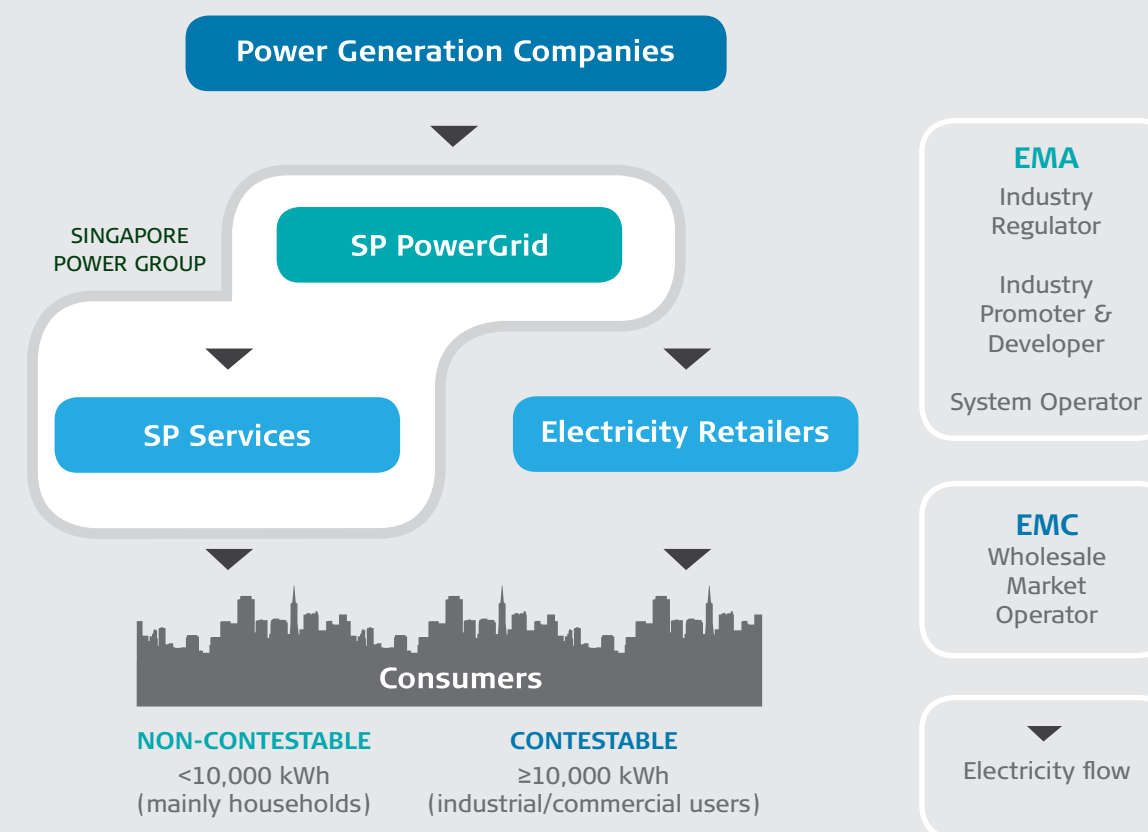


Fig. 3.1 Interaction between the different players in the electricity industry

ELECTRICITY DEMAND

The EMA's current electricity demand forecast is based on projections of Singapore's Gross Domestic Product (GDP) and population growth. The EMA has forecasted a contraction in electricity demand of 2.5 per cent to 4.0 per cent (depending on forecasted GDP growth) in 2009 as a result of the current economic downturn (Fig. 3.2). With electricity consumption closely linked to economic growth (Fig. 3.3), when the economy recovers over time, the EMA expects electricity demand to pick up accordingly. Between 2009 and 2018, demand is expected to increase at an annual rate of between 2.5 and 3.0 per cent (Fig. 3.2).

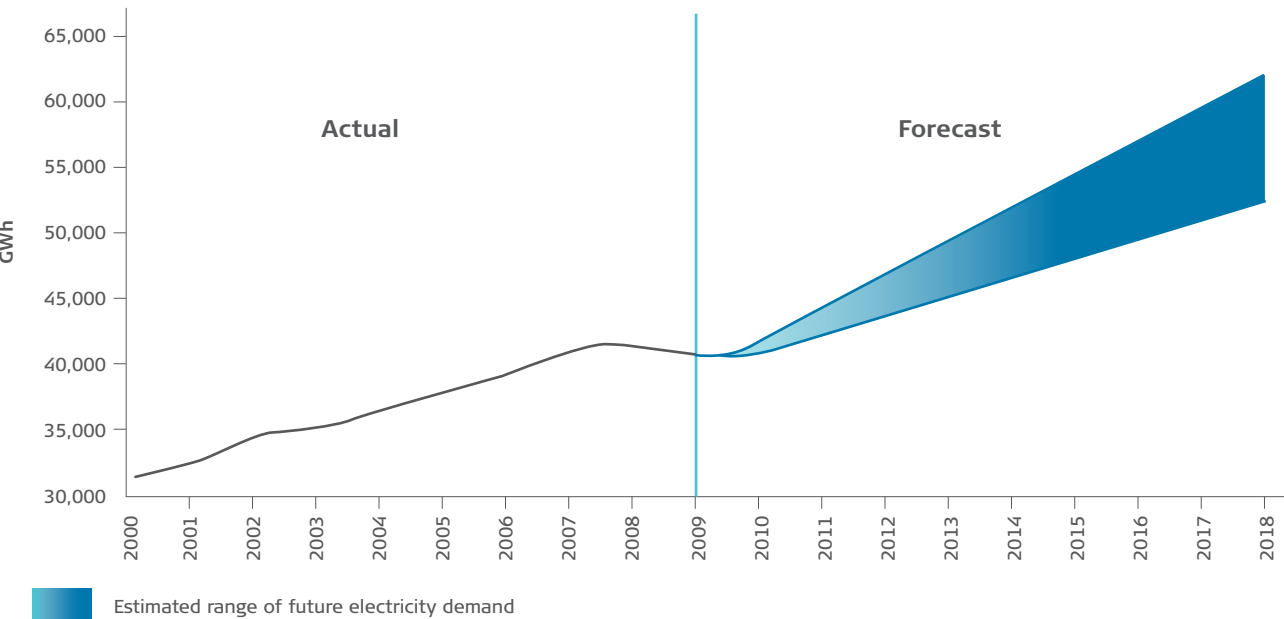


Fig. 3.2 Total electricity demand trends. Forecasted demand is based on GDP and population projections.

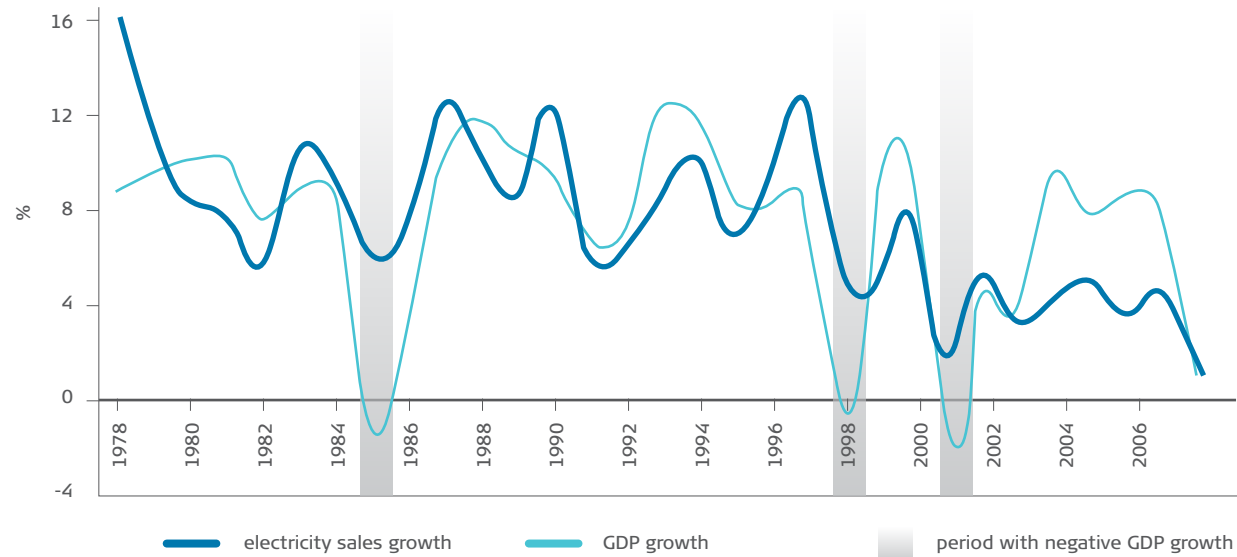


Fig. 3.3 The trend of electricity sales and GDP growth

It is however important to note that the demand projections do not take into account any structural changes in Singapore's economy or energy efficiency efforts that may be undertaken to optimize our use of energy. Singapore has established an Inter-Ministerial Committee on Sustainable Development, which has set a target for the country to reduce its energy intensity (or energy consumption per dollar GDP) by 20 per cent from 2005 levels by 2020, and by 35 per cent from 2005 levels by 2030. Efforts to realise these targets by encouraging electricity users to be more energy efficient could potentially reduce electricity demand to below the projected range.

ENSURING SINGAPORE'S SUPPLY OF ELECTRICITY

In Singapore, the minimum reserve margin has been set at 30 per cent above annual peak demand. This margin of 30 per cent is based on a loss of load probability of three days per year. The required reserve margin is to cater for scheduled maintenance as well as forced outages of generating units in the system. The projected reserve margin (Fig. 3.4), which forecasts the need for new generation planting, is based on the projected demand (Fig. 3.2) and projected generation capacity (Fig. 3.5). As mentioned above, these projected figures are currently based on GDP and population growth forecasts, and do not take into account changes in Singapore's economic structure or demand patterns due to energy efficiency measures. These can potentially delay the timeline for additional generation capacity to come onstream.

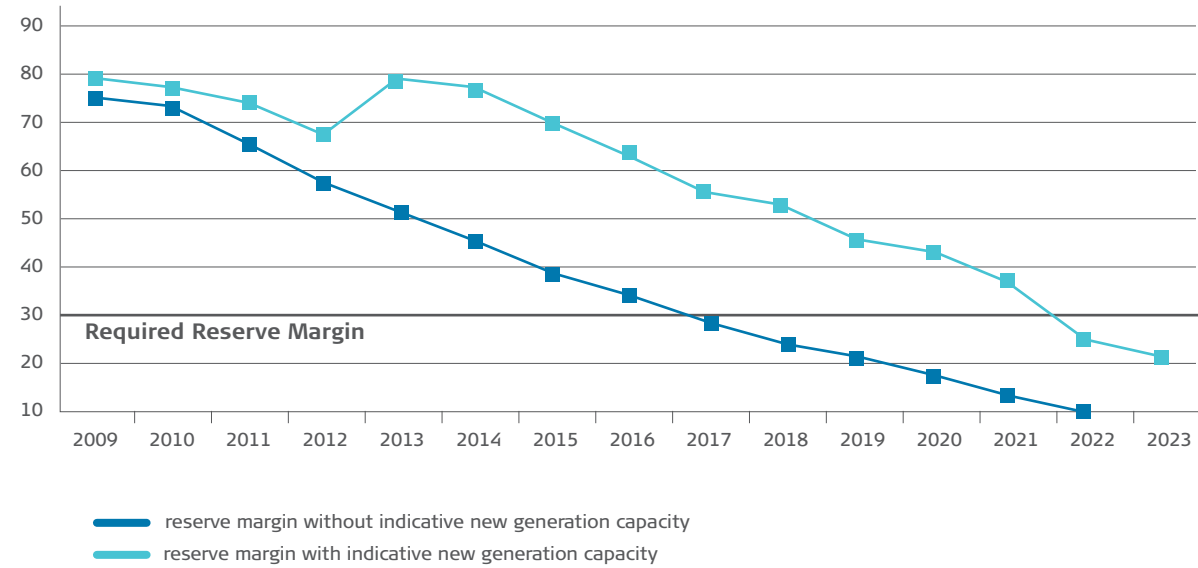


Fig. 3.4 Projected reserve margin

Several new generation plants are expected to come online in the coming years. ExxonMobil's cogeneration plant, producing an additional 220 MW of capacity, is expected to begin operations in 2011. Tuas Power is building the Tembusu Multi-Utilities Complex (TMUC) fuelled by biomass and coal, which targets to commence operations in 2012. Island Power Company intends to build an 800 MW gas-fired plant by 2013. Keppel Merlimau Cogen plans to build two generation plants of 450 MW each. Based on current indications, the earliest commissioning dates for the two plants are around 2013 and 2014 (Fig. 3.5).

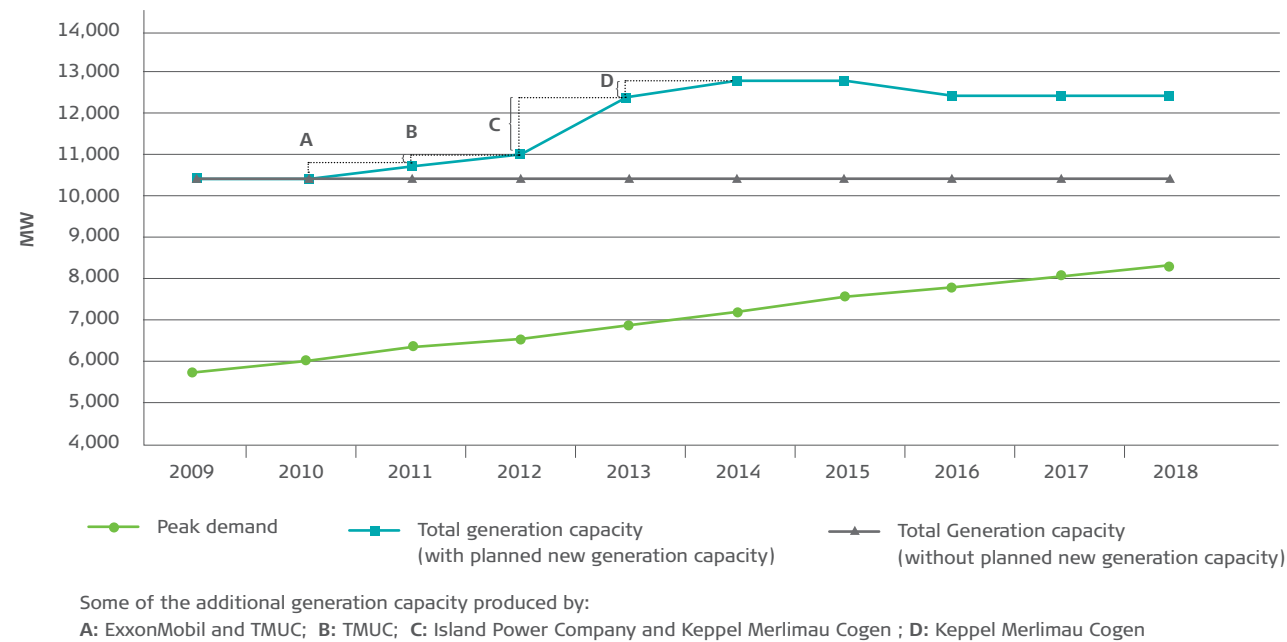


Fig. 3.5 Projected generation capacity¹

OPPORTUNITIES FOR NEW GENERATION PLANTING

Currently, two of the three biggest power plants are located in the west, PowerSeraya (2,700 MW) and Tuas Power (2,670 MW), along with Sembcorp Cogen (785 MW) and Keppel Merlimau Cogen (500 MW) on Jurong Island. Only the 2,655 MW Senoko Power is located in the north² (Fig. 3.7).

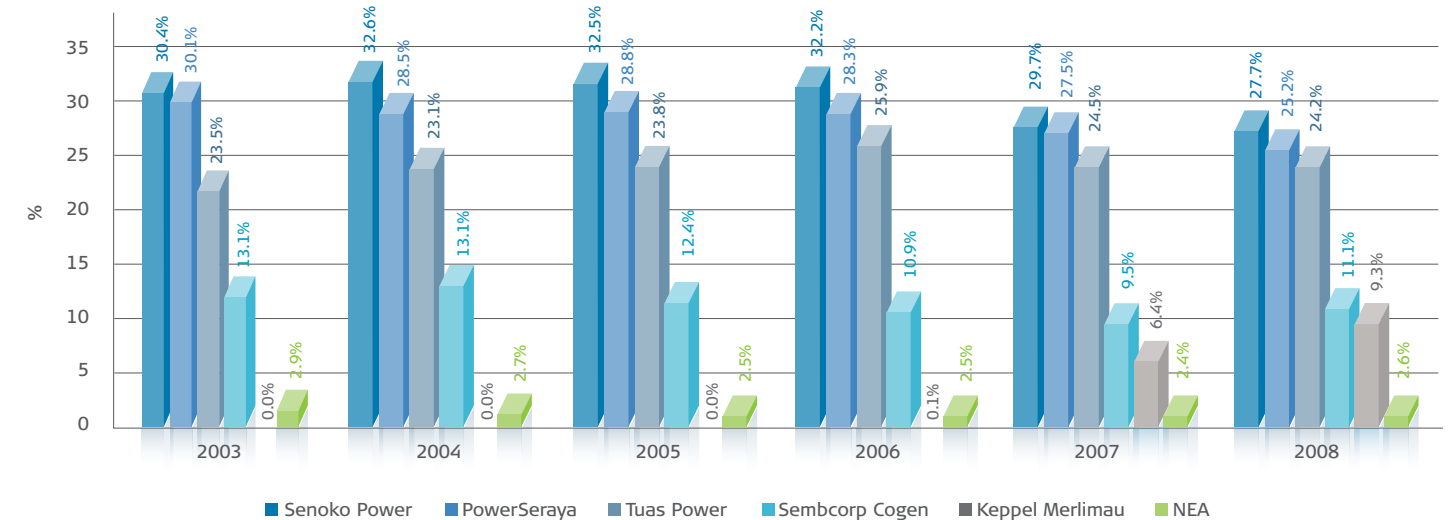


Fig. 3.7 Market share of generation companies

Currently most of our generation companies are located in the western part of Singapore, especially on Jurong Island. For the next major power plant, the EMA has set aside land in the northeastern part of Singapore, at Lorong Halus (Fig. 3.8). This new plant would cater to the growing demand for electricity in the northeastern region (Table 3.1) as new industrial clusters develop in this area, thereby reducing transmission losses. The EMA is currently working out the process for the sale of this land parcel to interested parties. More information will be released in due course.

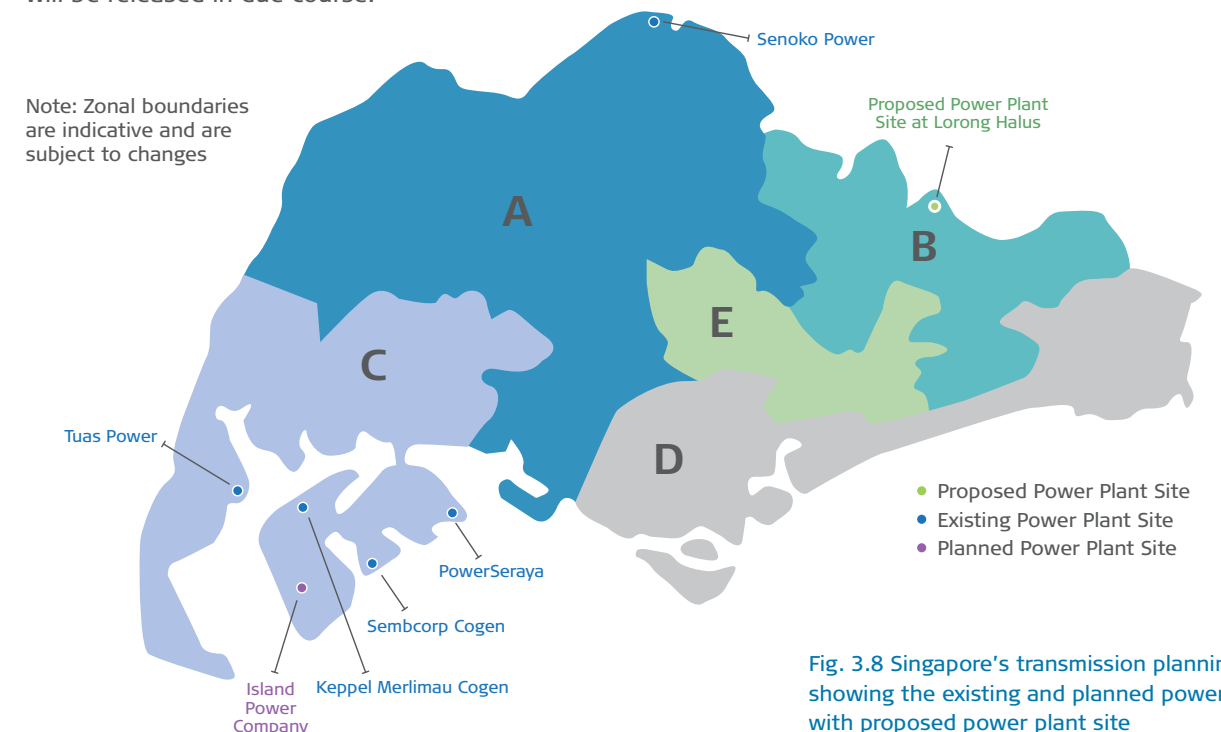


Fig. 3.8 Singapore's transmission planning zones, showing the existing and planned power plants, with proposed power plant site

VESTING CONTRACTS

To limit the market power of the generation companies, the EMA introduced vesting contracts between the incumbent generation companies and SP services as the counter party. Vesting contracts require generation companies to sell specific amounts of electricity (the vesting contract level), at a specified price (the vesting contract price).

Both the vesting contract level and the parameters used to set the vesting price are reviewed every two years by the EMA. The vesting level is currently set at 55 per cent of the total electricity demand. If there is keener competition in the generation market, and a corresponding reduction in market power, the EMA will progressively rollback the vesting contract level, possibly to a level of around 40 per cent over the medium-term. For example, the vesting level was reduced from 65 per cent to the present 55 per cent in 2007, following the commercial operation of Keppel Merlimau Cogen (Fig 3.6).

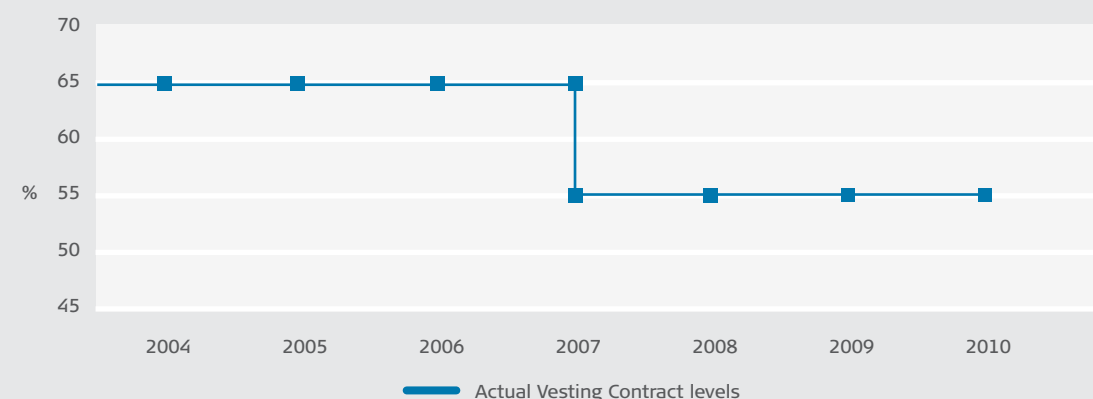


Fig. 3.6 Actual vesting contract levels. Prior to 2007, the actual vesting contract level was at 65 per cent. This was reduced to 55 per cent from the third quarter of 2007.

¹ Fig. 3.5 only shows investments in new generation capacity and excludes PowerSeraya's and Senoko Power's plans to repower their generators.

² All this figures indicate the licensed capacity, excluding those not commissioned, of each respective generation company, as of September 2009.

ZONE		MAX IMPORT CAPACITY	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Zone A (Northwest)	Generation Capacity	1,275	1,809	1,809	1,809	1,809	1,809	1,809	1,809	1,809	1,809	1,809
	Demand		1,162	1,208	1,294	1,360	1,399	1,426	1,503	1,597	1,647	1,647
Zone B (Northeast)	Generation Capacity	1,275	1,191	691	691	1,491	1,491	1,491	1,491	1,491	1,491	1,491
	Demand		1,251	1,294	1,294	1,360	1,399	1,426	1,503	1,513	1,564	1,647
Zone C (Southwest)	Generation Capacity	1,275	1,982	1,982	1,983	2,783	2,783	2,783	2,783	2,783	2,783	2,783
	Demand		1,251	1,294	1,466	1,530	1,646	1,677	1,837	1,933	1,976	2,059
Zone D (Southeast)	Generation Capacity	1,275	2,583	2,405	2,405	2,405	2,405	2,405	2,405	2,405	2,405	2,405
	Demand		1,877	1,898	1,898	1,954	1,563	1,677	1,670	1,681	1,811	1,811
Zone E (Central)	Generation Capacity	1,275	0	0	0	0	0	0	0	0	0	400
	Demand		0	0	0	0	494	587	585	588	576	659
400kV			2,670	3,398	3,398	3,398	4,298	4,298	4,298	4,298	4,298	4,298

Table 3.1 Zonal generation capacities and demand. Zones B and E have less zonal generation capacities compared to zonal demand.

DIVERSIFYING FUEL SOURCES FOR ELECTRICITY GENERATION

Currently, about 80 per cent of Singapore’s electricity is generated from natural gas, piped in from Malaysia and Indonesia (Fig. 3.9). To diversify our energy sources, the EMA currently controls the import of piped natural gas and other fuels for new commercial generation capacity so as to facilitate the introduction of liquefied natural gas (LNG) as an alternative feedstock for Singapore.

The EMA will review Singapore’s import control policy when LNG imports reach 3 mtpa or in 2018, whichever is sooner. If there is sufficient demand for LNG at this point, the EMA will consider opening up the fuel market for power generation.

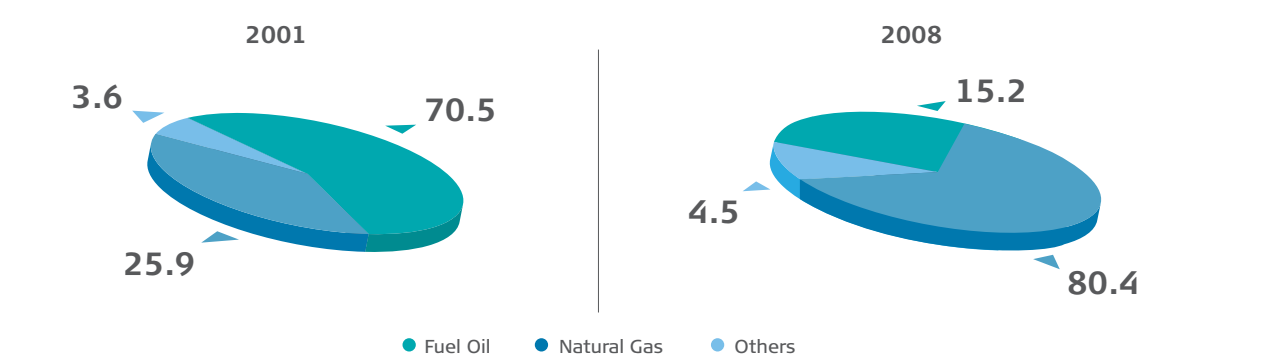


Fig. 3.9 Fuel mix for electricity generation

ELECTRICITY RETAIL MARKET - FULL RETAIL CONTESTABILITY

Since 2001, approximately 10,000 large consumers in Singapore, whose monthly consumption exceeds 10,000 kWh, have become “contestable”. These consumers make up of around 75 per cent of total load and are able to purchase electricity from retailers of their choice. The trends of the market share of Electricity Retail Market is shown in Fig. 3.10.

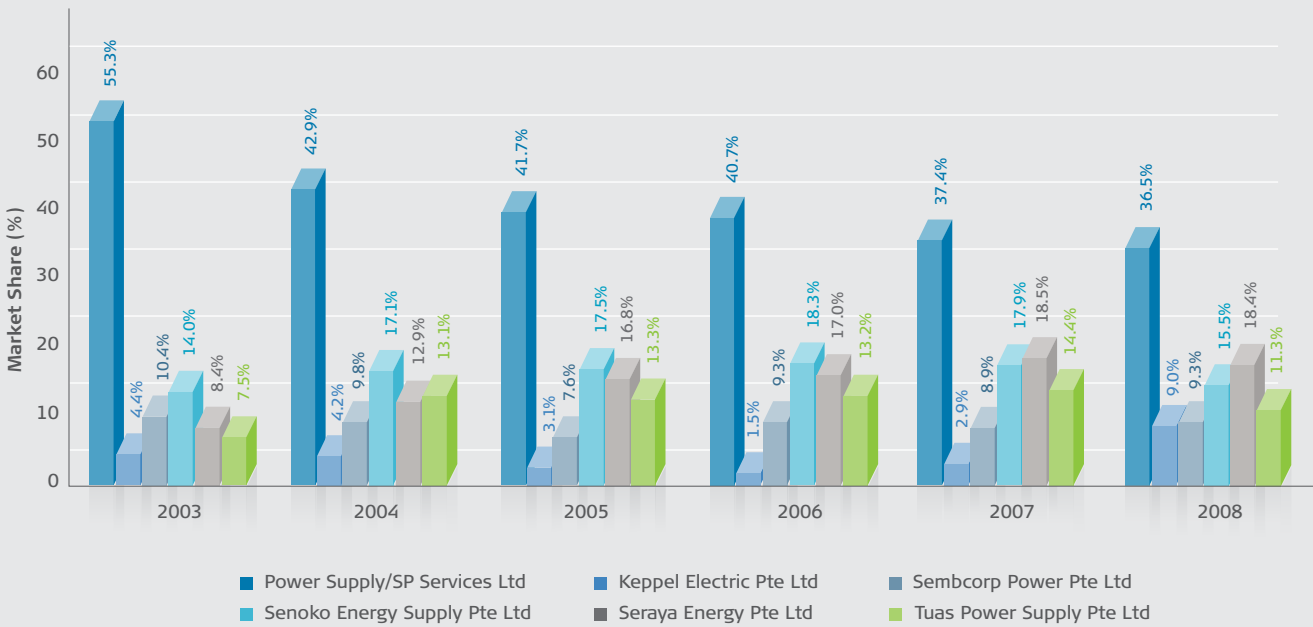


Fig. 3.10 Market share of electricity retailers and SP Services

The remaining 25 per cent of the retail market, comprising some 1.2 million small consumers, is still not contestable. The EMA plans to open up this sector so that consumers can enjoy the full benefits of competition. However, progress towards full retail contestability has been difficult thus far because of the high costs of maintaining and servicing small accounts. Hence the EMA is proactively exploring possible solutions for market liberalisation, including the use of smart meters. In particular, the EMA has initiated an Electricity Vending System prototype using smart meters and piloted this system for some 400 households. The pilot is due to be completed by the end of the year, following which a full study will be done to assess the feasibility of scaling up a smart meter system for nationwide deployment. The EMA is also studying the experience of other jurisdictions to learn relevant lessons that may be applicable to Singapore.



TRANSMISSION NETWORK PERFORMANCE

Singapore's electricity network is one of the most robust and reliable in the world. Based on a benchmarking study, our grid performance (as measured by the System Average Interruption Duration Index or SAIDI³) far exceeds those of other cities and countries. More importantly we have been able to deliver this high-quality grid performance while keeping the grid charge within reasonable levels (Fig. 3.11 and 3.12).

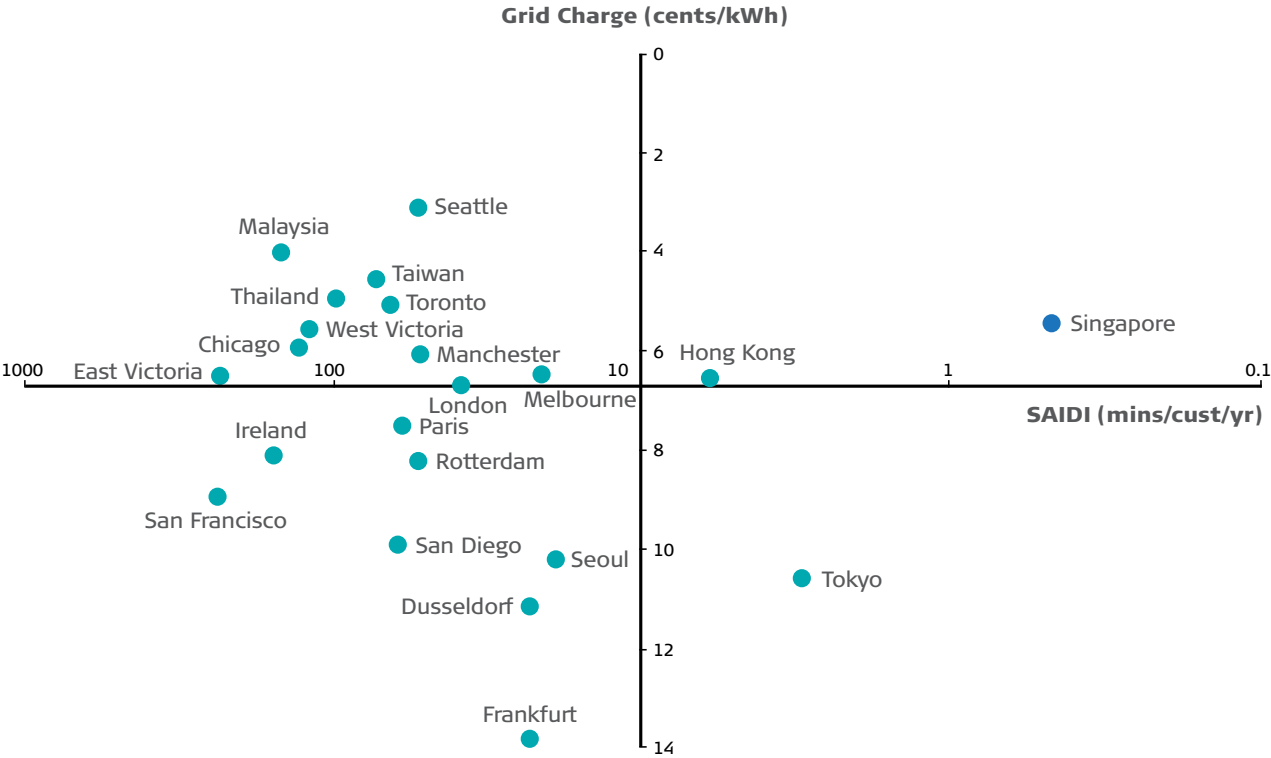


Fig. 3.11 Summary of benchmarking results for domestic customers (Low Tension – Small) (Source: SPPA⁴)

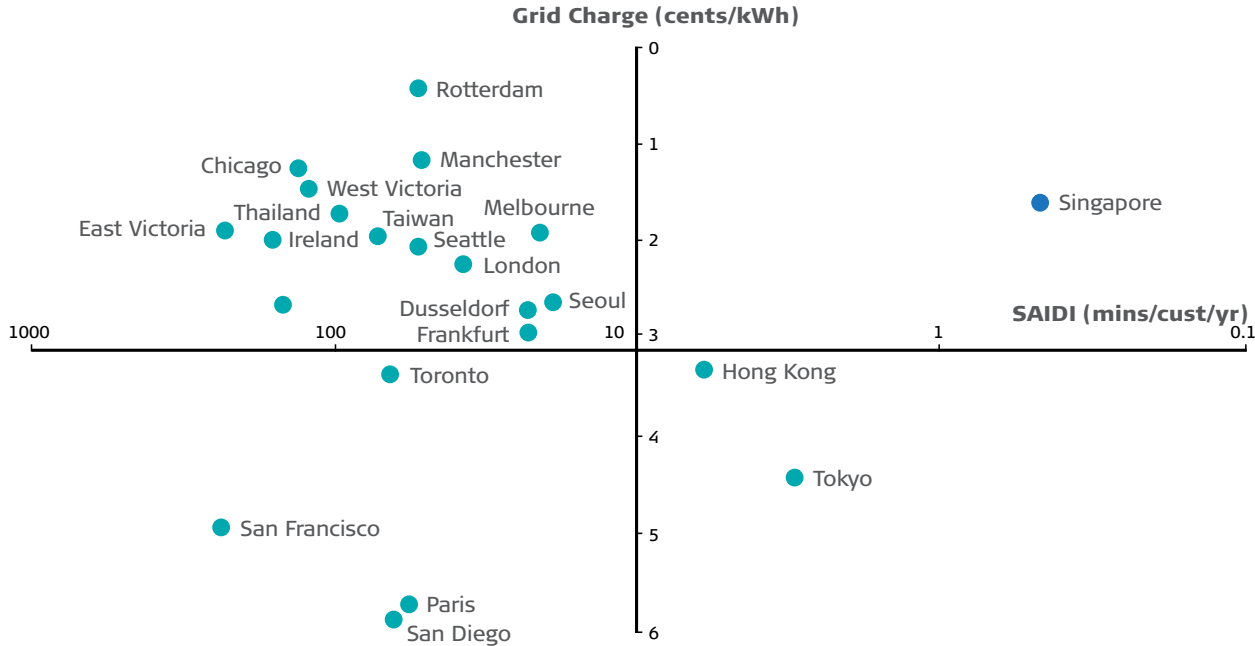


Fig. 3.12 Summary of benchmarking result for industrial customers (High Tension) (Source: SPPA²)

The performance of Singapore's transmission system has also improved over the last 10 years with a decline in both the duration (SAIDI) and the frequency of interruptions (as measured by the System Average Interruption Frequency Index or SAIFI⁵) (Table 3.2).

YEAR	1999	2000	2001	2002	2003	2004*	2005	2006	2007	2008
SAIDI (min)	4.46	3.53	2.57	1.68	2.39	5.72	0.46	1.12	1.31	0.53
SAIFI	0.088	0.064	0.061	0.025	0.109	0.103	0.009	0.029	0.027	0.012

* SAIDI for 2004 was affected by the one-off outage incident at a transmission substation in April 2004. This single incident alone accounted for 3.86 minutes.

Table 3.2 Transmission system annual SAIDI and SAIFI

³ The SAIDI measures the annual average interruption time per consumer in minutes.
⁴ Grid Price and Benchmarking Study. Tender reference no. TC050212; Final report reference no.: 0160-KCS/IMS 05-0422; Date: 7 July 2007.

⁵ The SAIFI measures the average frequency of consumer interruptions.



CLEAN ENERGY
AND RESEARCH & DEVELOPMENT



chapter 4

CLEAN ENERGY AND RESEARCH & DEVELOPMENT

Climate change and energy security are two of the most urgent issues facing the international community. One strategy is to shift towards clean and renewable energy, like wind and solar power, with a smaller carbon footprint. Currently, renewable energy solutions are expensive and they lack the scale to replace more than a small proportion of fossil fuel use. However, the higher support for energy research worldwide will inevitably drive technological advances. Over time, clean and renewable energy options are likely to become more economically competitive and viable as sources of power generation.

SOLAR ENERGY

Singapore is located in the tropical sunbelt with an average solar yield⁵ per unit of installed capacity 1,150 kWh/kWp/year. There is therefore potential to tap on solar energy for power generation, although our heavy cloud cover means that the energy from solar would be intermittent and highly variable in nature.

Singapore's position as a major semiconductor hub allows us to tap on our highly skilled workforce with skills and knowledge that can be easily transferred to support the manufacture of photovoltaic (PV) arrays. Singapore's urban environment with excellent logistics and supply chain capabilities would also facilitate the export of technologies to the region including markets with a potential demand for off-grid power generation solutions such as India, China, Sri Lanka and many of the Southeast Asian countries.

In Singapore, solar PV systems have been deployed in various pilot projects, as led by the Housing and Development Board (HDB) at two public housing precincts. These systems, which generate 220 kWh of electricity per day, were funded by the Clean Energy Research and Test-bedding (CERT) grants from the Economic Development Board (EDB). As of June 2009, Singapore has played host to 31 commercial and 9 household solar PV installations connected to the grid with a total capacity of 478.7 kWp⁶.

⁵ Solar yield is the amount of electricity (measured in kWh) that the photovoltaic system will produce on an annual basis, based on the rated capacity of the system (measured in kWp).
⁶ kWp is a nominal measurement of a solar PV system's output under a set of standard conditions (defined as an irradiance of 1000 W/m², specific air mass and cell temperature of 25°C).



Fig. 4.1 Solar PV system on a HDB building

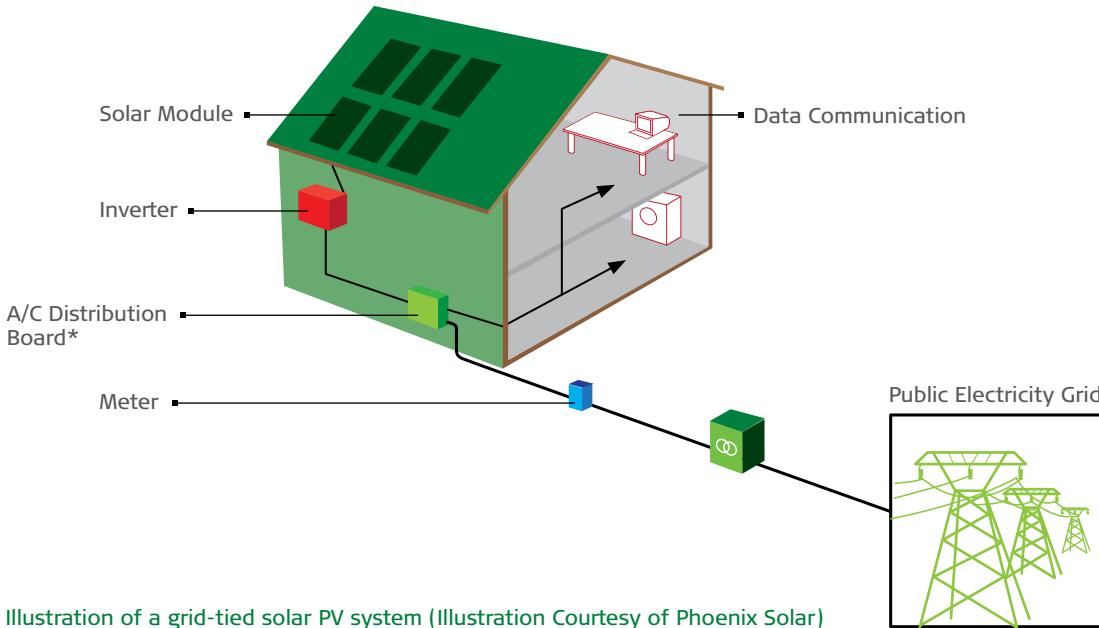


Fig. 4.2 Illustration of a grid-tied solar PV system (Illustration Courtesy of Phoenix Solar)

Leading industry leaders have established a presence here including Norway's Renewable Energy Corporation (REC), which will be building the world's largest solar manufacturing plant here, slated to begin operations in 2010. REC will produce end-to-end PV solar energy components such as wafers, cells and modules for the international market. Germany's Solar Energy Power manufactures ultra-thin wafer-based solar cells in Singapore and Singapore-based Eco-Solar produces solar panels and solar-powered consumer products. In addition, SolarWorld and Conergy have their Asia Pacific headquarters based in Singapore.

SOLAR PV INSTALLATIONS IN SINGAPORE

There are 31 grid-connected commercial solar PV installations with a total capacity of 422.1 kWp (as of June 2009) in Singapore (Table 4.1).

Solar Installation	System Size (kWp)
Glaxo Wellcome Manufacturing	57
Singapore Telecommunications Ltd	40
Republic Polytechnic	30
Seagate	16

Table 4.1 Selected grid connected commercial solar PV installations

There are also 9 households with solar PV installations with a total capacity of 56.6 kWp (as of June 2009) connected to the grid.

EDB has awarded grants to 9 public projects to install solar PV systems under the CERT platform (Table 4.2).

Solar Installation	System Size (kWp)
Building & Construction Authority's (BCA) Zero Energy Building	190
HDB Sembawang & Serangoon North	146
National Parks' Gardens by the Bay	To Be Confirmed
Public Utilities Board (PUB) Marina Barrage	70
Singapore Polytechnic	47
Changi Airport Budget Terminal	250
Khoo Teck Puat Hospital	150
Ngee Ann Polytechnic	14
National Environment Agency's (NEA) Meterological Services Building	25

Table 4.2 Public projects with PV systems installed

EDB has also awarded 5 private sector projects under the S\$20 million Solar Capability Scheme (SCS) (Table 4.3).

Solar Installation	System Size (kWp)
Applied Materials Manufacturing Facility	366
City Development Limited Tampines Grande	108
Lend Lease Retail's 313 Somerset	76
Lonza Biologics Manufacturing Facility	181
Robert Bosch SEA HQ Building	88

Table 4.3 SCS projects

CERT and SCS will add another 4 MWp of installed solar capacity to Singapore's solar energy landscape.

BIOFUELS

As the regional hub for oil and gas, Singapore is well-positioned to capitalise on opportunities in the biofuels market. Our extensive experience and expertise in oil trading can easily be applied to biofuels trading as the industry develops further and matures.

Singapore is close to countries that provide the source of raw materials, thus simplifying the process of obtaining feedstock. In addition, the well-connected global shipping routes would greatly facilitate export of the processed biofuels. Companies would also be able to benefit from the many free trade agreements Singapore has signed with our foreign partners. Finnish oil refiner Neste Oils has already invested S\$1.2 billion to establish the world's most advanced and largest commercial-scale biodiesel production facility in Singapore and is expected to commence operations in 2010.

Singapore also plays host to a network of research institutes who have conducted extensive work in the development of second and third generation biofuels, including Temasek Life Science Laboratory (TLL), the Institute of Chemical and Engineering Sciences and the Institute of Environmental Science & Engineering. TLL, through its spin-off company, JOil Pte Ltd, has entered into a joint venture with India's Tata Chemicals to develop jatropha as a biodiesel feedstock. Jatropha holds tremendous potential as it can be grown on marginal land, thus leaving arable land for the cultivation of food crops.

SINGAPORE'S BIOMASS INDUSTRY

There are currently 3 incineration plants operated by the NEA and 2 private co-generation plants converting wastes into electricity in Singapore generating up to 184 MW of electricity (Table 4.4).

Turbine Capacity (MW)	
Incineration Plants	
Tuas Incineration Plant	46
Senoko Incineration Plant	56
Tuas South Incineration Plant	80
Co-generation Plants	
Eco Special Waste Management Pte Ltd	0.5
IUT Singapore Pte Ltd	2

Table 4.4 Waste to electricity plants in Singapore

WIND ENERGY

Although wind speeds in Singapore and the rest of the tropics are generally low, there are still business opportunities to exploit, especially in the development of wind turbine generators adapted for low wind speed conditions. Vestas Wind Systems A/S, the world's leading supplier of wind power solutions established its regional Research and Development (R&D) Hub for Asia at Singapore's newly launched Fusionopolis research centre in November 2008. Recognising Singapore's strong engineering and technology talent pool, Vestas has identified collaboration opportunities with local research institutes and universities. Vestas envisions that its Singapore R&D Hub will accelerate its capabilities to harness wind power and expand its operations in Asia.

ENERGY RESEARCH AND DEVELOPMENT

Singapore is rapidly developing its research capabilities in the energy sector to support business innovation and development. Research institutes under the Agency for Science, Technology and Research (A*STAR) have established research programmes in various areas including fuel cells, biofuels, next generation solar PV technology, carbon management and intelligent energy distribution systems. The Solar Energy Research Institute of Singapore at the National University of Singapore (NUS) focuses on research in silicon PV technology, nano-structured solar cells and energy efficient buildings. The Centre for Sustainable Energy Research, through its Energy Research Institute at Nanyang Technological University (NTU), conducts research on advanced fuel cell technology, charge storage, wind and tidal energy and smart buildings.

Extensive government support

The funding support for research and the push to transfer technology and drive adoption in industry demonstrate the commitment of the Singapore government to seize the opportunities presented by the energy industry.

The EMA has launched a S\$25 million Energy Research Development Fund (ERDF) to be disbursed over five years to drive research, development and demonstration initiatives to address issues pertaining to Singapore's

energy sector such as energy security, energy efficiency and the development of a competitive energy industry in Singapore.

The ERDF is targeted at a wider spectrum of projects that can include solutions to optimise grid operations, enhance energy efficiency in Singapore's industries or facilitate the entry of new sources of fuel into Singapore. The EMA has also recently set up a S\$5 million Market Development Fund (MDF) to encourage the adoption of renewable energy solutions. The MDF will help to offset the market charges associated with selling renewable energy into the electricity grid.

The EDB is funding both upstream and downstream research in clean energy with the S\$50 million Clean Energy Research Programme. To date, the EDB has awarded a total of S\$10 million to eight research teams. EDB also has a S\$17 million CERT programme to assist private companies which are interested in partnering with government agencies to develop and test-bed applications and solutions in clean energy. EDB also has a S\$20 million SCS to facilitate the installation solar panels in new building projects.

The NEA has also recently established a S\$15 million seed fund focusing on waste management under the Environment Technology Research Programme (ETRP). The desired outcomes of the ETRP are to build R&D capabilities, develop technological competencies and to develop sustainable waste management solutions for Singapore. The ETRP research grants will be competitively funded via the Request-for-Proposal (RFP) scheme and the RFP will be called twice a year in January and July.

In 2009, A*STAR has awarded a total of 28 research grants worth S\$27.5 million to fund new research programmes in Sustainable Development. The award of these grants marks the first time programmes are brought together in a concerted effort to address challenges relating to the environment such as energy, sustainable materials and sustainable construction. The recipients of the grant awards are research teams from A*STAR research institutes, local universities and polytechnics. A*STAR also has a number of programmes to help local industries with technical assistance and manpower. Under the Technology for Enterprise Upgrading Programme, A*STAR, together with other government agencies, will second research scientists and engineers to local enterprises to help them to leverage on the available talent pool.



Fig. 4.3 Artist's impression of Jalan Bahar Cleantech Park

JALAN BAHAR CLEANTECH PARK

Singapore is setting up a 55-ha special tech park for companies involved in clean technology activities such as R&D, test-bedding, prototyping and light manufacturing. The Jalan Bahar Cleantech Park will have sustainable building and infrastructure features and provide a plug-and-play environment to test-bed solutions aimed at cities. It is located next to NTU and will be developed over 20 years, with the first phase scheduled to go online in 2011.

A*STAR’s ENERGY RESEARCH INITIATIVES

A*STAR’s Science and Engineering Research Council (SERC) has a number of research programmes and initiatives focusing on key areas in energy. They are as follows:

Intelligent energy distribution systems

An intelligent power grid will ensure more efficient usage and deployment of power throughout the transmission system. A*STAR’s intelligent energy distribution systems programme will focus research on sensor and communication technologies, power control and distribution devices, software for advanced energy management and integration of these technologies at a systemic level as well as a system-of-systems level.

Carbon capture and utilisation

As a major greenhouse gas, the presence of carbon dioxide in the atmosphere adversely impacts the global climate and is thus of considerable concern. A*STAR’s carbon capture and utilisation programme looks at technologies and processes to efficiently capture, store and utilise carbon dioxide to address the level of atmospheric carbon dioxide and, as such, reduce its harmful effects on the environment.

Bioenergy and biofuels

Bioenergy and biofuels from non-food derived feedstocks hold tremendous potential as a sustainable energy resource. A*STAR’s bioenergy and biofuels programme aims to harness renewable energy with a three-prong approach: enhance the capacity of the biomass to generate bioenergy, improve the conversion efficiency of the biomass feedstock, and maximizing residual biomass resource value via production of specialty chemical and nutraceuticals.

Fuel cells

Fuel cells have long been viewed as a viable avenue to produce clean and sustainable energy. A*STAR’s fuel cell core research programme builds up Singapore’s capabilities in fuel cell technology in two priority areas, namely ceramic-based Solid Oxide Fuel Cells and polymer-based Proton Exchange Membrane Fuel Cells. Singapore has four world-class research institutes doing cutting edge work on fuels cells – the Institute of Materials Research and Engineering, the Institute of Chemical and Engineering Sciences, the Institute of High Performance Computing and the Singapore Institute for Manufacturing Technologies.

Solar PV research

In terms of solar research, A*STAR is engaged in two key research areas, namely organic solar PV and silicon-based solar PV. Organic solar PV research is being undertaken by the Institute of Materials Research and Engineering, together with the Institute of High Performance Computing, the Singapore Institute of Manufacturing Technology and the National Metrology Centre. This research focuses on materials design and synthesis, modelling and simulations, device manufacturing processes and solar device characterization, calibration and certification. Research on third generation silicon-based solar PV is being done at the Institute of Microelectronics together with NTU.

The Experimental Power Grid Centre

The S\$38 million Experimental Power Grid Centre was established as a research unit within A*STAR to support the development of next generation grid technology in Singapore. The centre boasts of a state-of-the-art physical infrastructure consisting of an experimental micro-grid and a remote command and control facility, and will focus on developing a system-of-systems approach for intelligent/micro-grids and distributed energy technologies in collaboration with the research community, public agencies and industry.

SUMMARY OF SELECTED RESEARCH AND PILOT INITIATIVES

Research/Pilot Initiative	Description	Technologies	Organisations
Pulau Ubin Renewable Energy Project	A project to incorporate clean and renewable energy test bedding on Pulau Ubin (see chapter on “Test-Bedding”)	Various clean and renewable energy and energy storage technologies	EMA
Electric Vehicle Test-Bed	A project to test-bed various electric vehicle and charging infrastructure technologies (see chapter on “Test-Bedding”)	Electric vehicles	EMA, LTA
Treetops@Punggol	An eco-friendly housing precinct which incorporates various clean technologies	Solar PV, water conservation, waste management and energy efficiency technologies	HDB
Jatropha Cultivation Project	A project to develop techniques for more efficient cultivation of jatropha for biodiesel production	Biofuels	TLL, JOil, Tata Group
Vestas R&D Hub	A collaborative project with local institutes of higher learning for wind power research	Wind energy	Vestas, NUS, NTU, A*STAR
Jalan Bahar Cleantech Park	A 55-ha special tech park for companies involved in clean technology activities such as R&D, test-bedding, prototyping and light manufacturing	General clean energy technologies	EDB, JTC
Thematic Research Programmes	Research programmes which focus research efforts on three distinct areas	Intelligent energy distribution systems, carbon capture and utilization and bioenergy	A*STAR
Fuel Cell Research Programme (SERC)	Fuel cell core research programme to build up Singapore’s capabilities in fuel cell technology	Fuel cells	A*STAR
Solar PV Research Programmes	A*STAR has several research programmes which focus on organic solar PV and silicon-based solar PV	Solar energy	A*STAR
Experimental Power Grid Centre	Research unit within A*STAR to support the development of next generation grid technology	Intelligent/micro-grids and distributed energy technologies	A*STAR

Table 4.5 Some of Singapore’s research and pilot initiatives

TEST-BED PROJECTS



TEST-BED PROJECTS

It is an interesting time to be in the energy sector now. Recent technological advances have opened up a range of exciting possibilities in the energy space for clean and renewable energy solutions, intelligent grid management systems, new concepts for powering transportation and better energy usage efficiency. Opportunities abound for enterprising companies, with the current flurry of business activity in the realm of smart grid solutions as well as the race among automotive manufacturers to develop electric vehicles being cases in point.

To take advantage of the opportunities in the energy sector, the Energy Market Authority (EMA) is working with its partners to make Singapore a 'living laboratory' for novel energy solutions. To facilitate this process, Singapore has developed various test-bedding projects as platforms for companies to test out their solutions in a real-life environment, learn from the experience, and use Singapore as a springboard to launch these solutions overseas. Singapore's small size and good infrastructure makes it easy to roll out new concepts quickly and our highly skilled workforce and advanced engineering sectors also mean that manpower and technical support are readily available for pilot projects.

PULAU UBIN

The EMA recently embarked on a project that could potentially transform Pulau Ubin, one of our offshore islands, into a model 'clean' island powered entirely by clean and renewable energy integrated into an intelligent micro-grid. Pulau Ubin currently does not draw electricity from the main power grid and it is not economical to lay power transmission cables from mainland Singapore to Pulau Ubin due to its modest energy demand. All the inhabitants of the island draw electricity from their own diesel-powered generators, which are not only pollutive but also unreliable.

The vision for this test-bed is for a small-scale, clean and intelligent power supply network to be created on the island to gradually replace the diesel generators. Pulau Ubin lends itself very well to such a system because

of its unique conditions. The island's small size and isolation makes it an ideal location for such a test-bed because it is easy to set up an intelligent micro-grid there, on which different power systems can be tested without interfering with the main grid.

While there is a whole range of clean and renewable energy options available in the market, not all of these solutions may be suitable for the conditions in Singapore and around the region. For instance, Singapore's low wind speeds may require specially designed wind power turbines and tidal energy solutions may have to be customized to local sea levels and tidal patterns. One of the aims of the Pulau Ubin project is to test out the feasibility of the various clean energy solutions and to further develop them to suit Singapore and the region. The EMA is close to completing a feasibility study that started in November 2008 on the different clean and renewable energy solutions for the island and an invitation will soon be put out for companies to propose clean energy solutions for the project.

In Singapore, solar PV systems have been deployed in various pilot projects, as led by the Housing and Development Board (HDB) at two public housing precincts. These systems, which generate 220 kWh of electricity per day, were funded by the Clean Energy Research and Test-bedding (CERT) grants from the Economic Development Board (EDB). As of June 2009, Singapore has played host to 31 commercial and 9 household solar PV installations connected to the grid with a total capacity of 478.7 kWp.

CLEAN AND RENEWABLE ENERGY CONCEPTS FOR PULAU UBIN

Being a small rural island, Pulau Ubin does not consume a lot of electricity. The maximum anticipated load on the island is estimated to be 1.7 MW. There are a few major loads on the island where electricity usage is likely to be concentrated. Marina Country Club in the southern part of the island constitutes a load of approximately 800 kW while Outward Bound Singapore contributes about 400 kW.

There are geographical features on the island, which can possibly be exploited and incorporated into the plans to deploy clean and renewable energy solutions. Some of these features include two rain water-filled disused granite quarries of different heights, which can be used as a pumped-storage hydroelectricity system where excess energy generated by the renewable energy solutions can be used to pump water from the lower quarry to the higher quarry. In the absence of sufficient sunlight or wind for power generation, water can be allowed to flow back into the lower reservoir through a microturbine, which can generate electricity on demand. This helps mitigate the problem of intermittency in the generation of renewable energy solutions such as solar photovoltaic (PV) systems or wind turbines.

The island is also home to some disused prawn farms, which could be possible sites for the cultivation of algae for biomass. The biomass can then be processed into biogas and biodiesel to fuel power generators and vehicles on the island.

Table 5.1 summarises some of the concepts for clean and renewable energy as well as energy storage that can possibly be implemented on the island.

High Potential Technologies	Description
Solar PV systems	Like the mainland, Pulau Ubin experiences good solar irradiation, making it an ideal location for the implementation of solar PV systems, which directly convert solar energy into electricity.
Pumped-storage hydroelectricity system	Water can be flowed between disused granite quarries of different heights to power a micro-water turbine to generate electricity when other intermittent sources of energy are not available.
Micro-wind turbines	Wind speeds on Pulau Ubin (and the tropics in general) are low but it is possible to design smaller and lighter wind turbines, which can still generate power in these conditions.
Battery technology	Batteries can be used to store excess energy generated from intermittent renewable sources such as solar PV systems or wind turbines for use when these sources are not available.
Fuel cells	Excess electricity generated from intermittent renewable sources can be used to electrolyse hydrogen, which can then be stored and used to power fuel cells to generate electricity on demand.
Biogas and biodiesel by anaerobic digestion	Disused prawn farms can be used to cultivate algae to produce biomass, which can be processed into biogas and biodiesel to fuel power generators or land transportation on the island.

Table 5.1 Possible clean and renewable energy and energy storage concepts for Pulau Ubin

ENERGY FOR TRANSPORT

In urbanised areas like Singapore, petrol- and diesel-powered vehicles are a significant source of carbon emissions and pollution. Recent technological developments, however, have made it feasible to implement a host of new, more environmentally-friendly and efficient transportation solutions. These technologies encompass a wide spectrum ranging from vehicles powered by compressed natural gas (CNG) to hydrogen fuel cell vehicles. In particular, one promising development is the introduction of electric vehicles. In March 2009, the US announced US\$2.4 billion worth of funding with the goal of putting one million plug-in hybrids on the road by 2015. UK Prime Minister Gordon Brown also recently pledged €115 million to support electric, hybrid and other environmentally friendly vehicles over a five year period to make Britain “the European capital for electric cars”. China has also openly declared its intention to become a world leader in electric vehicle manufacturing.

Electric Vehicle Test-Bed

On Singapore’s part, we recently launched our Electric Vehicle Test-Bed on 6 May 2009 with S\$20 million worth of funding. This is envisaged as an open platform where all automotive manufacturers and electric vehicle charging infrastructure players are welcome to develop and test their concepts. The test-bed is a multi-agency effort involving the EMA, the Agency for Science, Technology and Research (A*STAR), the Economic Development Board (EDB), the Land Transport Authority (LTA) and the National Environment Agency (NEA).

Many factors make Singapore an ideal place to test electric vehicle technology. Because Singapore is a small, highly urbanised country, driving distances are short. Most vehicles do not travel more than 60 km a day, well within the range for most electric vehicles under development currently. Singapore also has an extensive, robust and reliable electricity grid that can easily support the charging of electric vehicles and, in the future, can incorporate technologies for electric vehicles to supply electricity into the grid to supplement current power generation. In addition, Singapore has the capability to test, operate and maintain electric vehicles. Our well-developed electronics, power and precision engineering industries provide the workforce with the necessary expertise. Singapore is also developing a critical mass of scientists and researchers in the energy sector, giving investors and partners a ready talent pool to draw upon in adapting their technologies to Singapore’s tropical conditions.

The multi-agency taskforce has signed a Memorandum of Understanding with Renault-Nissan as a vehicle manufacturer partner and Keppel Energy as a partner for infrastructure development. Nevertheless, as the test-bed is an open platform, Singapore welcomes more partners to participate in the project.

To facilitate the adoption of electric vehicle charging infrastructure in Singapore, the EMA will be developing a Technical Reference for charging infrastructure standards to be published in early 2010. The Technical Reference will lay the foundation for the deployment of electric vehicle charging points in Singapore by laying down standards for safety and interoperability between different electric vehicle models. At the same time, the taskforce is studying options to implement charging infrastructure solutions in Singapore and welcomes discussions with industry players in this sector.

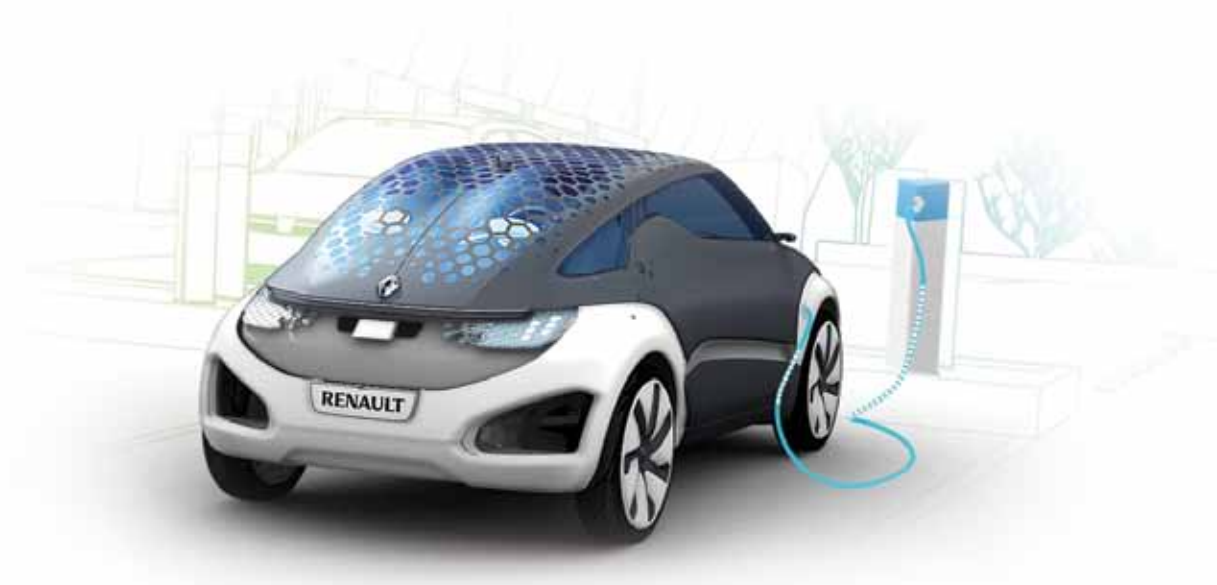


Fig. 5.2 Charging of an electric vehicle

Source: Renault

Test-Bedding of Other Vehicle Technologies

Apart from the Electric Vehicle Test-Bed, Singapore is also keen to serve as a ‘living lab’ for other clean vehicle technologies. We are currently running a biodiesel test-bed programme led by Robert Bosch (Southeast Asia) Pte Ltd and eight other partners. The three-year project aims to test the use of B5 palm oil methyl ester as a motor fuel, and to establish a greater understanding of its use in Southeast Asia’s climate.

In support of such test-beds, the EDB and the LTA jointly administer the Technology Innovation and Development Scheme⁷ (TIDES) which allows companies to register vehicles used for research and development (R&D) and testing of new transport technologies with a waiver of vehicle taxes.

ALTERNATIVE FUELS VEHICLE USAGE

Singapore has seen an increasing use of alternative fuels for vehicles over the years. The government introduced the Green Vehicle Rebate⁸ (GVR) in 2001 to encourage take up of green vehicles such as hybrid electric vehicles, electric and natural gas cars by narrowing the cost differential between green vehicles and the conventional gasoline-powered vehicles.

A growing number of vehicles, including public buses, taxis and private cars, are fuelled by CNG. We have also seen a rise in demand for hybrid vehicles⁹ (Fig. 5.3).

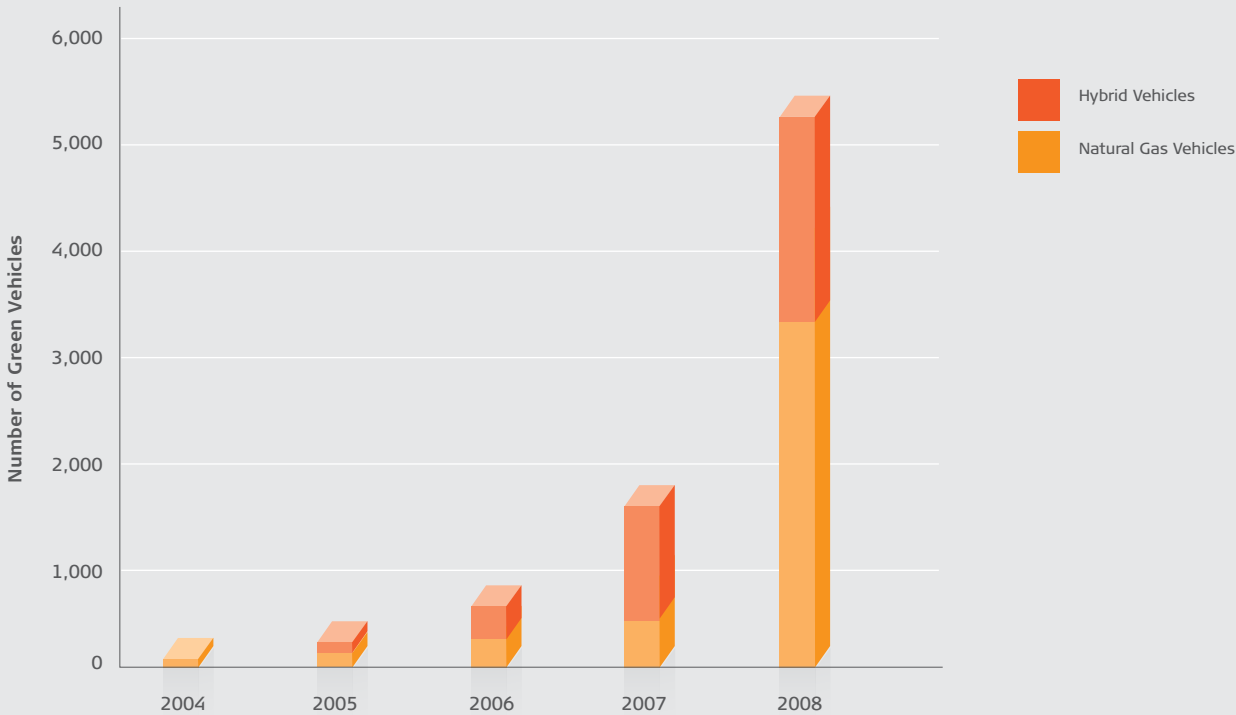


Fig. 5.3 Growth in green vehicle population in Singapore from 2004 to 2008 (data from LTA)

⁷ Through TIDES, vehicles incorporating new technologies undergoing R&D and test-bedding in Singapore are granted exemptions on Certificate of Entitlement (COE), Additional Registration Fee (ARF) and Road Tax upon approval. There is a current cap of 300 vehicles allowed under the scheme. Prospective electric vehicles (EVs) fleet owners will only need to pay the Open Market Value (OMV), insurance and a Special Purpose Licence of \$1,600 per year for any EVs that they acquire. The EVs will be issued with a blue and yellow “RD” licence plate.

⁸ Under the GVR scheme, new green vehicles registered until 31 Dec 2011 enjoy a 40% rebate off the Additional Registration Fee (ARF) of the vehicle.

INTELLIGENT ENERGY SYSTEMS

The concept of the “smart grid” has taken off in the past year. Worldwide, companies and governments are looking at improvements in grid automation through the use of advanced information communication technologies. The aim is to enhance the capabilities of the power infrastructure to achieve greater efficiency and reliability.

Singapore already has a highly-automated grid with reliability and performance levels that are amongst the best in the world. However, there is scope to do more. One key enabler in the smart grid system is an advanced metering infrastructure (or smart meter), which captures and shares more information between the utilities and consumers. With smart meters and the progressive liberalisation of the retail market, consumers will be able to choose between retail packages on offer from a range of electricity suppliers.

Solutions such as home and building automation systems, which incorporate smart metering technologies, will also enable consumers to monitor and control their electricity consumption, and save on their electricity bills.

A more intelligent network will also facilitate the integration of energy sources that are intermittent in nature, such as solar PV systems, micro-wind turbines and even electric vehicles of the future which may be capable of supplying electricity back into the grid to supplement peak electricity demand. The interaction between such intermittent sources of energy and the grid will require an intelligent interface in order to provide for a greater degree of optimisation around the energy supply.

Work on smart grids in Singapore is proceeding on several tracks. The A*STAR is developing an Experimental Power Grid Centre, which will involve a micro-grid (not connected to the main grid) for research and testing purposes. At the same time, the EMA is looking at what can be done within our existing power infrastructure, both to enhance the grid capabilities and also to deploy smart metering solutions in a cost-effective manner. We look forward to engaging industry players as we develop our plans to create an intelligent energy system for Singapore.

⁹ Almost all of the hybrid vehicles sold in Singapore so far are of the traditional variety (also known as charge-maintaining hybrid electric vehicles or CHEVs), meaning that they utilise both a conventional internal combustion engine and an electric motor as power sources but cannot be plugged into an electricity source to be recharged like a full electric vehicle. The batteries used to power the electric motor are charged using regenerative braking, which converts the vehicle’s kinetic energy into battery-replenishing electric energy, rather than wasting it as heat energy as vehicles equipped with conventional brakes do.

SUMMARY OF OPPORTUNITIES





chapter 6

SUMMARY OF OPPORTUNITIES

Singapore’s energy sector holds tremendous promise, with opportunities existing in all major segments of the industry, from oil and gas to electricity generation to renewable energy. The Energy Market Authority (EMA) works closely with our partners in the Singapore government as well as the industry to fulfil Singapore’s aspirations to maximise the opportunities in this growing industry.

OIL AND GAS INDUSTRY: ENHANCING REFINING CAPACITY AND PRODUCT RANGE, PROMOTING LNG TRADING

In the oil industry, Singapore aspires to cement its role as Asia’s undisputed oil hub by working with both the existing players as well as any potential partners in the future to expand our refining capacity, advance our technology base and develop innovative logistics solutions.

Singapore will work to optimise its existing refineries and promote research and development (R&D) activities in the areas of high-value products, process optimisation and catalyst development. Integral to this strategy will be our work to pioneer innovative logistics solutions to overcome our land constraints such as the Jurong Rock Cavern project, which will hold close to 1.47 million m³ of crude oil and condensates.

Singapore is committed to beef up its energy security through its investment in the liquefied natural gas (LNG) terminal project. Excess capacity will be built into the terminal to support our aspirations to open up opportunities in the LNG trading arena. Singapore has already put in place schemes such as the Global Traders Programme to enhance our attractiveness as an LNG trading hub.

ELECTRICITY INDUSTRY: NEW GENERATION PLANTING, LNG SUPPLY FOR POWER GENERATION

To meet Singapore’s rising demand for electricity in the future, especially with industries developing in the eastern part of Singapore, land has been set aside for a new generation plant to be built in the northeast region. Potential investors are encouraged to explore opportunities in this area.

In the fuel market for power generation, BG Asia Pacific Pte Ltd (BG) has been appointed as the LNG aggregator, whose role will be to consolidate local demand for LNG. BG will have the exclusive right to import

LNG and sell regasified LNG to end users in Singapore, up to 3 mtpa. The EMA will review Singapore’s import control policy when LNG imports reach 3 mtpa or in 2018, whichever is sooner. Should there be sufficient demand for LNG at this point, the EMA will consider opening up the fuel market for power generation.

CLEAN ENERGY AND R&D: SIGNIFICANT GOVERNMENT SUPPORT FOR DEVELOPMENT PROJECTS

With numerous exciting R&D opportunities in the clean and renewable energy sector, Singapore will seek to leverage on its strong engineering and technology talent pool as well as its already established R&D funding programmes under the EMA, the Economic Development Board (EDB), the Agency for Science, Technology and Research (A*STAR) and the National Environment Agency (NEA) to grow Singapore’s status as an R&D centre in the energy sphere.

The EMA has launched a S\$25 million Energy Research Development Fund (ERDF) to drive research, development and demonstration initiatives to address issues pertaining to Singapore’s energy sector. While clean and renewable energy is a key area of interest for Singapore, the ERDF will also focus on solutions to enhance our energy security, energy efficiency or to grow the energy industry in general. The EMA has also recently set up a S\$5 million Market Development Fund to encourage the adoption of renewable energy solutions in Singapore.

The EDB is funding both upstream and downstream research in clean energy through its S\$50 million Clean Energy Research Programme, S\$17 million Clean Energy Research & Testbedding Programme and the S\$20 million Solar Capability Scheme. Likewise, the NEA recently established a S\$15 million seed fund focusing on waste management under the Environment Technology Research Programme.

The A*STAR has awarded a total of 28 research grants worth S\$27.5 million to fund new research programmes in sustainable development alone. Its Science and Engineering Research Council has a number of research programmes and initiatives focusing on key areas in energy including fuel cells, biofuels, next generation solar photovoltaic technology, carbon management and intelligent energy distribution systems.

TEST-BED PROJECTS: SINGAPORE AS A LIVING LABORATORY

With recent technological advancements, new concepts in clean and renewable energy solutions, intelligent grid management systems, energy for transportation and energy efficiency are rapidly emerging. Singapore’s dense urban space and excellent infrastructure make it an ideal location for industry players to roll out new concepts quickly and test them out rigorously in a real-life environment. With the demonstrative value of proving these concepts in Singapore, a leading market adopter of high tech solutions, these companies can quickly leverage on our highly skilled workforce, advanced engineering and commercial services sectors to use Singapore as a springboard to market these solutions overseas.

The EMA has plans to establish a test bed on one of our offshore islands, Pulau Ubin, to implement clean and renewable energy systems integrated into an intelligent micro-grid on the island. The EMA will soon be concluding a study on the various options for the project and will invite companies to participate thereafter.

Singapore has also launched the Electric Vehicle Test-Bed on 6 May 2009 with S\$20 million worth of funding. This is envisaged as an open platform where all automotive manufacturers and electric vehicle charging infrastructure players are welcome to develop and test their concepts. Renault-Nissan and Keppel Energy have signed a Memorandum of Understanding with the multi-agency taskforce as partners in the project. Singapore welcomes more partners to participate in the project.

The EMA is also exploring the implementation of a range of “smart grid” technological solutions, which can potentially enhance the capabilities of Singapore’s power infrastructure to achieve greater efficiency and reliability. Such intelligent energy systems will open up exciting options for the electricity grid which include facilitating better integration of intermittent renewable energy solutions, introducing new concepts to allow consumers to better manage their electricity demand and, in the future, even allow electric vehicle users to sell electricity back into the grid. We look to engage a whole range of “smart grid” industry players as we develop our plans to augment the capabilities of our power grid.

CONTACT DETAILS

For more information about opportunities in Singapore’s energy sector as outlined in the previous chapters, potential partners are invited to contact the relevant agencies as follows:

Energy Market Authority

The Energy Market Authority is a statutory board under the Ministry of Trade and Industry. Its main goals are to promote effective competition in the energy market, ensure a reliable and secure energy supply, and develop a dynamic energy sector in Singapore. For more information, please visit www.ema.gov.sg

Mr Yeo Tze Han

Deputy Director
Industry Development Department
991G Alexandra Road
Singapore 119975
Tel: 6376 7578
E-mail: yeo_tze_han@ema.gov.sg

Singapore Economic Development Board

The Economic Development Board (EDB) is the lead government agency for planning and executing strategies to enhance Singapore’s position as a global business centre and grow the Singapore economy. The EDB dreams, designs and delivers solutions that create value for investors and companies in Singapore. In so doing, the EDB generate economic opportunities and jobs for the people of Singapore; and help shape Singapore’s economic future.

‘Host to Home’ articulates how the EDB is sharpening its economic development strategies to position Singapore for the future. It is about extending Singapore’s value proposition to businesses not just in helping them improve their bottom line, but also in helping them grow their top line. The EDB plans to build on existing strengths and add new layers of capabilities to enable Singapore to become a ‘Home for Business’, a ‘Home for Innovation’ and a ‘Home for Talent’.

For more information on how the EDB can help your business, please visit www.sedb.com
To learn how EDB can help in your business and investments, please contact:

For Clean Technology:

Mr Goh Chee Kiong

Director
Cleantech Group
250 North Bridge Road #28-00 Raffles City
Tower, Singapore 179101
Tel: 6832 6994 Email: ckgoh@edb.gov.sg

For Energy:

Mr Liang Ting Wee

Director
Energy, Chemicals & Engineering Services
250 North Bridge Road #28-00
Raffles City Tower, Singapore 179101
Tel: 6832 6343 Email: twliang@edb.gov.sg

Agency for Science, Technology and Research

The Agency for Science, Technology and Research (A*STAR) is the lead agency for fostering world-class scientific research and talent for a vibrant knowledge-based Singapore. The A*STAR actively nurtures public sector research and development in Biomedical Sciences, and Physical Sciences and Engineering, and supports Singapore’s key economic clusters by providing intellectual, human and industrial capital to our partners in industry and the healthcare sector. It oversees 23 research institutes, consortia and centres located in Biopolis and Fusionopolis, as well as the area in their vicinity, and supports extramural research in the universities, hospitals, research centres, and with other local and international partners. For more information about the A*STAR, please visit www.a-star.edu.sg

Science and Engineering Research Council

1 Fusionopolis Way
#20-10 Connexis
Singapore 138632
Email: A-STAR_ContactSERC@a-star.edu.sg

National Environment Agency

Formed on 1 July 2002, the National Environment Agency (NEA) is the leading public organization responsible for improving and sustaining a clean and green environment in Singapore. The NEA develops and spearheads environmental initiatives and programmes through its partnership with the People, Public and Private sectors. It is committed to motivating every individual to take up environmental ownership and to care for the environment as a way of life.

By protecting Singapore’s resources from pollution, maintaining a high level of public health and providing timely meteorological information, the NEA endeavours to ensure sustainable development and a quality living environment for present and future generations.

For more information, please visit www.nea.gov.sg

Mr Lee Aik Beng

Senior Engineer (Central Building Plan Unit)
Pollution Control Department
National Environment Agency
13th floor Environment Building
40 Scotts Road
Singapore 228231
Tel: 6731 9104
Email: lee_aik_beng@nea.gov.sg

JTC Corporation

The JTC Corporation (JTC) is the lead agency in Singapore, which plans, promotes and develops a dynamic industrial landscape, in support of the nation’s economic advancement. Currently, the JTC has under its management many developments including four wafer fabrication parks, an advanced display park, two business parks, a chemicals hub at Jurong Island, biomedical parks in Tuas as well as logistics hubs for aerospace, chemical and general warehousing industries.

The JTC also plays a catalytic role in introducing leading-edge real estate solutions - such as Seletar Aero+sPace; Jurong Rock Cavern; and specialised research facilities at one-north to anchor important activities

critical to the growth of the economy. The 200-hectare development at one-north, which houses the Biopolis, Fusionopolis and Mediapolis, provides a niche and creative R&D space within a work-live-play-learn setting.

In line with its vision of making Singapore the choice investment location, the JTC is committed to providing a pro-business environment for its customers and optimising land resources to meet the needs of industries and enterprises. For more information on the JTC, please visit www.jtc.gov.sg

Ms Tan Yee Fern

Assistant Director
Land Planning Division
JTC Corporation
The JTC Summit
8 Jurong Town Hall Road
Singapore 609434
Tel: 6883 3124
Email: yeefern@jtc.gov.sg

SP Services

SP Services, a member of Singapore Power Group, provides a convenient and efficient one-stop service to customers requiring electricity, water and piped gas supplies in Singapore. As the Market Support Services Licencee, SP Services provide meter reading, meter data management and billing services to the electricity market and facilitates competition in the retail market by enabling customers to switch seamlessly between retailers. For the convenience of its customers, SP Services also provides billing and payment collection on behalf of other utility service providers such as the PUB for water charges, CityGas for gas charges and the various refuse collection companies for refuse removal fees. Serving 1.26 million residential and commercial customers, SP Services is currently one of the largest providers of consolidated utility bills in Asia, managing billings of about S\$ 5 billion annually. For more information on Singapore Power/ SP Services, please visit www.singaporepower.com.sg

Ms Lynette Tan

Manager (Client Relations)
SP Services
111 Somerset Road #06-05
Singapore 238164
Tel: 6823 8210
Email: lynettetan@singaporepower.com.sg

SP PowerGrid Ltd

SP PowerGrid, a member of Singapore Power Group, manages Singapore's electricity and gas transmission and distribution networks. It uses cutting-edge technology to deliver highly reliable and efficient energy supply to industrial, commercial and residential customers. SP PowerGrid is the management company of SP PowerAssets Ltd and PowerGas Ltd.

For more information on SP PowerGrid, please visit www.sppowergrid.com.sg

Ms Quek Swee Xian

Senior Engineer
Transmission Planning Section
SP PowerGrid Limited
111 Somerset Road #08-05
Singapore 238164
Tel: 6823 8574
Email: sweexian@singaporepower.com.sg

Mr Lionel Lee Soon Hian

Senior Engineer
Transmission Planning Section
SP PowerGrid Limited
111 Somerset Road #08-05
Singapore 238164
Tel: 6823 8453
Email: leesoonhian@singaporepower.com.sg

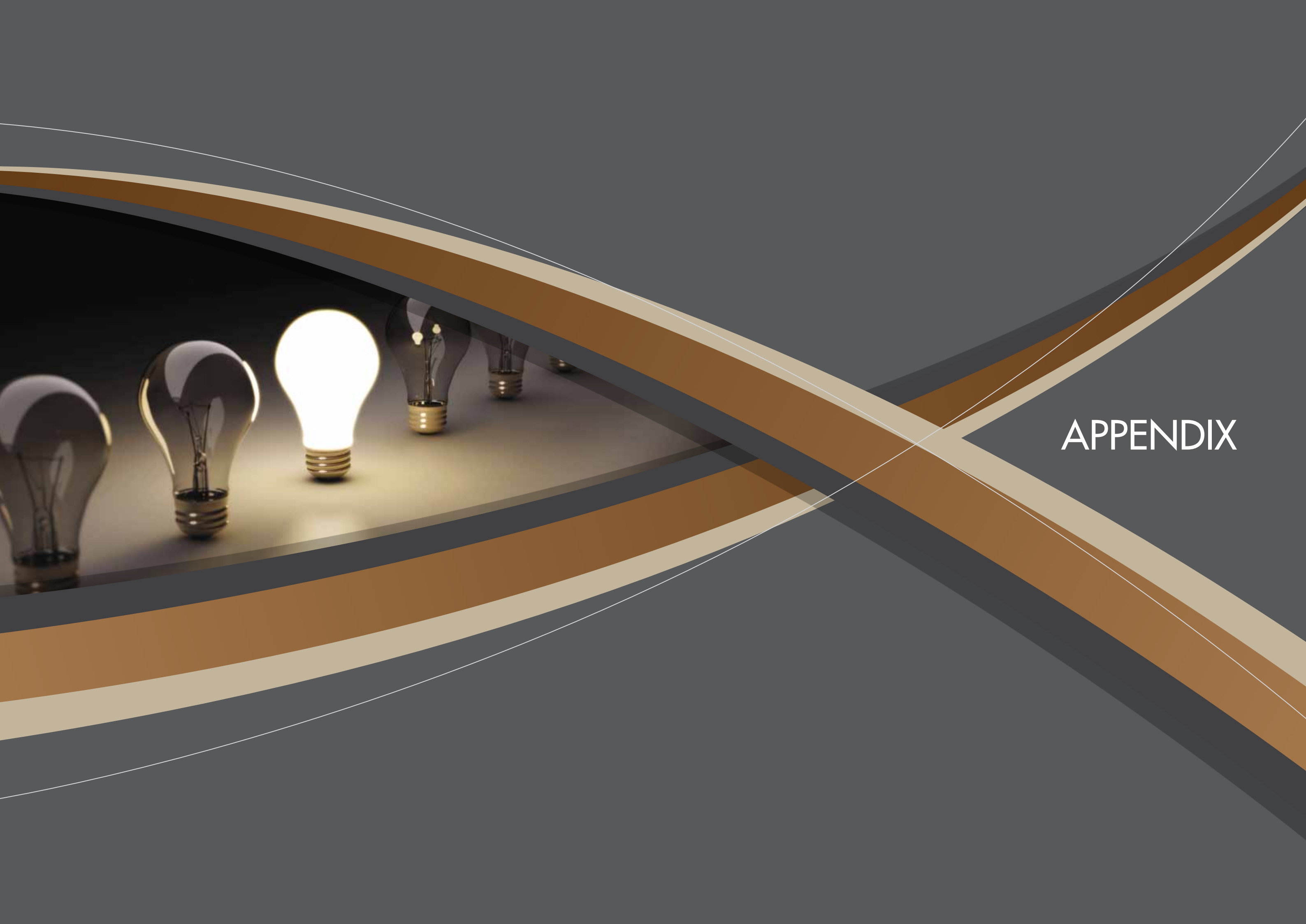
Energy Market Company

Energy Market Company Pte Ltd (EMC) operates Singapore's wholesale electricity market – Asia's first liberalised electricity market. The National Electricity Market of Singapore (NEMS) opened for trading on 1 January 2003.

EMC is the exchange for wholesale electricity trading, providing a transparent and competitive trading platform. Our key activities include calculating prices, scheduling generation, clearing and settling market transactions as well as supporting the governance of the market. EMC's key business priorities are the availability of market systems, accuracy of pricing and security of settlement, provision of market information, compliance to market rules and the evolution of the market framework.

Mr Tan Liang Ching

Senior Economist
Market Administration
238A Thomson Road
#11-01 Novena Square Tower A
Singapore 307684
Tel: 6571 9872
Email: liangching.tan@emcsg.com



APPENDIX

APPENDIX

PLAYERS IN THE ELECTRICITY INDUSTRY

The Market Operator

Energy Market Company (EMC), the market operator, is a joint venture between the EMA and M-Co (The Marketplace Company) Pte Ltd, a wholly-owned subsidiary of M-Co International Ltd of New Zealand.

The Power System Operator (PSO)

As the PSO, the EMA ensures the reliable supply of electricity to consumers and the secure operation of the power system. The PSO controls the dispatch of generation facilities in NEMS, coordinates outage and emergency planning, and directs the operation of Singapore's high-voltage transmission system.

The Transmission Licensee

SP PowerAssets is the Transmission Licensee, which owns the national power grid. It is also responsible for the operation and maintenance of the grid. The company has appointed SP PowerGrid as the Transmission Agent to operate and maintain the power grid.

The Generation Licensees

Singapore's three largest electricity generating companies are Senoko Power, PowerSeraya and Tuas Power. All companies that generate electricity need a Generation Licence if one or more generating units have an individual nameplate rating of 10 MW or above. If connected to the power grid, the generating unit(s) must be registered with EMC and will have to compete to secure dispatch in NEMS.

The Wholesaler (Generation) Licensees

If a company has a generating unit with an individual nameplate rating of less than 10 MW but more than 1 MW, and if that generator is connected to the grid, it will need a Wholesaler (Generation) Licence. A licence is also needed if a company has a generating unit whose nameplate rating is less than 1 MW but where the company wishes to sell this electricity to the grid.

The Wholesaler (Interruptible Load) Licensees

Consumers who offer to have their load interrupted, or companies who provide services to other consumers who are willing to offer their loads to be interrupted, need to have a Wholesaler (Interruptible Load) Licence.

The Market Support Services Licensee (MSSL)

SP Services is the MSSL. It provides market support services such as retail settlement, meter reading and meter data management, consumer registration, and transfer processing for contestable consumers who switch from one retailer to another. The company provides indirect access to NEMS by contestable consumers who have not appointed a retailer. It also supplies electricity to non-contestable consumers at regulated tariffs. In addition, it provides billing and payment collection of charges for use of the power grid on behalf of the Transmission Licensee, SP PowerAssets.

The Electricity Retail Licensees

There are two types of licensed electricity retailers: market participant retailers (MPRs), and non-market participant retailers (NMPRs). MPRs have to be registered with EMC to purchase electricity from NEMS to sell that electricity on to contestable consumers. NMPRs do not have to register with EMC to participate in the NEMS since they purchase electricity indirectly through SP Services, the MSSL.

EMBEDDED GENERATION

In Singapore, embedded generation refers to the use of an onsite source of power by a company for its own use.

All generating units (embedded or otherwise) are subject to the electricity licensing requirements as set out in the Electricity Act (Chapter 89 A) part III, Section 9 (Electricity Licences), except for existing embedded generating units in operation before 1 January 2003.

Companies are further required to register with EMC as a market participant and comply with the Market Rules if the embedded generating unit(s) has an individual nameplate rating of 1 MW or more and is connected to the power grid, or if the embedded generating unit(s) has an individual nameplate rating of less than 1 MW and the company wishes to be paid for the electricity it exports to the grid.

Because of the scarcity of land in Singapore, the EMA amended the rules on self-supply of electricity in 2007. Under the new rules, a company may outsource the embedded generating units and/or install the embedded generating units on land that is non-contiguous. This is provided that there is insufficient or no contiguous land available for the company to accommodate the embedded generating units and load facilities. The load facilities and the land on which the load facilities and embedded generating units are located must be majority owned by the same company.

The EMA does not allow outsourcing of embedded generating units to a company if this creates market power or adds to the existing market power of the company.

Net Treatment Of Non-Reserve Market Charges For Embedded Generators

There are broadly two types of market charges: reserve and non-reserve market charges. The reserve market charges are the Regulation (AFP) charge, and Spinning Reserve (SR) charge. The non-reserve market charges include the Energy Market Company (EMC) fee, the Power System Operator (PSO) fee, the Monthly Energy Uplift Charges (MEUC), and the Market Support Services (MSS) fee.

If a company's embedded generating unit will not export electricity into the power grid, the company will be given the "net treatment" for the non-reserve market charges. The company will pay for the non-reserve charges based on the amount of electricity it draws from the power grid. If the company will export electricity, it will be required to pay the non-reserve market charges on a gross basis, i.e. according to its gross generation output and gross load. Companies have to pay reserve charges (where applicable) on a gross basis, regardless of whether or not the company will export power into the power grid.

System Limit on Embedded Generation Capacity

Embedded generation plants are usually non-frequency responsive (NFR), i.e. their plant control system does not vary the plant's output in response to changes in system frequency, and therefore cannot provide reserves. As such, the EMA has set a system limit on embedded generation to safeguard system security. This limit will be reviewed periodically by the EMA. Companies planning to install embedded generation can contact the EMA for further details.

DAILY LOAD PROFILES

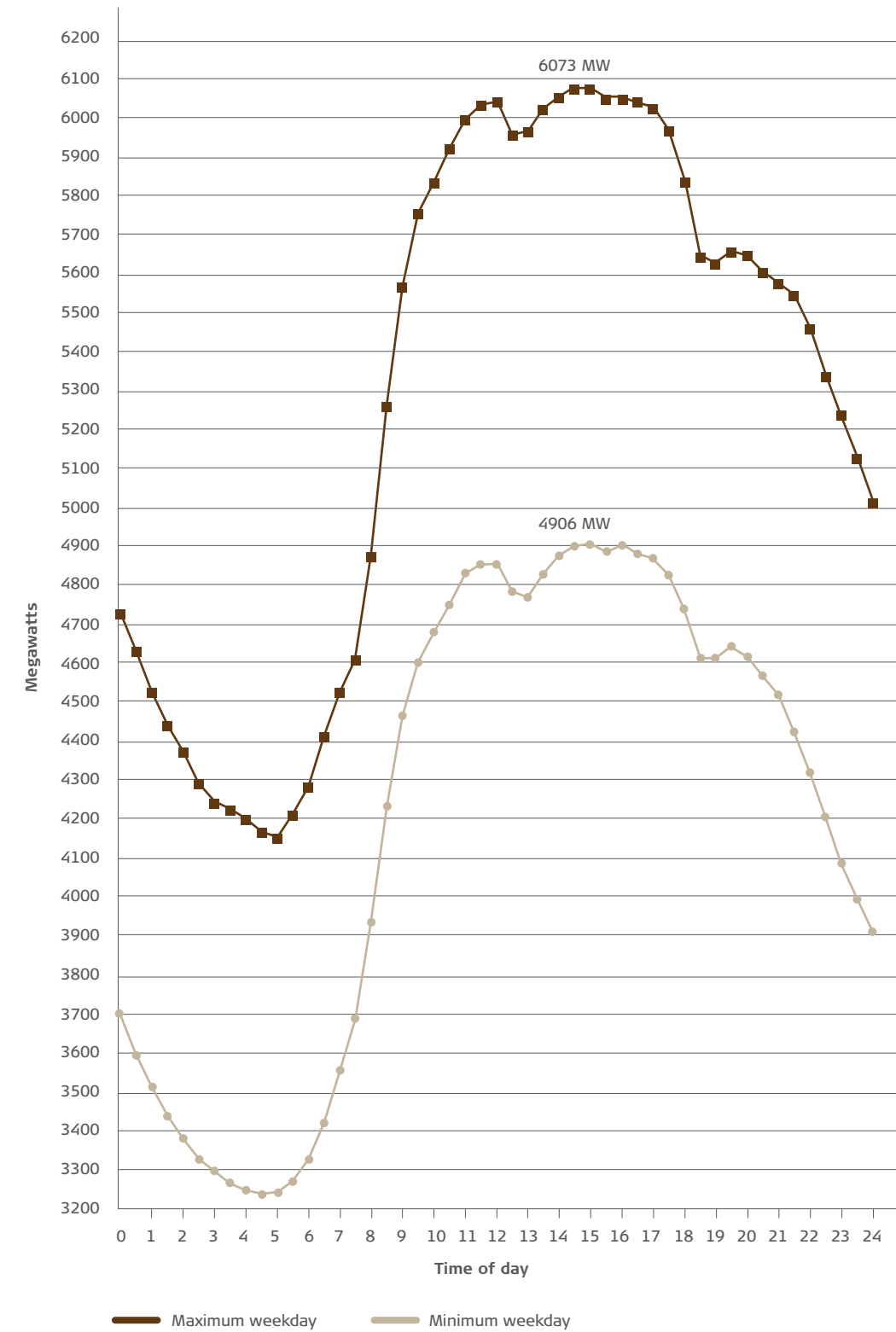


Fig. 7.1 Weekday demand
Note: Weekday maximum (20.05.08) and minimum (26.12.08) demand 2008

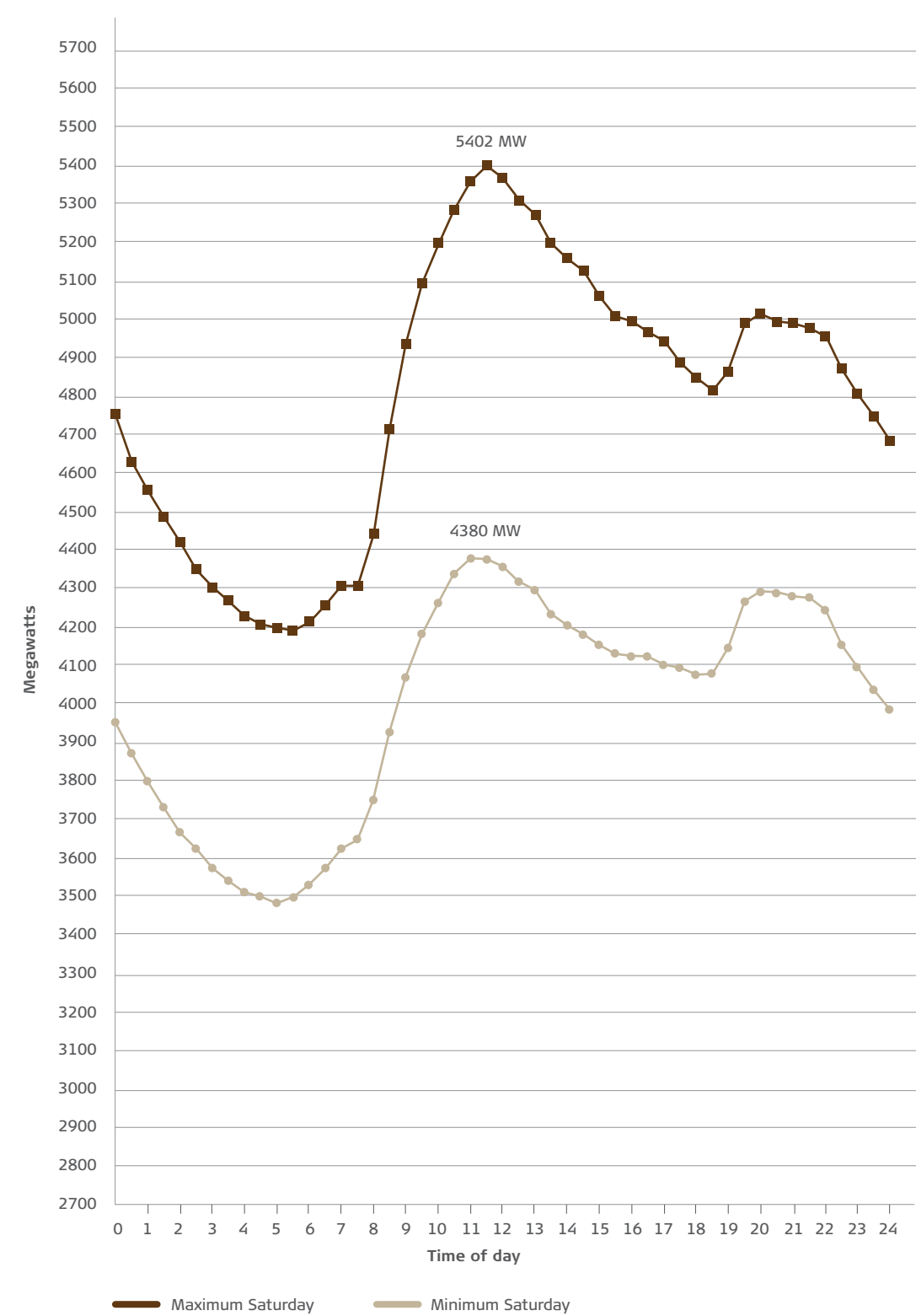


Fig. 7.2 Saturday demand
Note: Saturday maximum (03.05.08) and minimum (09.02.08) demand 2008

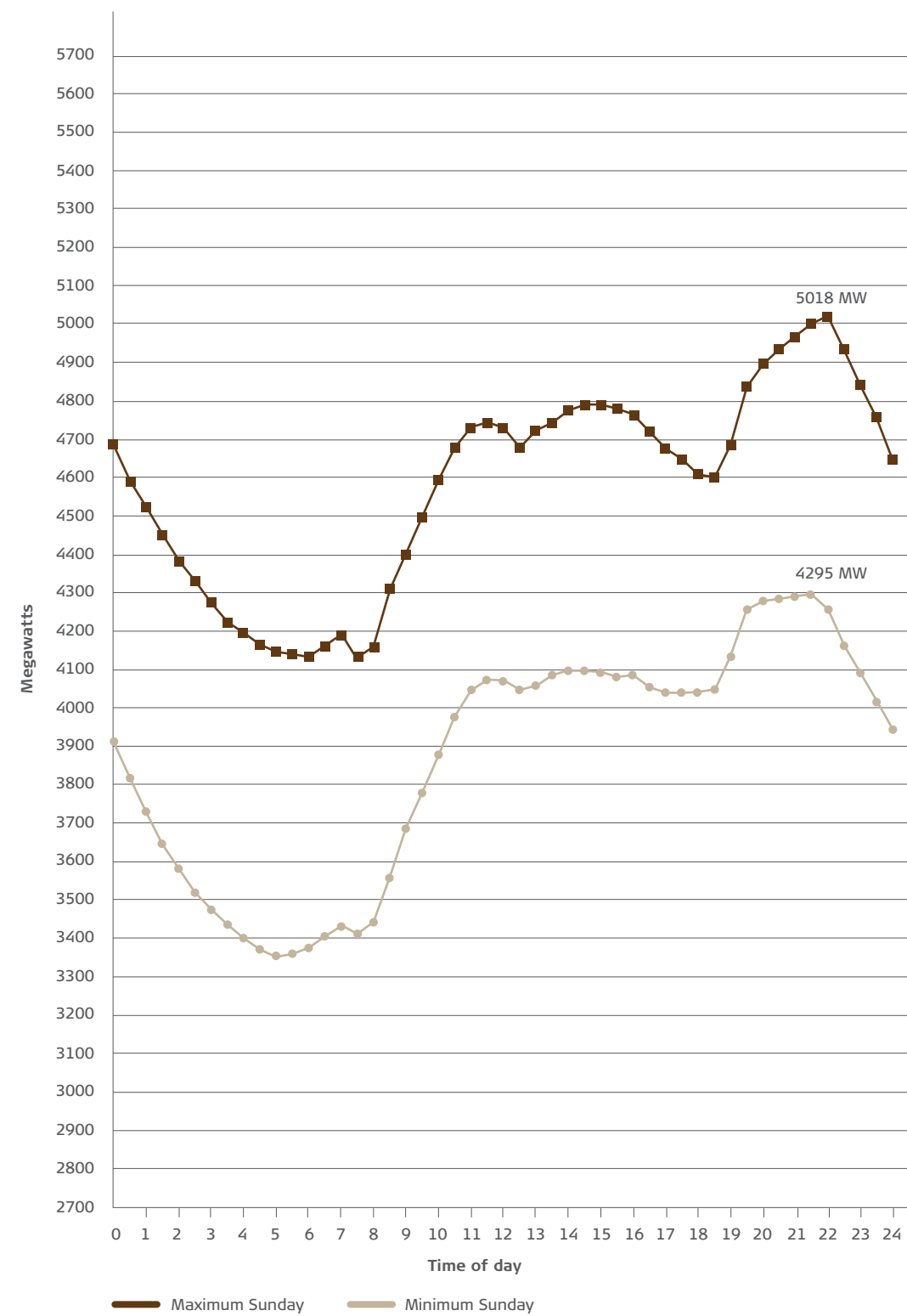


Fig. 7.3 Sunday demand

Note: Sunday maximum (04.05.08) and minimum (28.12.08) demand 2008

Energy Market Authority

991G Alexandra Road #01-29

Singapore 119975

Tel.: +65 6835 8000

Fax.: +65 6835 8020

www.ema.gov.sg