

OVERVIEW

ELECTRICITY IN SINGAPORE: FROM BEGINNING TO BEYOND

# BRIGHTER

ELECTRICITY IN SINGAPORE: FROM BEGINNING TO BEYOND



Smart Energy, Sustainable Future

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# PARCARTER

ELECTRICITY IN SINGAPORE: FROM BEGINNING TO BEYOND

WRITTEN BY  
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AND  
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ENERGY MARKET AUTHORITY



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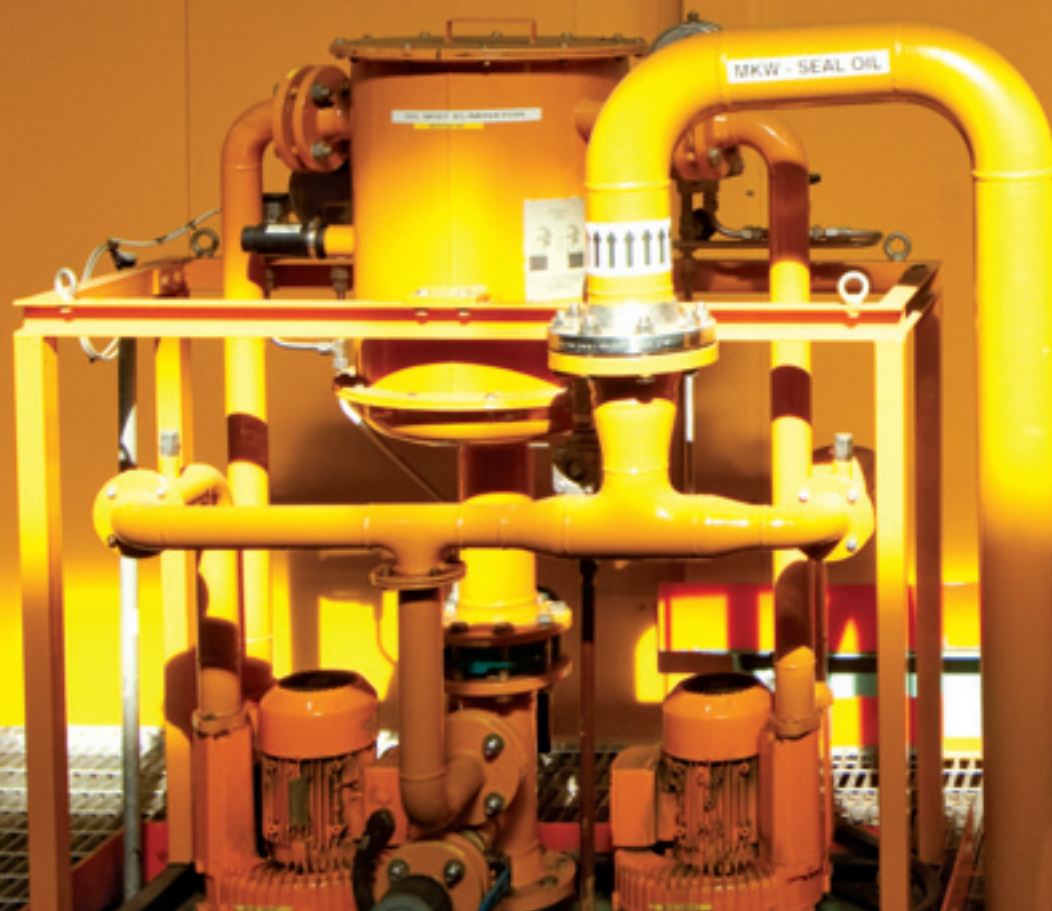
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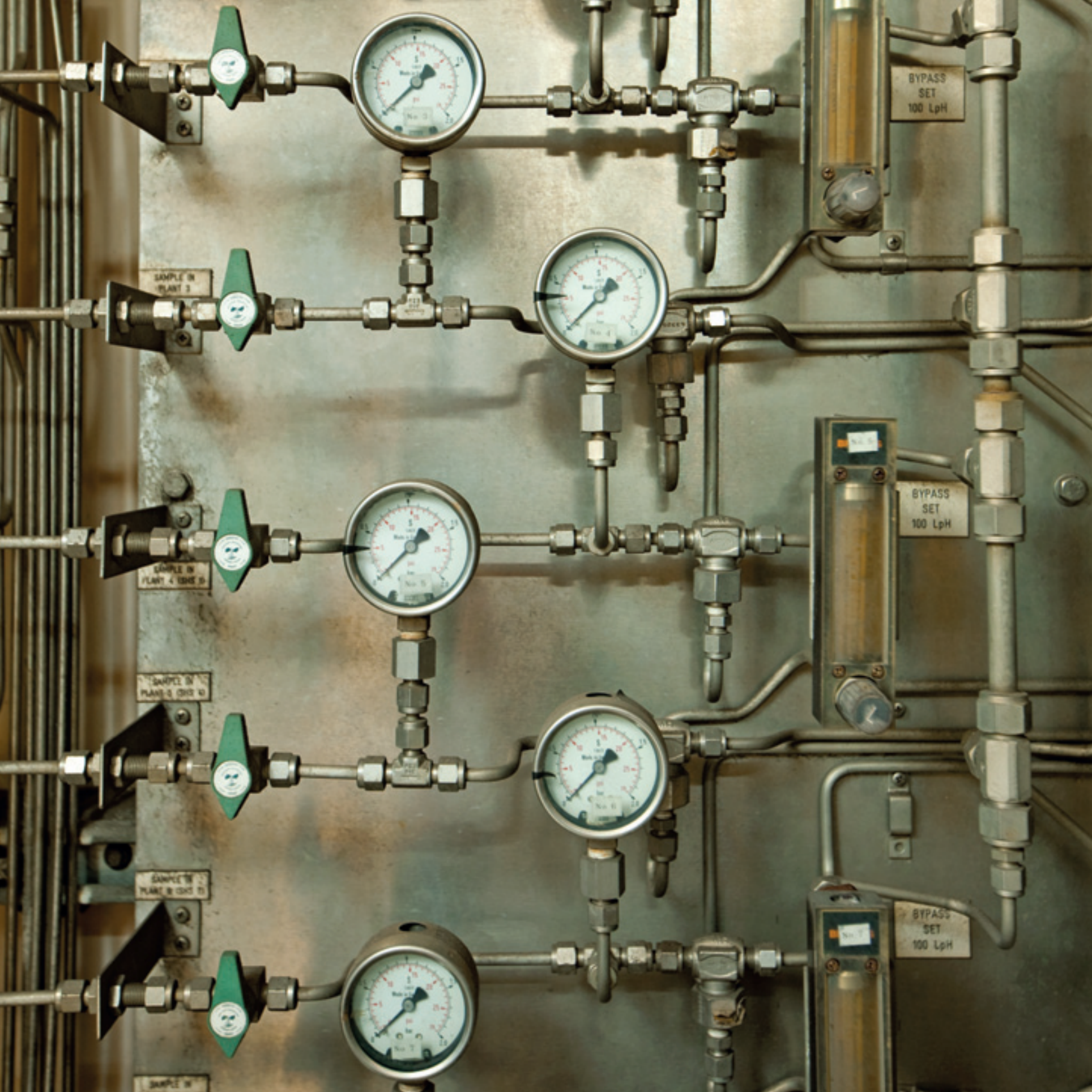
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# **F O R E W O R D**

**B Y**

**P R I M E M I N I S T E R**

**L E E H S I E N L O O N G**

—

Electricity powers our economic development, drives many of our machines and appliances, and thus enriches our daily lives. It is critical to us, yet in Singapore we take it for granted. This is because over the past 10 years, the Energy Market Authority (EMA) has delivered one of the world's most reliable electricity supplies to Singaporeans. As industry regulator, the EMA has ensured a competitive and efficient electricity industry which has benefited Singapore consumers.

The EMA has also enhanced our energy security. It is developing our first liquefied natural gas (LNG) terminal, expected to be ready by the first half of 2013. The LNG terminal will enable Singapore to diversify our gas sources by importing natural gas from all over the world.

The EMA is working with other government agencies and the industry to build up our energy capabilities, including research and development, test-bedding new technologies, and manpower development. These efforts will help nurture a vibrant industry and develop new solutions to realise EMA's vision of a "Smart Energy, Sustainable Future". A vibrant energy industry will also contribute to the Singapore economy and create good jobs for Singaporeans.

The next few years will be challenging, with supply uncertainties and rising energy demand from emerging economies. However, there will also be opportunities for Singapore to enhance its energy efficiency, energy security and environmental sustainability. I am confident that the EMA will continue to partner the industry to forge a progressive energy landscape and a brighter future for all Singaporeans.





# **M E S S A G E**

**BY**

**CHAIRMAN, ENERGY MARKET AUTHORITY**

**CHAN LAI FUNG**

—

As a small nation which imports almost all its energy needs, Singapore is a price-taker in the global energy market. Hence, much emphasis has been placed on securing Singapore's energy supply, forging a competitive energy market and fostering a dynamic energy sector. We have made good progress in these areas since the formation of the Energy Market Authority in 2001.

With an average electricity interruption time of less than one minute per customer, Singapore's electricity grid today remains one of the most reliable in the world. We have liberalised the electricity generation market and introduced more competition, which have enabled consumers to benefit from efficiency gains and lower prices. EMA has also spurred industry innovation through test-bedding projects and programmes such as the Smart Energy Challenge to support the development of new energy technologies and solutions for Singapore.

All these would not have been possible without the people who had worked tirelessly behind the scenes in the energy sector. This book is a tribute to their contributions over the years. I also wish to thank our industry partners for their support, and look forward to working even more closely with them in our efforts to develop Singapore into a global energy hub.

My appreciation goes out to all the interviewees who have set aside time to share their insights and anecdotes for this book. Last but not least, this book is dedicated to all past and present EMA and PUB colleagues. Thank you for your hard work and commitment in growing Singapore's energy sector and keeping the lights on.







# ELECTRICITY 101

## WHAT IS ELECTRICITY?

Electricity is the flow of electrical charge used to power up electrical appliances such as lights, televisions and computers.

## WHO USES ELECTRICITY?

Consumers of electricity can be generally classified into three types: the industrial consumers including factories and plants; the commercial consumers including offices, schools and shopping centres; and residential consumers.

## HOW ELECTRICITY IS GENERATED

Electricity is generated in power stations by burning fossil fuels such as coal, fuel oil or natural gas to drive generators to generate electricity. Other methods of generating electricity such as using hydropower, solar and fuel cells do not involve the combustion of fossil fuels.

The electricity then flows from the generating power plant via the transmission and distribution network to the consumers.

## HOW ELECTRICITY IS TRANSMITTED

Electricity is transmitted via the transmission network. The transmission network is an interconnected group of power lines and electrical equipment used to transmit electrical energy at high voltage between the power plants and distribution networks.

Electricity is usually stepped up using transformers to a higher voltage to reduce energy loss in long distance transmissions. The voltage at which electricity is transmitted is measured in kilovolts, kV (equal to 1,000 volts).



**WHAT IS A DISTRIBUTION NETWORK?**

A distribution network is the electrical system which connects electricity directly to consumers' electrical installation. The network consists of substations where electricity of high voltage from the transmission system is stepped down using transformers to a lower voltage suitable for consumers to use.

**MEASUREMENT OF ELECTRICITY GENERATING CAPACITY**

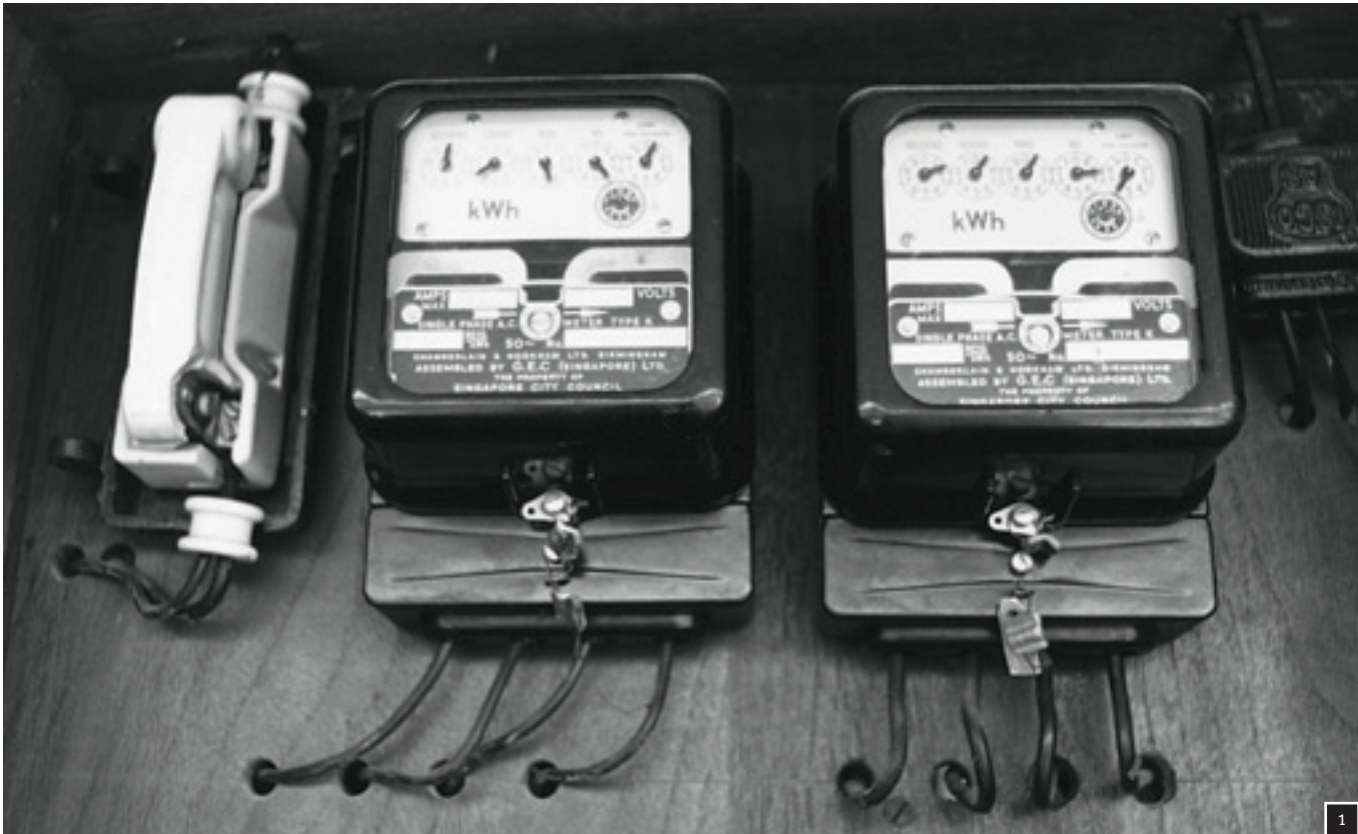
The generating capacity of a power plant is usually measured in kilowatts (kW) or megawatts (MW), which quantifies the amount of electrical power converted from energy stored in fuel sources. One kilowatt is equal to 1,000 watts and one megawatt is equal to 1,000 kilowatts.

**HOW DO WE MEASURE ELECTRICITY USAGE?**

Electricity consumption is derived by multiplying the electrical power used and the time period of its usage. For example, if a 1.5 kilowatt electrical appliance is switched on for an hour, it will use up 1.5 kilowatt-hours of electricity. And if the power utilities company charges 5 cents for every kilowatt-hour of electricity consumed, the user will be charged 7.5 cents for every hour the electric iron is used.

**HOW DO WE MEASURE THE RELIABILITY OF A POWER SYSTEM?**

The reliability of a power system is indicated by its System Average Interruption Frequency Index (SAIFI) and System Average Interruption Duration Index (SAIDI). The former measures the average number of electricity interruptions per customer in a year, while the latter measures the average interruption time per customer in a year, in minutes.



- 1 Meters in the good old days.
- 2 Gas pipelines in Singapore.
- 3 Putting the best foot forward.

|                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                            |
|-------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <div>1906</div> <ul style="list-style-type: none"><li>■ Electric street lighting was introduced in Singapore.</li></ul> | <div>1952</div> <ul style="list-style-type: none"><li>■ Pasir Panjang Power Station was commissioned.</li></ul>                                                                                                                                                                                                                                                 | <div>1965</div> <ul style="list-style-type: none"><li>■ Pasir Panjang B Power Station was officially opened by then Prime Minister Lee Kuan Yew.</li></ul> |
|                                                                                                                         | <div>1963</div> <ul style="list-style-type: none"><li>■ The Rural Electrification Programme was started. It cost nearly \$20 million and more than 200,000 people enjoyed the benefits of electrification.</li><li>■ The Public Utilities Board (PUB) was formed as the agency responsible for the supply of electricity, water and gas in Singapore.</li></ul> |                                                                                                                                                            |
| <div>1924</div> <ul style="list-style-type: none"><li>■ Construction of St James Power Station began.</li></ul>         |                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                            |



**1970**

- Jurong Power Station was officially opened by then Minister for Finance, Dr Goh Keng Swee.

**1977**

- Senoko Power Station was officially opened by then Minister for Foreign Affairs S. Rajaratnam.

**1988**

- Pulau Seraya became home to the country's first offshore power plant with three 250 MW generating steam plants.

**1995**

- Electricity and piped gas undertakings of the PUB were corporatised on 1 October to introduce competition in the energy sector.
- Tuas Power Pte Ltd was formed to take over the development of Tuas Power Station, which had started off as a PUB project. This signalled the start of the privatisation of power generation and the split between supply and distribution of electricity.

**1998**

- PowerGrid Ltd started the Singapore Electricity Pool as a wholesale electricity market to facilitate competitive bidding between generation companies.

**2001**

- Energy Market Authority (EMA) was set up on 1 April to oversee the further liberalisation and inject competition into the electricity and gas industries.
- The Energy Market Company (EMC) was formed as a joint venture between EMA and M-co (The Marketplace Company) Pte Ltd to oversee the operation and administration of the electricity market.
- About 250 companies with electricity demand of 2 MW and above became contestable consumers.

**2004**

- A blackout occurred on 29 June, which caused about 300,000 consumers to lose their electricity supply for up to one-and-a-half hours.

**2006**

- Large consumers comprising business industries, which formed 75 per cent of total electricity demand, became contestable.

**2009**

- EMA introduced a new system of pegging electricity tariffs to the average of fuel prices in the previous three months.
- EMA set up Singapore LNG Corporation Pte Ltd in June to build, own and operate Singapore's first LNG terminal.

**2010**

- Groundbreaking ceremony for Singapore's first LNG terminal was held at Jurong Island.





AS

DOWN

PREMISE

1906

—

1945









## **LIGHTING UP SINGAPORE**

**AMIDST THE DARK TIMES OF WORLD WAR II, SINGAPORE WAS RENAMED “SYONAN-TO”, OR “LIGHT OF THE SOUTH” BY THE JAPANESE ARMY. BUT THE STORY OF THE “LIGHTING UP” OF THE ISLAND – IN A LITERAL SENSE – ACTUALLY BEGAN MUCH EARLIER, IN THE SECOND HALF OF THE 19TH CENTURY, WHEN ELECTRICITY SUPPLY ARRIVED ALONG WITH ADVANCEMENTS IN TECHNOLOGY. ■ THE ABILITY TO TURN NIGHT INTO DAY EXPANDED NOT ONLY THE HOURS OF PRODUCTIVITY AT THE WORKPLACE BUT ALSO THE OPTIONS FOR RECREATION AT HOME. IT ALSO PROVIDED SECURITY AND SAFETY TO RESIDENTS.**



### TANJONG PAGAR: ELECTRICITY ARRIVES

The original investment in electricity generation in Singapore was made by private investors, not the government. In hindsight, this makes for a kind of coming full circle, as after decades of state provision, the island's electricity market was later to return towards greater private investment around the close of the 20th century.

It was the Tanjong Pagar Dock Company that started to invest in electric lighting as early as 1878. Brighter electric lighting meant that work in the Tanjong Pagar wharves could continue after sunset, and also provided better security from crime.

In his 1956 book, *Tanjong Pagar Dock Company 1864-1905*, George Bogaars, former head of Singapore's civil service, wrote: "The installation served the docks and workshops principally but was extended to the wharves and roadways. The power station was built just outside the eastern dock entrance. A marine boiler supplied the steam which drove three engines of 108 horsepower each, geared to three generators capable of developing 480,000 candle power together."

The work was completed in 1897 and cost the company \$23,000 a year on average to maintain, but the gain in working hours amply compensated for the expenditure.

Subsequently, public supply was made available on a larger scale. Streets such as Raffles Place and the area from North Bridge Road to Boat Quay were lit for the first time with electric lamps.

### MACKENZIE ROAD: A NEW POWER STATION

After the Dock Company became a government agency, the Tanjong Pagar Dock Board, it submitted plans for a new power station at Mackenzie Road.

The power station was well-located: right next to the Bukit Timah waterworks with its clean water supply for the turbines. Excavation work for the power station started back in 1903. However, as the power station was located inland from the wharves, there was the problem of moving huge pieces of equipment to the station.

The transportation technology then was primitive – mainly consisting of bullock carts and a few steam-powered traction engines. Some of the heavy machinery of the power plant could be taken apart into smaller sections for re-assembly onsite. But equipment such as the eight huge boilers, which could evaporate 6,000 lbs of water per hour, could

## Street Lighting, Crime and Safety

All modern criminologists note the important role that good lighting plays in crime prevention by turning night into day. There were about 1,000 gas lamps in Singapore in the 1890s, and gas lighting would remain until the 1930s. However, gas lamps were not very bright and created huge pools of darkness. Hence, the Municipality continued looking for better and brighter street lighting. Throughout the early 20th century, the Electricity Department experimented with different types of lamps, tried varying the intervals between street lamps, and even the sizes of lamps.



Pockets of darkness: gas lighting left much to be desired.





***The Municipal government soon encountered the classic public policy problem of having to invest first in infrastructure in anticipation of future demand, while shouldering the risk of suffering substantial losses in the initial period.***

not be taken apart that way. Adding to the problem were uneven road surfaces and bridges that were relatively small then.

So, the moving of equipment from Tanjong Pagar to Mackenzie Road was a massive logistics and transportation exercise.

By 1905, the equipment was finally put together. And by 1906, Singapore's first power station was in business – and it was quite a sight! The Mackenzie Road Power Station, with its red brick walls and tall smokestack, became a landmark in the Tekka area until it was demolished later after the Japanese Occupation of World War II.

The “official turning-on” of electricity in Singapore can therefore be traced back to the year 1906.

### **TRAMWAYS: ADDITIONAL SUPPLY**

Aside from the Mackenzie Road Power Station, the Municipality – the local government administration under the British – was to receive its first supply of electricity from the Tramway Company, by tapping electricity from the power station that was built for its trams.

Back then, a group of British investors thought that a thriving port like Singapore needed a good modern transport system, and formed such a company to run electric trams in Singapore.

In July 1903, the Tramway Company began work on the tram tracks. Although the company had optimistically projected March 1905 to start supplying electricity, it was to take another year before this goal was realised.

When the people employed by the Tramway Company were found to be ineffectual, the Municipality staff had to take over the track-laying and cabling for extra pay. Because of the involvement of his staff, the Municipal Engineer, R. Peirce (after whom Singapore's Peirce Reservoir is named) himself, had to oversee some of this work, and he stayed on as Municipal Engineer until 1916.

After his retirement to the United Kingdom, Mr Peirce served as the Municipality's agent there during negotiations for the iconic St James Power Station that would later be built.

### THE MUNICIPALITY INVESTS IN FUTURE DEMAND

The Municipal government soon encountered the classic public policy problem of having to invest first in infrastructure in anticipation of future demand, while shouldering the risk of suffering substantial losses in the initial period. This was a challenge that the government of independent Singapore would later come to grips with, in a much bigger way.

The Municipal Commissioners were right about the potential demand for electricity but the initial failure to meet the minimum target was an expensive matter for the Municipality.

Initially, the electricity tariff for private consumers was set at 40 cents for every Board of Trade Unit (BTU), or what is today the equivalent of a kilowatt-hour (kWh). But after much debate and negotiation, the tariff was eventually set at 25 cents per unit with a minimum monthly billing of \$2, and with equal shares going to the supplier (the Tramway Company) and distributor of electricity (the Municipality).

Even with the lower tariff, demand for electricity in the first year was considerably lower than projected. In the very first year of supply, the number of units consumed was 39,613 for lighting plus a few paltry units for other miscellaneous consumption like electric fans.

This was considerably below the minimum 100,000 units that the Commissioners had at first projected. When the usage figures for the first year came in, the Commissioners engaged in protracted correspondence to reduce the amount to be paid for the unconsumed units, finally settling at \$7,591.12.

While Mr Peirce commented bitterly that "this was an absolute dead loss", he also noted that "there is no doubt that the demand for energy is growing and the Commissioners must be prepared to provide additional capital in an early loan. I think there is every prospect of a reasonable increase of consumers".





## Ice Houses and Colonial Drinks

Before the invention of commercial refrigeration equipment and refrigerators in the 20th century, wealthy homes in temperate countries had ice houses or large ice boxes regularly supplied with ice to keep raw meat chilled in summer. The ice used in ice houses was cut from frozen lakes and rivers during winter to be stored until summer. In tropical Singapore, ice houses were also built to supply ice for chilled drinks. The ice was natural ice harvested in the US and shipped out from Boston by Frederic Tudor, who became known as the 'Ice King of the World' at the height of the ice trade. The importer and supplier of ice in early Singapore was a wealthy Chinese merchant named Hoo Ah Kay, better known as Whampoa, who had his ice house in Boat Quay.

Before the spread of domestic refrigerators, most households in Singapore – which did not have ice houses – bought and cooked as much food as they could consume on the same day. Salted and pickled foods were common and a daily trip to the wet market was routine. Cooked food meant for dinner was stored in the food cupboard – a well-ventilated cupboard with net-covered doors and kept in the coolest part of the kitchen. Such food cupboards were still in use in the 1960s, especially in the rural areas, where refrigerators were out of reach for the average rural household, even if there was electricity to power them.



Importing ice – in the absence of refrigerators – was big business.

## LAYING THE FOUNDATIONS

There were two other problems that the early power engineers of Singapore had to overcome – building a stable and suitable distribution network, and reducing transmission loss.

The Electricity Department under the Municipal government soon found the network of distribution cables to be one of the most unsatisfactory parts of the electricity supply system. The cables were bitumen-covered ones and, although a similar method of cabling had been used in Hong Kong and China, they were unsuitable for Singapore. Singapore's seasonally heavy rainfall and unsealed road surfaces affected the cables badly and cable faults led to electricity disruptions.

This led to the Electricity Department embarking on a programme of replacing the bitumen cables with more resilient lead-covered cables.

As the Electricity Department was replacing the cables, it was also extending the network of cables to meet increasing demand. As more cables snaked underground, the first mention of cables being dug up accidentally was made in 1914.

Although the Municipality published an annual map showing the positions of the cables, changes above ground made the maps inaccurate. Cable damage from earth-works was a major concern affecting supply stability.

## ELECTRICITY CATCHES ON

Despite the early problems, electricity demand rose with new big consumers which were in need of electric lighting, such as the Singapore Cricket Club and the new Victoria Theatre. Between 1906 and 1907, the number of electricity accounts shot up to 132, an increase of more than 400 per cent.

Thereafter, the number of accounts kept going up as businesses were quick to see the advantages of electricity. Also adding to demand was public lighting, including those on Anderson Bridge and other bridges along the Singapore River.

Apart from the Municipality, there were also private generators that produced electricity for their own use as well as for their neighbouring users.

For instance, Scotts Road had the Scotts Road Private Generating Plant. However, when the plant broke down, it prompted applications for Municipal supply of electricity.

## Ice Works

Once there was a supply of electricity, starting up an ice factory in Singapore was just a matter of investing money in ice works. In 1916, there was the New Singapore Distilled Water Ice Factory, under the care of an engineer named Abraham Jacobus Kruis. The ice was meant for drinks as it was made with distilled water. Singapore Ice Works, once thought of as the first ice-making plant in Singapore, was started only in the 1930s. Located at the junction of Sungei Road and Pitt Road, it was renamed New Singapore Ice Works in 1958 and taken over by Cold Storage. In 1984, the Housing Development Board acquired the site for public housing. By then, ice made by domestic refrigerators was becoming common-place. However, commercial ice works are still thriving businesses today, supplying ice to large-scale events that require plenty of iced drinks.



Staying cool was just a drink away.



***St James Power Station remains at the same location today, and is still known by the same name. It is now not only a popular nightspot, but also a national monument gazetted in 2009.***

With the convenience of being able to hook up to the Municipality's supply becoming obvious, any plans for private generation were gradually abandoned.

Singapore's entrepot economy boomed, taking off in the 1920s with total trade of almost \$1.9 million. Prosperous companies transformed Raffles Place from single-storey shophouses at the start of the 20th century to multi-storey buildings.

With electricity demand past two million units, the Mackenzie Road Power Station was pushed to its limit. Since 1906, the generators had been working non-stop with almost no downtime for maintenance work.

### **ST JAMES: BOOSTING SUPPLY**

In 1921, the Municipality's Engineer-in-Chief, H. L. Pearson, concluded gloomily: "The backward state of the electrical situation is holding back the progress of the town not only in respect to public and private lighting, and power and road improvement on tram routes but the high price of current has also ruled out of consideration the adoption of electric vehicles which have many advantages for Municipal work of certain kinds."

The 1920s was also a time of big infrastructure projects in Singapore. The Colonial government, Municipality and private enterprise soon embarked on a huge rebuilding programme spurred by the post-World War I boom. The Fullerton Building (which housed the General Post Office), Municipal Building (later called City Hall), and the Causeway linking Singapore and Malaya were among some of the structures that came up in the 1920s.

Hence, in November 1923, Engineer A. H. Preece arrived in Singapore from the United

Kingdom to do a study, and reported favourably on the choice of Cape St James as the site for a new power station. There was access to seawater for the station's turbines, and proximity to the wharves where coal for firing the power station would be unloaded.

St James Power Station remains at the same location today, and is still known by the same name. It is now not only a popular nightspot, but also a national monument gazetted in 2009 – a tribute to the history of electricity in Singapore.

The Municipality paid \$375,000 for the land to build the power station, but it had some trouble with squatters. Relocating the squatters and getting vacant possession took most of 1924, and site preparation commenced at the end of that year with work to level the ground.

By Christmas 1925, the foundations for three key buildings of the power station were completed – boiler house, turbine house and switchgear house.

As St James Power Station started operations, there was a corresponding reduction from the overworked Mackenzie Road Power Station.

Eventually on 29 October 1926, electricity supply from Mackenzie Road Power Station ceased. By November 1927, the Electricity Department was already recommending for St James Power Station's capacity to be boosted, as the maximum load on the power station had surged significantly.

In early 1928, a new company took over from the Dock Company. Called the Singapore Traction Company, it announced that it would decommission the Mackenzie Road Power Station and take its electricity supply from St James.

The first era of private power generation was coming to an end. The State had taken over from private providers of power generation in order to meet the burgeoning demands of a growing city-state.

The Municipal government also had to take on the "commercial" role of stimulating electricity demand. In 1928, the Electricity Department opened an office at 21 Orchard Road to provide the public with information and advice on acquiring and using small electric appliances such as cookers, fans and water heaters.

Electric fans were very popular but not electric cookers and heaters. By then, the Gas Department had already introduced gas water heaters and cookers, and the instantaneous heat made possible with gas made these appliances more popular.

## Hiring Department

The Hiring Department opened its 21 Orchard Road showroom in 1928 to rent out fans and water heaters to domestic consumers. Hiring out fans and water heaters for a small fee proved popular because many of the wealthier families were only temporary residents in Singapore. The turnover was high enough to warrant a workshop for the reconditioning of these rental appliances before they were rented out again. This workshop was built in 1938 in Thomson Road.

By the 1970s, Singapore's growing prosperity meant that electrical appliances were within the reach of the average household, and stores in Singapore were filled with an increasing range of refrigerators, stoves, water heaters and other domestic electrical appliances. The Hiring Department closed in 1974 and households were given the option of buying the appliances that they had been hiring. Nearly 82 per cent of the 55,453 appliances that were out on hire were sold. The remaining appliances were then sold to staff and members of the public.



Renting out electrical appliances to families in Singapore.





## THE GREAT DEPRESSION, AND AFTER

It was the Great Depression years in the 1930s that saw a halt in rising electricity demand. The Electricity Department reduced the tariff for consumers to 17 cents per unit (kWh in today's terms) and also provided free wiring services within homes. Previously, consumers had to pay for the cost of wiring within their premises.

Despite the Electricity Department's measures to boost demand, this dropped further, and so did revenues. In its 1931 report, the Municipal Secretary and Treasurer, W. Marsh, said: "Although the times call for every economy, and although it is obvious that the lavish expenditure of the last few years cannot be maintained, there appears to be no reason for anxiety as to the town's ability to meet all its obligations punctually and to carry on all essential services as usual."

Meanwhile, the Electricity Department continued to grow, albeit more slowly. In 1930, it designed and put up Singapore's first traffic signals at Empress Place to improve traffic flow. In 1936, to enhance the pricing system, a tiered system was introduced for two categories of charges. For lighting and fans, the first 5,000 units per month were set at 15 cents per unit; the next 5,000 units at 3½ cents; and the next 15,000 units at ½ cent. For motors and motor generators (required by industrial users) the first 5,000 units per month were set at 4 cents per unit; the next 20,000 units at 3 cents per unit; and any subsequent units at 2 cents per unit.

In tandem with the global economic recovery in the late 1930s after the Great Depression, St James Power Station began to work on meeting expected demand by putting in a second 10,000 kW set for completion in 1937. By then, the per unit cost of electricity generated nearly doubled, going from 0.497 cent to 0.883 cent when the cost of coal – used for electricity generation then – shot up from \$6.40 per ton in 1937 to \$9 per ton in 1938, and for a lower grade of coal to boot.

The Department decided to look into using fuel oil for power generation and to make a start by installing two fuel oil tanks and converting two of the boilers for oil-firing, with work to be completed by 1940.

Despite the increase in cost of electricity, demand continued to rise in the late 1930s with the improving economy. The introduction of air-conditioning in large commercial establishments added to the total electricity demand.

***Despite the increase in cost of electricity, demand continued to rise in the late 1930s with the improving economy. The introduction of air-conditioning in large commercial establishments added to the total electricity demand.***

Cathay Cinema was opened in 1939 with air-conditioning, the first cinema to do so. Singapore Dairy Farm in Bukit Timah even air-conditioned its barns so that the milk cows would get an approximation of conditions in England or Australia and so improve their yield.

#### **WORLD WAR II: KEEPING THE LIGHTS ON**

The opening salvoes of the Japanese invasion were fired in the early hours of 8 December 1941. At about the same time as the Japanese fleet began bombing Pearl Harbor in Hawaii, Japanese troops landed in southern Thailand and northern Malaya.

By 30 January 1942, the Japanese were poised in Johor Bahru, the southernmost part of what is today West Malaysia, ready to battle for Singapore. In response, the British military ordered a “scorched earth policy” to deny facilities to the Japanese. It must have been heart-wrenching for the staff of St James Power Station to disable what they had carefully built up.

The British surrendered Singapore on 15 February 1942 and the Japanese Occupation started the next day. The very first issue of *Syonan Times* printed on *The Straits Times*’ presses in Cecil Street ordered Municipal workers and engineers in the Gas, Electricity and Water Departments to report for duty. Maintaining the city infrastructure was of top priority.

The threatening demands were made repeatedly as many Asian Municipal workers stayed away for fear of their lives. When the demands did not produce results in the early days, the Military Administration pulled out the European civilian internees from



## The Electric Fan

In equatorial Singapore, wealthy residents in the 19th and early 20th century coped with the humid heat by employing *punkah wallahs*, young Indian boys or men, to pull large pieces of stiff cloth suspended from the ceiling to cool the air. Tropical homes were also designed with high ceilings to encourage air circulation.

In 1889, Westinghouse Company introduced a three-bladed electric fan in the United States of America. It was one of the first domestic appliances to be fitted with an electric motor. This invention would eventually throw *punkah wallahs* out of work. In 1905, the Municipality installed electric lighting and electric fans at the Governor's residence (known today as the Istana).



## First Air-Conditioned Cinema

Opened in 1939 with a showing of Alexander Korda's *The Four Feathers*, Cathay Cinema was the first air-conditioned cinema in Singapore and could seat 1,300 people. The 16-storey Cathay Building, which was linked to Cathay Cinema, was twice as tall as Union Building, the tallest building at the time. Completed in 1941 on the eve of the Japanese Occupation, Cathay Building had 32 flats with hot and cold water, refrigerators and the most modern of home appliances. However, because of the imminent war with Japan, Cathay Building was leased to the British government and various floors were taken over by the Department of Broadcasting. During the Japanese Occupation, it functioned as the office for the Syonan Broadcasting Department.

Hitting the big screen in air-conditioned comfort became fashionable.



**“When there was a cable fault that needed fixing, the Japanese would send someone to my house to pick me up to fix the fault. And it was a good job because they gave me a lot of rice and vegetables for my work.”**

Engineer Lim Loo Cheong was a staff of the Electricity Department when Singapore became Syonan-to and electricity was privatised.

Changi Prison to work on restoring the damaged infrastructure until such time as they could be replaced by Japanese civilians.

### **“LIGHT OF THE SOUTH”**

After Singapore became Syonan-to, or “Light of the South”, electricity generation initially came under the Japanese Military Administration Department. But on 1 February 1943, electricity generation was officially handed over to a private company, Nippon Hassoden Kabushiki Kaisha (NHKK) or Nippon Power Supplies Company.

In May 1942, the company sent engineers from Japan to restore St James Power Station and made plans for extensions. In March 1943, it brought down from Batu Gajah in Malaysia a new steam engine generator of 12,000 kW capacity and installed two transformers.

Thus, the Japanese engineers were able to maintain St James Power Station at its pre-war capacity of 32,000 kW. Not surprisingly, demand was low at only 10,000 kW and never reached the pre-war maximum load of 19,600 kW.

Gradually, some Asian staff in the Municipality started to return to work. One Electricity Department staff member who went back to work was Lim Loo Cheong. He joined the Electricity Department back in 1941 as a wireman, wiring consumers’ residences for electricity supply. Another was Lawrence R. Estrop, who had been hired as an engineering assistant in 1937.

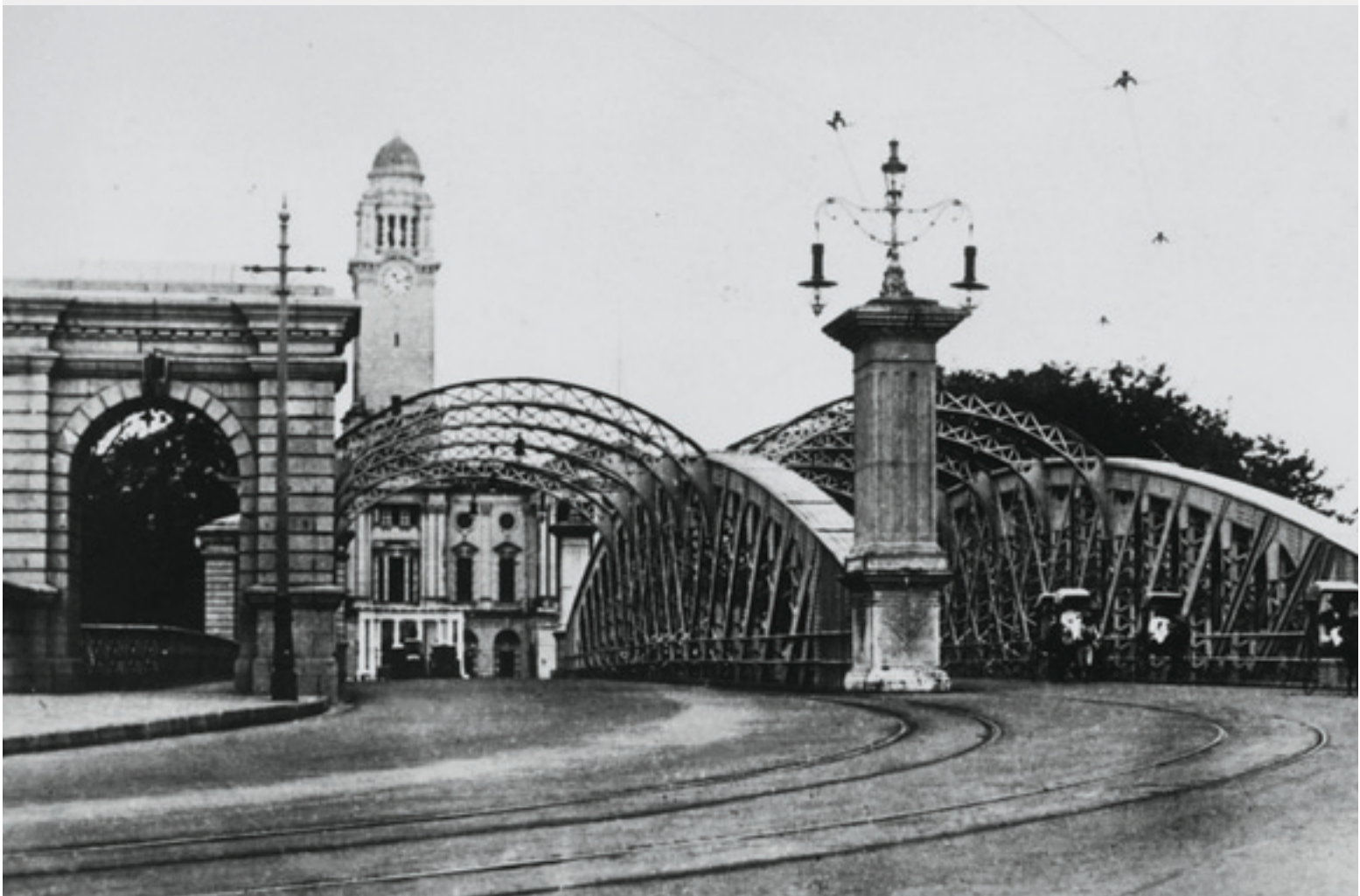
Mr Lim remembered that there were five such engineering assistants in the distribution section where he worked. The section was headed by two English-speaking Japanese civilians, Kitamura-san and Otani-san, who were either engineers or technicians.





## Street Lamps and Period Charm

The Electricity Department had a Street Lighting Section that looked after every aspect of street lighting, ranging from its supply to its design and hardware. In 1984, the Section fitted specially designed lamps on some of Singapore's oldest bridges to give each bridge a distinct character. These bridges were Coleman Bridge, Crawford Bridge, Anderson Bridge, Read Bridge, Elgin Bridge and Sir Arthur's Bridge.



Specially designed lampposts added ambience and character to each bridge.



**“In the distribution section, there were just these two Japanese and we were running the whole section by ourselves... Sometimes we did not have the spares and we would look for them on the black market.”**

An engineering assistant hired in 1937, Lawrence Estrop was in charge of the distribution network after Singapore became Syonan-to.

The staff were paid in the Japanese wartime currency called “banana money” as well as with rations, of which rice was the most valued. Mr Lim recalled: “When there was a cable fault that needed fixing, the Japanese would send someone to my house to pick me up to fix the fault. And it was a good job because they gave me a lot of rice and vegetables for my work.”

As Mr Estrop remembered, the whole distribution network was run by these two Japanese who, very wisely, left the work to the local engineering assistants. He said: “In the distribution section, there were just these two Japanese and we were running the whole section by ourselves. We did not have much of a problem running the system. We knew the system. We still had some spares. Sometimes we did not have the spares and we would look for them on the black market. All the expatriates were gone. The local senior officer, who was born in England, was also taken away. There was nobody with experience left. There were only the foremen. When there was any breakdown they had to call us. It was sink or swim. We had to do a lot of things that we had never done before.”

1906  
-  
1945

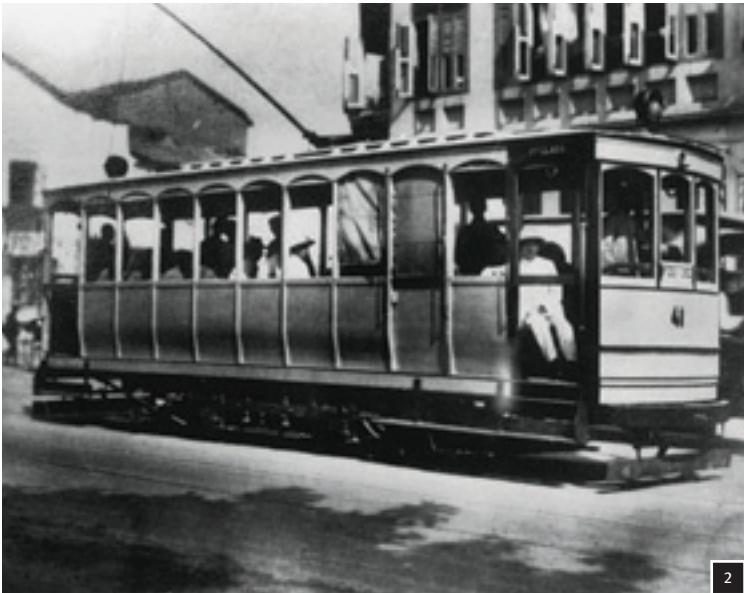


1

- 1 Street lights for the first time.
- 2 An electric tram in action.
- 3 St James Power Station: up and running.
- 4 Empress Place in the 1930s.

**1906**

- Electric lighting of streets came on for the first time.
- The Singapore Electric Tramway Company's power station in Mackenzie Road began supplying electricity in bulk to the Municipality, which in turn sold it to consumers.



2



1924

- Construction of St James Power Station began.



1928

- Electricity Department opened an office at Orchard Road to help the public with information and advice on electrical appliances.

1930

- Electricity Department designed and put up Singapore's first traffic lights at Empress Place.



1939

- Air-conditioning was introduced at Cathay Cinema, the first cinema to do so.

1942-1945

- Japanese Occupation. The Electricity Department was taken over by Nippon Hassoden Kabushiki Kaisha (NHKK) or Nippon Power Supplies Company.



LIGHT

IN

THE

TUNNEL



1946

—

1955







## **REBUILDING AFTER THE WAR AND INTO SELF-GOVERNMENT**

**THREE HARD YEARS OF THE JAPANESE OCCUPATION HAD COME TO AN END IN AUGUST 1945. WAR NOT ONLY WRECKED SINGAPORE'S PHYSICAL INFRASTRUCTURE, IT ALSO CAST A BLACKOUT – LITERALLY AND FIGURATIVELY – ON A WHOLE WAY OF LIFE. NOW WAS THE TIME FOR SINGAPOREANS TO BEGIN TO BUILD THEIR OWN FUTURE AND FATE.**

### SUPPLY STRUGGLES TO KEEP UP

In April 1946, after seven months of restoration work by the British Military Administration, civilians once again took over the Electricity Department. But they found that things were not as they should be.

Although St James Power Station was in working order, the British engineers found that it was a “time bomb”. The 1946 Colony of Singapore Annual Report said of the power station: “Numerous extensions were carried out by the Japanese and in view of their highly dangerous condition, these required prompt removal.” The station’s “dangerous condition” arose from makeshift repairs and a lack of the right parts, as all the equipment was British-made.

The post-war recovery efforts were slowed down further by having to compete with a war-ravaged UK for the same spare parts.

Other shortages plagued Singapore, including labour. As stated in the 1946 Colony of Singapore Annual Report: “The acute shortage of the staple of the labour force, rice, had contributed to labour unrest and a general lowering of vitality and efficiency. Not only is labour in short supply, the recruitment of professional officers and the supply of trained office and supervisory staff have been insufficient to maintain the high standards of former days.”

As little had been done before the war to develop skilled Asian manpower, there was a dearth of talent in Singapore. The pre-war skilled personnel who ran essential services such as electricity had all been British.

Despite the challenges, the engineers in the Electricity Department made the best of what they had, and improvised as they went about restoring facilities and ramping up supply.

This was critical as the domestic demand for electricity jumped 50 per cent and that for public lighting and machinery rose 12 per cent after the war.

### URGENT NEED FOR PASIR PANJANG POWER STATION BORN

To meet the post-war demand for electricity, a decision was made in 1948 to build Pasir Panjang Power Station. The station was designed for an ultimate capacity of 150,000 kW and scheduled for commissioning in 1952.

Work on the station was, in the words of the Electricity Department, “pressed forward

## The Monday Syndrome

The start of the work week on Mondays saw a sharp spike in electricity demand when plants and high-rise offices that had shut down for the weekend resumed work. The power stations and the distribution centre had to be ready to manage this spike in electricity demand from air-conditioners, lights and machinery being switched on. Any failure to do so would lead to a supply failure. This Monday morning spike came to be called “the Monday Syndrome”.

Engineer Lau Gar Ning recalled: “To meet this spike, the power stations were asked to move their start-up time to the early hours of Monday morning. One would start at, say, 3 am, another at 4 am.”



An electricity distribution centre monitoring demand spike.





**“To meet this spike, the power stations were asked to move their start-up time to the early hours of Monday morning. One would start at, say, 3 am; another at 4 am.”**

Engineer Lau Gar Ning explained “Monday Syndrome”: a Monday morning spike in electricity demand for air-conditioners, lights and machinery.

with the utmost vigour and, notwithstanding shortages of skilled labour, inadequate supplies of granite, and delayed deliveries of materials”.

Until Pasir Panjang Power Station was ready, Singapore lived with brownouts (when supply becomes unstable and voltage drops), blackouts (when supply is totally cut off) and load-shedding (an imposed rotational blackout when supply to certain areas is cut temporarily to avoid overloading the whole system).

In 1950, it was reported that outages hit 141.5 hours for the year with an average of 2.44 hours per outage. With supply so uncertain, every household kept candles and matches on hand in anticipation of a load-shed or a blackout. Pressure lamps fuelled by kerosene were popular, too, especially with hawkers and shops that needed brighter lighting than candle power.

However, the Electricity Department was still able to make special exceptions. Electricity Department Engineer Michael Khor recalled: “I remember well in 1952, when I was in the School Certificate class (now Secondary 4), I wrote to the Chief Electrical Engineer, appealing to him to leave the street lamp outside my house in East Coast Road next to Marshall Road out from the blackout. Surprisingly, he replied and left that street lamp out from the blackout list so that I could study and prepare for the exam. Otherwise, I would have had to depend on light from the kerosene lamp.”

### **LIGHTING UP THE NEW CITY**

Despite the serious crimp in supply in the early 1950s, the Electricity Department made itself proud when Singapore celebrated its new status as a city on the night of 22 September 1951.

## Standby Power

All essential service installations, such as hospitals, waterworks, sewerage works and the airport, have standby generators, as do commercial buildings, shopping centres, office blocks, hotels and other commercial and industrial operations that cannot afford to have any downtime.

During a power failure, these standby generators will automatically kick in to take lifts down to the ground floor to prevent people from being trapped in them and to power essential operations such as emergency lighting and firemen's lifts. Under Singapore's building regulations, all standby generators must be regularly checked and serviced.



Blackouts without downtime: business as usual for hawkers and diners alike.

## A Meter Tester's Perks

Electric meters were delicate instruments which had to be tested and calibrated before installation. Such checks were done by the Meter Section, an important part of the Electricity Department. P. Chandran, a meter tester in the 1960s, recalled: "Those days it was a privilege that when you become a meter tester, you worked in an air-conditioned room! That was the greatest privilege. Meter Section was a huge place. I think it was about 100 feet by 80 feet. Hundreds of meters were being tested simultaneously each time. The air-conditioning was not meant for us but for the meters, because they had to be dust-free. Completely dust-free as the meters were tested with opened covers."



'Privileged' meter testers working in dust-free, air-conditioned environments.



This was known as “City Day” when the Town of Singapore was officially made a City of the British Commonwealth, to reflect its increased size, population and importance.

Experimental coloured floodlighting illuminated the Municipal Building, later called City Hall. A parade of floats lit up the evening, and thousands converged on the Padang to usher in the country’s bright new phase of life.

City Hall, where the Electricity Department and other government agencies were located, was later to witness the significant political changes of the 1950s for Singapore, including civil unrest and agitation sparked by communism, anti-colonialism and other forces. During the 1957 installation of Ong Eng Guan as the Mayor of Singapore, Mr Ong threw out the “Mace of Office” in a theatrical anti-colonial gesture. Mysteriously, this symbol of government was found later in a cupboard of the Electricity Department!

In 1959, Singapore became self-governing under the People’s Action Party (PAP) with Lee Kuan Yew as Singapore’s first Prime Minister.

Singapore was given development assistance through the United Nations Development Programme. Dr Albert Winsemius, a Dutch economist and key planner in the Netherlands’ post-war recovery, recommended pushing for foreign investments, manufacturing for export and continued adherence to Singapore’s long tradition of free trade.

Applying this strategy was the Economic Development Board (EDB), a government agency set up in August 1961 with the twin objectives of creating new industries and accelerating the development of existing industries. EDB officers soon began wooing multinational corporations (MNCs) to Singapore’s new industrial estate in Jurong. Electricity, of course, was a vital part of this industrial estate.

## **PUB IS BORN**

In 1961, when the EDB unveiled its strategy of rapid industrialisation spurred by foreign MNCs, the Electricity Department knew that more power was needed. Pasir Panjang Power Station was ready to be expanded, and the decision was made to construct another power station – Pasir Panjang B Power Station – next to the original Pasir Panjang Power Station (which then became known as A Power Station).

Locating the new power station next to the existing one speeded up construction as common facilities such as fuel storage, bunkering, laboratory services, machine shops

and workshops could be shared. Work started in October 1962, just before the establishment of the Public Utilities Board (PUB) on 1 May 1963. PUB became the single agency responsible for the supply of electricity, water and gas for Singapore.

While construction of Pasir Panjang B Power Station was underway, the first factory to start operations at the new Jurong Industrial Estate was National Iron and Steel Mills in 1962.

That same year, about 20 other large industrial consumers started their operations and demand for electricity shot up a further 3,000 kW by year-end.

In October 1965, Pasir Panjang B Power Station was officially opened by then Prime Minister Lee Kuan Yew. The station's 120 MW brought the total installed generation capacity to 344 MW. Work on Phase II of Pasir Panjang B Power Station to add 120 MW capacity started soon after, and was completed by the end of 1966.

Even as Pasir Panjang B Power Station was nearing completion, planning had started for a new power station – Jurong Power Station – with an ultimate generating capacity of 480 MW. The need to be ahead of the curve was keenly felt by the Department in the late 1960s and 1970s, especially when EDB was very successful in attracting more MNCs to Singapore.

### KAMPONG ELECTRICITY BECOMES A PRIORITY

On 9 August 1965, when Singapore separated from Malaysia and became an independent nation, the government's first priority was to ensure the new nation's survival. Among the first tasks was to ensure an adequate supply of essential utilities such as water and electricity.

Along with industrialisation, there was now the political will to ensure that every rural home in Singapore was plugged in to electricity, to realise the 10-year Rural Electrification Programme that the Electricity Department had been tasked with in 1963.

The kampongs, or villages, were divided into three types: the first group was close to developed areas and thus near the power grid; the second group comprised villages whose houses were clustered together but at some distance from the power grid; and the third group – the most expensive to “electrify” – were the remote kampongs with scattered houses far from the grid.



PUB civil engineers ensuring safety and efficiency in utility stations.

## Architectural and Maintenance Department

The PUB had its own civil engineering department that undertook construction of the substations and other building projects for all three utilities then – electricity, water and gas. This had also been the Municipality's practice when it used its own staff to undertake the civil engineering work, from earth works to construction. It only turned to labour contractors when it wanted to speed up construction.





***Until Pasir Panjang Power Station was ready, Singapore lived with brownouts (when supply becomes unstable and voltage drops), blackouts (when supply is totally cut off) and load-shedding (an imposed rotational blackout when supply to certain areas is cut temporarily to avoid overloading the whole system).***

Between 1963 and 1969, about 300 electrification schemes were implemented at a cost of \$9 million, benefiting over 180,000 people. Most of the kampongs that were “electrified” were in the first category near the power grid, with a smaller number coming from the second category of kampongs.

But for the third category – comprising a number of areas which were either too remote or whose population size was small with dispersed housing – “electrification” was deemed too costly. So, in late 1969, a decision was made to shell out \$1 million yearly to subsidise the “non-viable” areas so that each and every home, no matter how remote, would have power and light.

Besides costing more, rural electrification posed technical problems different from those in urban areas. For one thing, where would the transformers be placed to transfer electricity from one circuit to another? Electricity was supplied at 6.6 kV, which had to be stepped-down and supplied to consumers at a lower voltage of 415 or 240 volts.

The first power grid in rural areas consisted of overhead bare, stranded copper conductors supported on poles. The use of bare wires cut costs and made the programme affordable when Singapore faced numerous infrastructure projects and budgets were tight.

Teo Heng Lam, who was with the programme when he first joined the Department in 1970, recalled: “Overhead lines are the cheapest form, so when the concern is costs you use overhead lines. But with overhead lines, when there is inclement weather you get breakages. When there is a storm, tree branches break and fall on the lines and there are blackouts.”

## Rural Electricity Bills

When the rural electrification programme started in 1963, the revenue was projected at \$5 per rural household per month. This rose with the increasing use of electricity in rural areas, as Soh Siew Cheong, EMA's former advisor, recalled: "Instead of carrying water from the well, they installed a pump to bring water to the vegetables. Then they started to buy welding machines to make repairs to bicycles, to make small gadgets to sell. The more enterprising housewives bought sewing machines. There were a lot of textile and garment factories. The factories started to get these housewives to make things like collars and sleeves from their homes. After 1963, television was introduced and demand went up even higher."

Hence, when the scheme ended in 1974, monthly revenue per household was between \$10 and \$25 per month, with revenue returns increasing yearly. To make bill payment easier for rural consumers, a Mobile Collection Unit was set up in 1964 by outfitting a minibus into a collection centre.



A Mobile Collection Unit reaching out to rural consumers.





**“Overhead lines are the cheapest form... when there is inclement weather you get breakages. When there is a storm, tree branches break and fall on the lines and there are blackouts.”**

Teo Heng Lam joined the rural electrification programme in the 1970s, when Singapore faced numerous infrastructure projects and budgets were tight.

The theft of electricity from bare copper wires was also relatively easy. All a thief had to do was to throw another bare wire onto the overhead line. Equally easy was theft of wiring. Ng Nam Wah, who was with Transmission and Distribution of the Electricity Department, said: “We suspected that the thieves were some of our workers because they are the people who know how to get in and get out, where they can cut safely.”

A review of what was available to achieve the objectives of cost-effectiveness, safety and reliability of supply led to the idea of pole-mounted, completely self-protected transformers and indoor-type switchgear. Singapore then had numerous flood-prone areas, and installing the overhead equipment meant that floods would not wash out electricity supply.

Bare overhead wires would start to be replaced with insulated wires only in the 1980s.

The rural electrification programme cost nearly \$20 million and more than 200,000 people enjoyed the benefits of electrification. Over time, the programme became less relevant as rural areas in Singapore shrank and public housing estates took their place. But in some small private housing estates in once rural areas such as Opera Estate, sections of overhead lines remained for some time.

### **HOUSING A NATION: WITH ELECTRICITY**

In the 1960s, there were other problems like acute housing shortages. Back in the 1950s, the colonial government had re-activated the 1920s public agency Singapore Improvement Trust (SIT) to build low-cost housing to address the acute housing shortage. All these new homes had electricity as a standard feature.



**“We suspected that the thieves were some of our workers because they are the people who know how to get in and get out, where they can cut safely.”**

Ng Nam Wah, Transmission & Distribution Engineer of the Electricity Department, highlights the relatively easy theft of wiring.

Despite the critical situation, the SIT worked at a leisurely pace. But not the Housing and Development Board (HDB), set up by the new PAP government as a statutory board with Lim Kim San as its chairman. He would later become chairman of PUB too.

The hectic public housing building programme became the foundation for improving the quality of life for many Singaporeans. In its first three years, the HDB built almost as many shophouses and housing units as the SIT did in its entire 32 years of existence. By 1965, there were 54,430 units. The housing programme gathered even more speed after Singapore became independent in 1965.

When developing a new block of flats, HDB planners would first apply to PUB for electricity supply nine to 12 months before the completion of building. Distribution equipment such as switchgears, transformers and cables had to be tendered for and purchased from overseas. High and low voltage cables had to be laid, substations built, equipment installed, meter rooms in blocks of flats laid out, and wiring put into each flat.

### **PUB AND HDB GET NEW HOMES READY**

PUB’s technicians and engineers installed the meters and inspected wiring systems in each block of flats before a certificate of compliance with the appropriate regulations could be issued and recorded.

The individual meters were installed only when the new flat-owners applied for electricity supply. At first, the technicians were making time-consuming repeated visits to the same block to install meters and turning on supply as and when owners moved





## Early Days of Air-Conditioning

Once, when asked what he thought had helped enable Singapore's success, then Prime Minister Lee Kuan Yew said: "Without air-conditioning you can work only in the cool early-morning hours or at dusk. The first thing I did upon becoming Prime Minister was to install air-conditioners in buildings where the civil service worked. This was key to public efficiency."

Marine Parade Community Library opened in 1978 as the first fully air-conditioned branch library, while the main library in Stamford Road remained only partially air-conditioned for years.



## Television in Singapore

The introduction of television in 1963 did not add to the demand for electricity because few households could afford a television set at that time. Transmission was in black-and-white and broadcasting hours were limited. Community centres that were springing up all over Singapore at that time had television sets placed in a spacious room so people could gather to watch the local news programmes, as well as the mostly imported TV programmes. Michael Khor, Chief Electrical Engineer who rose to the position of Deputy Chief Executive, PUB, recalled a live broadcast of a Miss Universe contest where "many shops with open spaces in front, like Fitzpatrick's supermarket in Orchard Road (now Paragon), installed television sets and laid out benches for the public. Of course, they sold a lot of snacks and soft drinks. Demand for electricity went up by about 20 per cent". For fear of a possible system collapse from the surge in demand, "all the engineers and engineering assistants were on standby".

Black-and-white TV programmes added colour to leisure and entertainment.



**“The new arrangement not only relieved us from the workload of installing our distribution boards, but also eliminated the problem of coordination.”**

Then PUB Deputy Superintendent Yeo Yek Seng in a 1983 article in *PUB Digest*, making a case for outsourcing the substation work.

in. To streamline the process, individual meters outside each flat were fixed in bulk at the same time as the testing and checks of wiring were done.

Finally, to cope with the increased workload of building and outfitting substations and cabling, the PUB began outsourcing the work. When the first few projects were found to meet the PUB’s standards, more such contracts were given out including complete turnkey projects.

To ensure that essential supplies like meters were always available, contracts for supplies were awarded to more than one supplier simultaneously and stock levels of essentials were raised from three months to six months to pre-empt delays from late shipment or a sudden surge in consumption.

Yeo Yek Seng, then Deputy Superintendent at the PUB heading the Customer Supply Branch, who rose to become Deputy Chief Executive of the Energy Market Authority, said in a 1983 article in *PUB Digest*: “The new arrangement not only relieved us from the workload of installing our distribution boards, but also eliminated the problem of coordination.”

To spread out the work of cable laying more evenly, low-voltage cables were laid several months ahead of completion. As the kampongs disappeared and more people moved into new towns like Tampines, Ang Mo Kio, Bedok and Woodlands, the overhead lines disappeared and cables went underground.

## **PUB BUILDS IN-HOUSE EXPERTISE**

In those early days, the PUB inherited a significant labour practice from the British – a





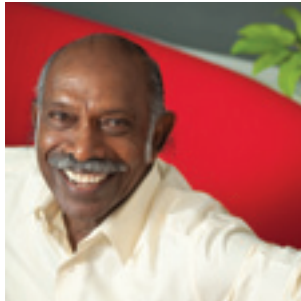
***In its first three years, the HDB built almost as many shophouses and housing units as the SIT did in its entire 32 years of existence. By 1965, there were 54,430 units and the housing programme would gather even more speed once the Malaysia years were behind Singapore.***

reliance on daily-rated employees to do the heavy work of digging trenches, laying cables as well as semi-skilled and skilled work. When the PUB was formed in 1963, there were nearly 2,000 daily-rated employees compared to nearly 600 monthly-rated employees comprising clerical workers, managers and engineers known as “senior officers” in the Electricity Department then.

P. Chandran, who joined the PUB in 1965, came from a family whose father and brothers had been employed in the daily-rated workforce. He recalled: “When you became a monthly-rated staff member, you became like a ‘crowned king’. The Malays called them ‘kerani’. It means clerk but in those days, a clerk was very highly respected. When you were promoted to a staff member like this, your status was very, very high.”

Unless there was overtime work, the hours were such that any daily-rated employees could supplement his daily wage with additional jobs. Said Mr Chandran: “They finished their job at 2.55 pm and they did part-time jobs. They could not depend on their salary. Some would become gardeners. Some would become car washers and some would go out in the evening and sell *kacang puteh*.”

The need for a better system of technology transfer was especially evident to those who worked with the colonial engineers in the mid-1960s. Engineer Chang Meng Teng said: “There were still some colonial chaps around. There was this engineer, when he wanted to do any switching, he was very secretive. He would shut the door, then he would do the switching and come out and say it was all done. Okay, maybe it was for safety reasons but probably that way, there was also no transfer of technology! There were people who would go to them and ask: ‘Can you help



**“When you became a monthly rated staff, you became like a ‘crowned king’. The Malays called them ‘kerani’. It means clerk but in those days, a clerk was very highly respected.”**

**P. Chandran, a meter tester in the 1960s.**

me?’ But they were not very happy to help. That was why PUB sent people like us for training with the manufacturers. It was only in the 1980s that we had more Asian engineers.”

Gradually, learning by seeing and doing was found at all levels. Mr Chang was among the young engineers who learned a great deal from the old hands who passed on their experience willingly. He said: “In those days there was a lot of team spirit among the engineers. At Armenian Street we had a chill-out area in the coffee shop opposite the substation. After work, young engineers like me drank coffee there with the older engineers. They told stories about the faults they had attended to and how they did it. We would sometimes sit there till 7 or 8 o’clock listening to these stories.”

Mr Chang found this informal sharing so useful that when he was president of the Senior Officers’ Association, he organised luncheon talks at which everyone zipped through lunch to spend 45 minutes on a talk or discussion about someone’s latest overseas course or attachment with a manufacturer.

### **DEVELOPING MANPOWER**

By the mid-1960s, the PUB had built up enough technical expertise to contribute to the training of school-leavers and vocational training institute students in its various engineering departments. It started an attachment training scheme which began in the late 1960s to include polytechnic students and undergraduates, with some from overseas universities.

## Daily-Rated Employees and Unions

Until the late 1980s, the hard work of digging up the ground and laying cables and pipes would have been impossible without the Daily-Rated Employees (DREs). These DREs were essential to the development of the utilities from colonial times. Unionist P. Chandran recalled in 2008: “The daily-rated people made up the bulk of the staff. When the Europeans were in charge, what they needed were casual workers. If there was rain, they looked for half-day workers. That was how these workers first started. Then they became daily-rated workers. Daily-rated employees had their own union. It was headed by Mr Suppiah, a very strong unionist who didn’t know English, but he was very conversant in Malay. The daily-rated union was very powerful in those days. They would go on strike; they would demand things which they thought were right and would always be ready to face any consequences.”



Where would we be without daily-rated workers toiling to lay cables and pipes?



## PUB Logos

The Public Utilities Board's (PUB) first logo was used from 1963 till 1976. A redesign was done at the request of then Chairman of the Board, Lim Kim San, who wanted a more modern image for the PUB than the chimney stacks in the old logo, said Choo Wai Chan, a former PUB staff. The new logo reflected the "progressive outlook of the Board in its essential function of providing a continuous supply of electricity, water and gas to the Republic".

PUB changed its logo in 2001 when its regulatory role in energy matters came under a new statutory board, the Energy Market Authority. It finally adopted its current logo in 2005 to reflect its water regulatory role.



1963-1976



1976-2001



2001-2005



2005-PRESENT



## PUB Building on Somerset Road

The design of the H-shaped PUB Building, which was said to look like a transformer, was the result of an architectural design competition. Organised in 1972, Group 2 Architects won the design competition with its H-shaped block on a low podium consisting of a multipurpose hall and other service sections. The judges commented: "In design concept, it is refreshing in that it has simplicity and yet maintains the required degree of formality and dignity necessary for such a building."

Construction started the year after, with an in-house team responsible for the electrical and mechanical engineering designs and the plumbing works. In 1977, the Board moved out of City Hall into the new PUB Building at 111 Somerset Road. With the restructuring of the PUB subsequently, the building was sold in 2008.



**“In those days, there was a lot of team spirit among the engineers. After work, young engineers like me drank coffee with the older engineers. They told stories about the faults they had attended to and how they did it.”**

Engineer Chang Meng Teng learned a great deal from the old hands.

One of the students was U. Popathi, the Energy Market Authority’s current Union Chairman, who had his technical training at St James Power Station in 1974. He recalled: “The training curriculum was well planned and very comprehensive. We had to learn the different types and functions of all the electrical installations and components, both for domestic and industrial use. Lessons included practical sessions when we would learn to operate the machines such as the lathe and welding machines. We also visited substations and power stations to familiarise ourselves with PUB’s work in power generation. And the examinations were really difficult! We really had to study hard in order to pass.”

As the economy developed further and the private sector demand for engineers grew, the Board found some of its well-trained engineers seeking greener pastures in the private sector.

One who stayed until retirement was Lau Gar Ning, who rose to become superintendent of Senoko Power Station, the largest PUB power station in the 1980s. He recalled: “What we had in the Electricity Department was unique compared to other departments. If you didn’t quit and you became a power station manager, you developed not only a sense of ownership but also a sense of duty. There is the interdependence between the guys who manage the computers, the guys who manage the furnace, the boilers and so on. It is a very team-driven portfolio, a collective effort.”

With more resources, PUB began offering tertiary and post-graduate scholarships to staff, thus renewing and strengthening the skills of its engineers.

This was in addition to the courses that the suppliers had provided for the engineers









**“The training curriculum was well planned and very comprehensive. We had to learn the different types and functions of all the electrical instruments and components, both for domestic and industrial use.”**

U. Popathi, current Union Chairman, recollects the tough examinations in the mid-1960s.

on handling new equipment. Such upgrading of professional skills was essential given the constantly evolving nature of technology and its growing sophistication.

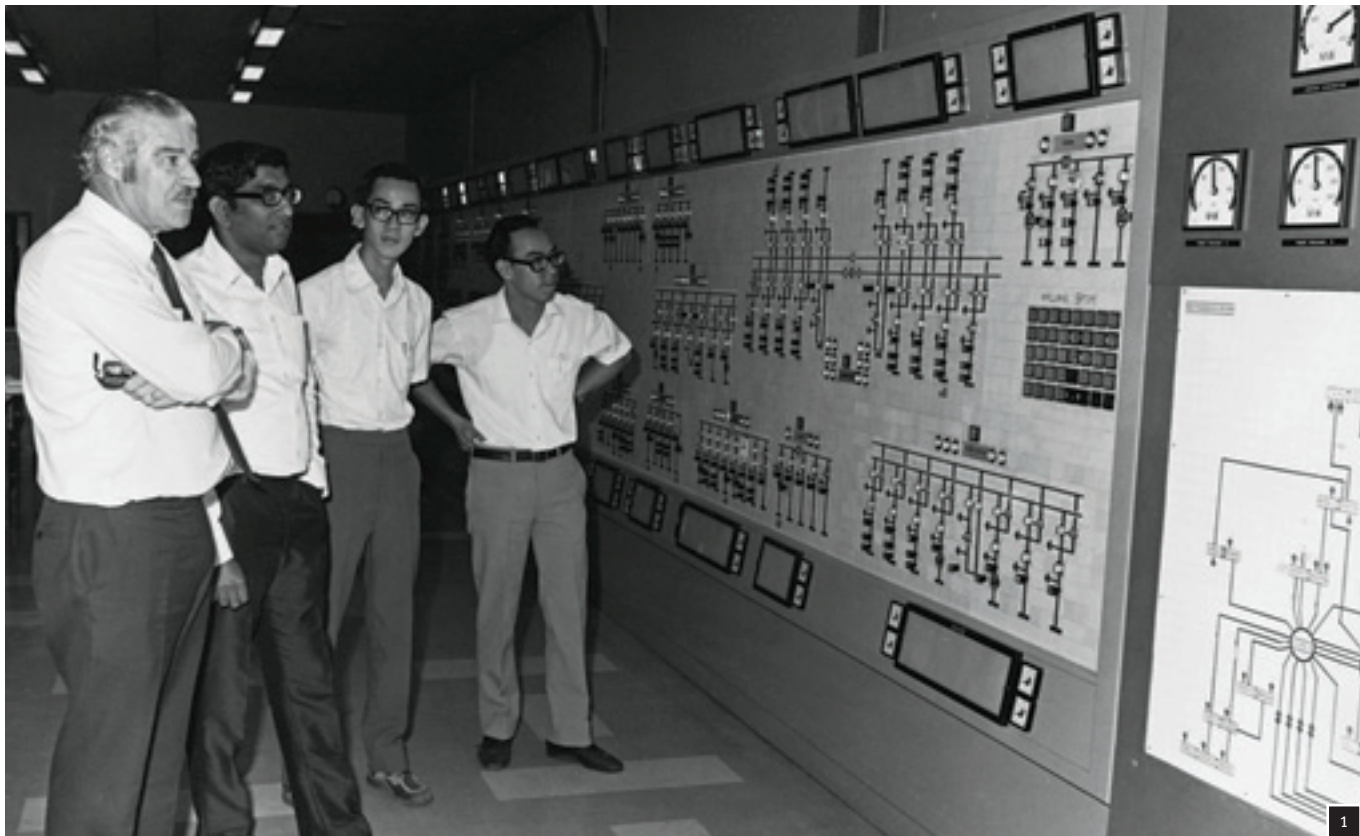
Before that, the Board had engaged expatriate consultants for its power projects as a condition imposed by the World Bank for its loans. As Mr Lau said: “with each new power plant we built, we took in all the difficulties encountered in the previous plant and so we became more and more reliable. We shared experience.”

Later, by 1989, PUB could even begin looking into selling its expertise internationally through its subsidiary, Development Resources Pte Ltd, which grew from internal expertise. That year, its total income from external consultancy services provided in Singapore was just \$0.84 million. This figure would rise to \$10.9 million by 1992.

This enviable position of having internationally exportable engineering expertise would have been hard to imagine back in 1965, when Singapore was beginning its struggle to survive as a nation.



1946  
-  
1965



1 A welcome visit from the Mauritius Electricity Board.

2 The Pasir Panjang B Power Station.

3 HDB flats in their luminous beauty.

4 Opening its doors to visitors, the Electricity Department helped the public with information and advice on electrical appliances.



1946

- Civilians took over the Electricity Department following seven months of restoration works by the British Military Administration after World War II.

1948

- Decision to build Pasir Panjang A Power Station was made.

1951

- Town of Singapore officially made a city of the British Commonwealth.

|                                                                                                                                      |                                                                                                                                                                                                                     |                                                                                                                                                                                                                         |
|--------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <div>1952</div> <div><div>■ Pasir Panjang A Power Station was commissioned.</div></div>                                              | <div>1959</div> <div><div>■ Singapore under People’s Action Party.</div></div>                                                                                                                                      | <div>1960</div> <div><div>■ Formation of Housing and Development Board.</div></div>                                                                                                                                     |
| <div>1961</div> <div><div>■ Formation of the Economic Development Board and an industrialisation programme got underway.</div></div> | <div></div> <div>3</div>                                                                                                         |                                                                                                                                                                                                                         |
| <div>1962</div> <div><div>■ Work started on Pasir Panjang B Power Station sited next to A Power Station.</div></div>                 |                                                                                                                                                                                                                     |                                                                                                                                                                                                                         |
| <div></div> <div>4</div>                          | <div>1963</div> <div><div>■ Singapore became part of the Federation of Malaysia.</div><div>■ Beginning of the Rural Electrification Programme.</div><div>■ The Public Utilities Board (PUB) was formed.</div></div> | <div>1965</div> <div><div>■ Singapore separated from Malaysia and became independent.</div><div>■ Pasir Panjang B Power Station was commissioned and officially opened by then Prime Minister Lee Kuan Yew.</div></div> |





SUNING

THADOM

1966

...

1995









## **POWER FOR A YOUNG NATION AND ECONOMY**

**ELECTRICITY IS AN “UNSUNG HERO” IN THE STORY OF SINGAPORE’S ECONOMIC SUCCESS, WITH ITS INSTANT AVAILABILITY AND RELIABILITY. THIS WAS CERTAINLY THE CASE IN THE THREE KEY DECADES BETWEEN SINGAPORE’S INDEPENDENCE IN 1965 AND ITS RISE TO BECOME A LEADING ECONOMY IN ASIA BY THE MID-1990S. AS A YOUNG NATION FINDING ITS FOOTING IN THE WORLD, AND WITH ITS ECONOMY JUST TAKING OFF, ENSURING AN ADEQUATE SUPPLY OF ELECTRICITY WAS FUNDAMENTAL TO SINGAPORE’S GROWTH IN THOSE EARLY DAYS.**



### THE QUEST FOR ADEQUATE AND RELIABLE SUPPLY

As Singapore's economy picked up, especially from 1965 onwards, the approach towards electricity was to plan ahead to achieve sufficiency for Singapore's needs. Lee Ek Tieng, who was PUB Chairman from 1978 to 2000, recalled that the key to PUB's work was to always aim to "stay ahead of the curve" and to build a power station ahead of time. This was done by forecasting demand growth accurately and acting fast, as each power station takes about five years to construct. This called for a blend of good engineering and good planning.

Soh Siew Cheong, who joined PUB in 1965 and became Chief Distribution Engineer in the 1980s, recalled that the reliability of electricity supply was linked to advances in technology and industrialisation. It moved from "do you have?" to "do you have enough?" to "how reliable are you?"

As Mr Soh said: "In the 1960s, the policy was about availability. After 1975, it was about reliability, and after 1985, it was about quality and price." Whether the goal was to simply ensure the availability of supply or higher order objectives like reliability, quality and price, it was important to ensure that three key areas in the electricity supply set-up were in place: generation, transmission and distribution.

So the PUB concentrated on getting these basics in tip-top shape.

### STAYING AHEAD OF THE CURVE

After Pasir Panjang A Power Station started generation in 1952, PUB built another four power stations – Pasir Panjang B, Jurong, Senoko and Pulau Seraya. Constant improvements in technology changed the way each new station generated and controlled power.

Jurong Power Station was officially opened on 7 August 1970 by then Minister for Finance, Dr Goh Keng Swee. In his opening speech, Dr Goh said: "The opening of this handsome new power station comes at a time when economic expansion is much in evidence in Singapore. But it was planned when such evidence was less demonstratable. As you know, it takes some five years between conception and commissioning of a power station. It is no mean feat to make correct five-year forecasts in Singapore and no small nerve to commit a few hundred million dollars on the basis of one's judgement."

Indeed, the planners had to have "no small nerve". Even before the official opening

## Preventing System Collapses

All electrical engineers dread a system collapse, which refers to a total blackout. “Think of the electrical system,” said transmission engineer Teo Heng Lam, “as a human pyramid with 10 men forming the base. Should five men suddenly jump on top of the pyramid, it will collapse if any of the 10 men at the bottom cannot hold up the unexpected weight. However, if the five men can be thrown off the pyramid quickly, the 10 men at the base of the pyramid might still recover and the pyramid will hold up. Now think of the 10 men as power stations at one end of the electrical system, the five men as electrical faults, and the collapse of the pyramid as a ‘system collapse’. The act of throwing the five men off the pyramid is how protective relays prevent the electrical system from collapsing.”

Protective relays operate at high speed, correcting faults within short periods of time ranging from 20 milliseconds to half a second. Said Mr Teo in a *PUB Digest* article published in the 1980s: “It is an inherent nature of all electrical power systems that they are very sensitive to faults, especially in the transmission network near generating stations. If a fault in the 66 kV or 230 kV system is not cleared within a short time, of about half a second or less, the generators will spin out of step with one another, that is, they will not be running synchronously, and the dreaded event in the Electricity Department’s terminology called ‘System Collapse’ or total blackout could occur.”



Keeping the electrical system humming along with little margin of error.





of Jurong Power Station, a planning team was already looking at another power station at Senoko.

Between 1971 and 1972, demand shot up by more than 20 per cent. PUB had to react swiftly to a sudden increase in demand, prompting the installation of two 20 MW outdoor gas turbine sets at Senoko in 1972, even before the completion of Senoko Power Station. Although more expensive to operate than steam turbine plants, these outdoor generation sets served as “black start units” for Senoko Power Station in the late 1970s and 1980s and were also very useful standby generators. Singapore’s “grand dame”, St James Power Station, had an installed capacity of six 6 MW and two 11 MW gas turbines, commissioned between 1960 and 1964, and this remained until the station’s “retirement” in 1983.

The pressure on electricity supply at the start of the 1970s was alleviated several years later when the Senoko Power Station was officially opened by then Minister for Foreign Affairs, S. Rajaratnam, on 31 July 1977. With a generation capacity of 1,610 MW when fully completed in 1983, it became one of the largest power stations in the region.

As Senoko took over more of the power generation in the late 1970s, St James and Pasir Panjang A Power Station became the “standby generators” and were eventually decommissioned by 1983.

Even so, the stations were not a complete write-off. Shum Siew Keong, who was in charge of the decommissioning of St James and Pasir Panjang A Power Station, recalled that a businessman from Indonesia bought the equipment in the two power stations to run his Sumatra steel mill because it was faster than buying and installing new generation sets from outside Asia.

The decision to build a power plant on Pulau Seraya was made as early as 1979, said Loh Weng Whye who was involved in the project planning at that time and subsequently in charge of the project management and commissioning of Pulau Seraya Power Station. Pulau Seraya, a small island south of Singapore, became home to the country’s first offshore power station in 1988, with three 250 MW generating steam plants as the first of the three stages of the power station. Pulau Seraya was one of the seven islands which were later merged to form Jurong Island. The other islands were Pulau Ayer Merbau, Pulau Merlimau, Pulau Pesek, Pulau Pesek Kecil, Pulau Sakra and Pulau Ayer

## Small Parts Make a Difference

In October 1976, there was an island-wide power failure triggered by the sudden failure of a 120 MW generator. All generators except Pasir Panjang A Power Station were down. This led to the installation of under-frequency alarms in the Load Despatch Centre to alert the Duty Engineer when system frequencies fell below certain ranges. Load was then automatically shed in pre-determined steps. A manually-operated bulk load-shedding switch allowed the Duty Engineer to quickly shed load from the system with the push of a button.

In 1978, there was an hour-long blackout around Orchard Road caused by a defective component in the switchgear. As similar explosions from that particular brand of switchgear had occurred before, the manufacturer was asked to replace all such components in use. This goes to show that equipment produced for different climates does not always stand up to the test of Singapore's high humidity and heat.



Averting power failure as Singapore shifted to higher gears.



**“The decision to build a power plant on Pulau Seraya was made as early as 1979.”**

Head of Generation Projects Loh Weng Whye was in charge of the project management of Pulau Seraya Power Station, Singapore’s first offshore power station.

Chawan. Reclamation work on the sea between the seven islands started in 1995 and was completed in 2009. Today, Jurong Island is home to chemical and petrochemical plants and facilities of many of the world’s leading companies.

In keeping with its pattern of anticipating needs before they were felt, the PUB announced plans in 1992 to build Tuas Power Station, even as more generators were being added to Pulau Seraya Power Station.

Preliminary work on Tuas started in 1993 as a PUB project and was built in two stages. But in October 1995, a new company, Tuas Power Pte Ltd, took over its development. When the station was fully completed in 2005, it had a total generation capacity of 2,670 MW. This would be the start of a new phase of power station investment, leading up to the privatisation of power generation and the split between supply and distribution of electricity.

### **ENSURING A RELIABLE SUPPLY**

An adequate supply of power is only as good as the reliability of the transmission and distribution network, made up of substations and power cables. The 1960s saw a rapid development of Singapore’s transmission and distribution system.

Electricity cables were either buried underground or hung overhead in the 1960s, the former being more expensive. An engineer who argued for the more expensive underground cables was former Chief Electrical Engineer, Lawrence Estrop, who had seen untidy overhead cables in many cities. He recalled: “No doubt, underground cables are expensive but the city looks neater. I told the Board: ‘One day you will thank me!’”



***Between 1971 and 1972, demand shot up by more than 20 per cent. PUB had to react swiftly to a sudden increase in demand, prompting the installation of two 20 MW outdoor gas turbine sets at Senoko in 1972, even before the completion of Senoko Power Station.***

During the post-World War II reconstruction, cables in the city went underground completely but overhead lines remained in rural areas in the 1970s. As the Housing and Development Board (HDB) built its estates, underground cables replaced overhead lines.

Today, a small number of overhead lines can still be seen in Singapore in older private housing estates such as Opera Estate and Serangoon Gardens. Engineer Soh Siew Cheong recalled: “In the 1990s, we wanted to take out the overhead lines but we had big problems. To convert to the present day scheme of underground cables, we have to lay cables in the main road, and then bring the cable into the house. Now imagine, we would have to cut through the garden, cut through the floor in the hall, cut through everything to get supply to the kitchen. Nobody is going to let us hack up their nice floors. So even though we wanted to bury everything, we could not.”

#### **CABLES ALMOST EVERYWHERE**

Mapping cables is imperative to preventing cable damage. With more road construction and housing development taking place from the 1970s onwards, underground hidden cables began posing unforeseen problems. Whereas earthworks in the earlier days were done mostly with manual labour using changkols or hoes – what the daily-rated employees called the “long pencil” – by the 1970s, increasingly bigger and more powerful excavators were used instead for earthworks and these dug deeper and faster than the changkols of old, causing damage to the underground electricity cables.

Engineer Lim Loo Cheong recalled that his cable-laying team had a surveyor whose job was to mark out where the new roads would go. In the early years, above-ground markers







**“Our cables are buried. With so many development projects taking place, digging has for many years been a favourite pastime in Singapore. Put the two together and we have disasters waiting to happen. They did.”**

Khoo Chin Hean, former Chief Executive of EMA, looks back to 1976 when damaged cables and power failures cost hundreds of thousands of dollars.

were used to record the position of the underground cables, but this soon proved problematic. Said Mr Lim: “Every time you laid a cable, the surveyor would record the location from the nearest coconut tree or the fire hydrant. Five or 10 years down the line, the fire hydrant is moved, the coconut tree has been chopped down, how do you find your cable?”

Some omissions and delays stemmed partly from the sheer volume of changes and insufficient skilled manpower. Engineer Teo Heng Lam from Transmission and Distribution recalled: “During the 1970s, when the cables were laid, we would call the draughtsman a few days later. The draughtsman would come and he would plot it and later on, he would go back and draw it on the maps. Sometimes, the information did not get into the maps for one reason or another.”

Khoo Chin Hean, former Chief Executive of EMA, foresaw another problem. Speaking at an event in 2002, he said: “One source of voltage dips in Singapore had been cable damage. Our cables are buried. With so many development projects taking place, digging has for many years been a favourite pastime in Singapore. Put the two together and we have disasters waiting to happen. They did.”

Damage to electricity cables during contractors’ earthworks hit a record in 1976 with 509 cases of high-tension cables damaged; about a third of major power failures that year arose from such damage and caused hundreds of thousands of dollars in losses.

At first, the Department issued only warnings to contractors found responsible for such damage and, in some cases, made them attend lectures conducted by their engineers on how to avoid such damage. When warnings and talks failed to get results, in 1979, the Board began fining recalcitrant contractors for damaging public property.





## Collecting Payment

Before the age of electronic bank transfers, households paid their utilities bills in cash at bill collection centres. In the 1960s, few people had bank savings accounts, and even fewer had chequing accounts. In 1971, to avoid the monthly crush at its bill collecting centres, the PUB worked out an arrangement for certain banks to collect payment on its behalf. In 1974, the Post Office Savings Bank (POSB) introduced the GIRO system as a pilot project with the PUB. Some 2,000 consumers signed up to pay their utilities bills via GIRO deductions. It was so successful that the GIRO scheme was subsequently extended to include payment for other government services. The scheme was later opened to other banks and was no longer restricted to payment for government services. In 1993, consumers who chose not to enroll into the GIRO scheme could pay their bills at post offices.

House to house: a meter reader dutifully recording electricity, gas and water usage.

## Singapore's First Water Desalination Plant

The first sea water desalination plant was an Electricity Department project. Installed on Pulau Seraya to provide an alternative source of water for boiler feed for the power station, the plant started in 1987. The \$4.7 million plant used reverse osmosis which was then a relatively new technology, said Ong Liong Chuan, a chemist with the Laboratory Services Division, who was based at the power station at that time. When the Seraya desalination plant was commissioned, there were only 1,330 reverse osmosis plants worldwide, he said in a *PUB Digest* article. The plant had been installed as back-up in case of disruption of the town water supply. There was actually very little call for this alternative supply and so the plant served as good training for staff who were later incorporated into the Water Department's desalinated water project.



Staff gathered for a shot at Singapore's first desalination plant.



**“When the Seraya desalination plant was commissioned, there were only 1,330 reverse osmosis plants worldwide.”**

Ong Liong Chuan, a chemist with the Laboratory Services Division, delves into seawater desalination in *PUB Digest*.

The punitive measures achieved results. In 1985, the number of cases of cable damage by contractors' excavation works showed a drop for the first time since the 1970s.

Another reason for the decline in cable damage was because the mapping system of these networks of cables and pipelines had made a quantum leap to a computerised system the year before. Accessing the information in these maps thus became easier.

### **CROSSING THE SEA**

Carrying electricity from generator to end-users sometimes involved elaborate undersea operations. In 1969, the Electricity Department undertook a multi-million-dollar project to lay undersea cables from Pasir Panjang B Power Station on the mainland to the oil refinery on Pulau Ayer Chawan.

The Pulau Ayer Chawan submarine cable project was said to be one of the largest of its kind in the world at the time. It involved 132 kilometres of conventional submarine cables in the sea from the island to the mainland, and some 27 kilometres of underground cables on the island and on the mainland to the Pasir Panjang power station.

Then in the mid-1980s, a submarine cable tunnel was built at the offshore Seraya power station at about 20 metres below sea level. With a terminal building at either end, the tunnel was designed to hold transmission cables as well as the alternative potable water supply for the power station.

Cables were laid inside the tunnel, which had tracks for two battery-operated maintenance vehicles to carry workers and maintenance equipment – this was operational before the days of the Mass Rapid Transit. Michael Khor, Deputy Chief Electrical









**“In 1968, we realised that 66 kV would soon be inadequate to meet demand. One school of thought was to step up to 132 kV or 175 kV, both British practices. We broke away and adapted 230 kV, the international practice.”**

Michael Khor, Deputy Chief Electrical Engineer, revisits the decision to reduce the loss of power over long distances.

Engineer responsible for the submarine cable tunnel project, recalled: “At the time, this was a novel idea.” The 2.6 kilometre submarine tunnel took between May 1985 and September 1986 to build, and cost \$81 million.

Former PUB Chairman Lee Ek Tieng recalled that using this tunnel saved millions of dollars, which was what it would have cost if a company had been engaged to lay conventional undersea cables.

### **JOURNEY OF THE TRANSFORMERS**

With the building of more generation capacity, transmission voltage also went up, mainly to reduce the loss of power over longer distances. Said Michael Khor: “66 kV transmission was introduced in 1965. In 1968, we realised that 66 kV would soon be inadequate to meet demand. One school of thought was to step up to 132 kV or 175 kV, both British practices. We broke away and adopted 230 kV, the international practice. We have no regrets, as it lasted us till 1993 when we adopted 400 kV.”

Planning and the start of work on the new 230 kV transmission system took place in 1972. During the initial stages of implementation, officers involved faced some challenges, especially in transporting the new transformers for the 230 kV substations to the site. Unlike the earlier smaller transformers for the 66 kV network, the new transformers weighed about 150 to 200 tonnes and needed a 200-tonne crane to lift them from the ship.

Trial runs had to be done. A civil engineer was needed to survey the route and check the height of overhead bridges along the way. Some road bridges, for example near Whitley Road at Wayang Satu, had to be reinforced because they were not designed for

that kind of load. Once the plan was worked out, the Traffic Police was needed to clear the road and guide the move, which usually took place slowly and late at night when there was less traffic.

Engineer Teo Heng Lam, who worked on setting up the 230 kV system, recalled: “Once, we were bringing a transformer up from Pasir Panjang along Cantonment Road. There was this overhead bridge which the trailer had to go under. Some of us were up on this overhead bridge supervising when suddenly, we heard this creaking sound and the whole bridge started to shudder. We quickly scuttled down the bridge. We were wondering how it couldn’t pass under. We had measured the heights and everything looked okay.

“Then we realised that the trailer was going up a slight slope. When we measured the bridge it was okay, but the slope reduced the height by just an inch. To get the trailer under the bridge, the men were quite ingenious. I think the trailer had 48 tyres and they calculated that if you lower the pressure a little bit and let the tyres sink, you can go under!”

### ENHANCING THE NERVE CENTRE

Transmission and distribution are vital to maintaining electricity supply. Up till the 1960s, operation of the electricity network was carried out manually on-site, and this meant that problematic equipment in unmanned substations could go undetected until a serious fault developed.

Engineer Chang Meng Teng recalled: “In those days, we had a drawing of the network. This was a big drawing that you had to carry with you when you went out to attend to a fault. We were told when we first joined: ‘This is the source. This is the cut. This is the substation. When something happens, this is where you must cut, this is how to make the changeover’.

“So in the early days, we needed a lot of people because it was all manual. They had to run down to all the substations if anything happened. And our substations are all over Singapore.”

In 1979, the PUB introduced computerised control with a new energy management system at the Ayer Rajah substation. Called SCADA, short for Supervisory Control and Data Acquisition System, it enabled the remote control and monitoring of the networks.







## What to Do During a Blackout

- Turn off all power switches but leave a couple of lights turned on so that you know when power is restored.
- Turn on a battery-powered radio to keep yourself posted on the progress of supply restoration.
- Keep the refrigerator closed to keep the temperature cool and slow down thawing of frozen food. Unopened refrigerators will keep food frozen for several hours.
- Do not turn on power guzzlers such as the air-conditioner or water heater and other non-essential appliances the moment power is restored. If all households turn on such appliances at the same time, the sudden surge in demand can trip the system again and cause another blackout.
- When trapped in a lift, stay calm, press the alarm button in the lift and wait for assistance to arrive.
- Do not attempt to rescue person(s) trapped in lifts but instead call the Emergency Maintenance Service Unit (EMSU) as they are trained and possess proper equipment for such rescues.
- Do not call the Singapore Civil Defence Force/Police hotlines unless there is a life-threatening situation or a need for emergency ambulance services.



Disseminating information in a colourful way.

Today, even more powerful and state-of-the-art systems are used to monitor and control the supply and transmission of electricity. Through such systems, the Power System Operator or PSO (a Division within the Energy Market Authority) effectively coordinates, controls and monitors the operation of Singapore's power stations and transmission substations.

The PSO operates from the Power System Control Centre, which is the nerve centre of the electricity generation and transmission system in Singapore. Disruptions in the system are immediately registered at the Control Centre, and actions can be taken to address the problems. The system is continually being improved to further enhance its response time and effectiveness.

### **SERVING CUSTOMERS BETTER**

Apart from the control system, mechanisation and computerisation of the PUB's other areas of work also led to greater productivity.

For instance, the PUB started to use machines to sort punch cards which were used mainly for financial transactions such as monthly utilities billings. An online Consumer Information System was also introduced in 1979, consisting of 20 computer terminals that allowed customers to help themselves rather than wait for assistance from officers at the counter. Customers were also encouraged to phone in with their queries rather than to queue in person.

Another important gain in productivity was made when the system to map the various electricity and gas cables and pipes was computerised. The computerised system simplified and speeded up the updating of maps when new cables were put in or diverted. This system eliminated the problem of tracking changes and made these maps more accurate.

This was particularly important in the 1980s and into the 1990s, when the Mass Rapid Transit (MRT) system was being constructed and the HDB building programme intensified. The maps were crucial to prevent cable damage during construction and excavation work.

Computerisation in the early years had its share of hiccups. In 2000, Power Supply Ltd implemented a new computerised Customer Management System to replace its old billing system. During the transition period in June of that year, it encountered data



migration problems, resulting in a delay in the generation of utilities bills as well as inaccuracies in billing amounts.

Efforts at that time to address the problems included extending opening hours for the customer service centre to 8 pm and operating an expanded call centre round the clock. In addition, enquiry counters were also set up at 40 community clubs throughout the island and Power Supply provided affected customers with an installment plan to facilitate payment for the delayed utility bills.

By January 2001, 12 per cent of the 1.1 million household customers were still receiving their monthly bills late. In Parliament that month, then Trade and Industry Minister George Yeo said that Power Supply had damaged its reputation with this major glitch. The incident, which he still recalls as “a disaster”, eventually took about two years to resolve completely.

### **SAFETY BECOMES PARAMOUNT**

Safety was another aspect that gained high importance with the increased usage of electricity across the country. In 1967, PUB formed an Inspectorate Division looking into safety and a study was done of the codes and regulations in industrialised countries, to be adapted for Singapore.

Meanwhile, mishaps were not uncommon. Between 1966 and 1987, there were 250 cases of fatal electrical accidents. Earth leakage (EL) circuit breakers greatly helped to reduce the risk of electrocution. First introduced in the mid-1970s, homeowners who had EL circuit breakers installed found themselves learning how to handle the device’s life-saving, but still disruptive, habit of tripping the electricity supply.

Senior Engineer Eng Kwee Chew, who was with the Installations section of the Inspectorate in the late 1970s, recalled phone calls from panicky housewives who found their electricity supply cut off as they were about to bake a Christmas cake or Chinese New Year cookies because the circuit breaker had tripped.

He said: “Members of the public would call with their problem and I had to do some technical detective work. When you don’t use your oven regularly, dampness will set into the electrical components. The heating element may get damp and dirt may have accumulated and that may have caused a higher flow of current and that trips the Earth



**“When you don’t use your oven regularly, dampness will set into the electrical components. The heating element may get damp and dirt may have accumulated and that may have caused a higher flow of current and that trips the Earth Leakage Circuit Breaker.”**

Senior Engineer Eng Kwee Chew recalls, in the late 1970s, phone calls from panicky housewives who found their electricity supply cut off because the circuit breaker had tripped.

Leakage Circuit Breaker. These sorts of calls were quite common before Christmas, Chinese New Year. I could tell them to call their contractor but if I could help over the phone, I tried to help them.”

In 1985, it became mandatory for all new houses and apartments to be fitted with high-sensitivity residual current circuit breakers.

Together with safety campaigns, the number of electrocutions went down. Chief Generation Engineer, Ng Heng Liat, said: “Before 1986, every year we had an average of 12 people dying from electrocution. After that, the figure was brought down to about five. So, we saved about seven lives every year. More significantly, in households, we had about five or six deaths each year. After 1986, the figure was less than one per year.”

Electrical fires were also a big risk. On 21 November 1972, a fire broke out at Robinsons Department Store in Raffles Place. Nine people died in the blaze which started from a short circuit on the first floor of the four-storey building. The fire was so big that flames were reported to be visible from as far away as Jurong and shot up more than 60 metres at one point.

After the fire, the PUB introduced stricter safety regulations which specified that all the lifts must be able to return to the ground floor in the case of a fire, and that the standby generator must kick in to operate the fireman’s lift. In public areas, there must be safety lights that can be switched on in an emergency situation, and staircases and emergency doors must be kept clear of obstacles at all times. PUB also specified that standby generators must be activated within five minutes of any power failure to power essential and critical equipment.



**“Before 1986, every year we had an average of 12 people dying from electrocution. After that, the figure was brought down to about five. So we saved about seven lives every year. More significantly, in households, we had about five or six deaths each year. After 1986, the figure was less than one per year.”**

Chief Generation Engineer Ng Heng Liat touches on a life-and-death issue.

Another consequence of the Robinsons fire was a tougher licensing requirement for all electrical contractors and electricity workers. Previously, anyone doing electrical work could register himself with the Department. It was presumed that only those who knew something about electrical work would want to register.

Engineer Teo Heng Lam recalled: “Before the Robinsons fire, anyone with some technical knowledge could go out and do simple repairs like change fuses, repair irons and fans. Things were definitely more relaxed.”

After the Robinsons fire, the regulations were tightened up. The Electrical Workers and Contractors Licensing Act, Electrical Workers and Contractors Licensing Regulations, Licensed Installations Regulations, Electricity Supply Regulations, and Electricity Regulations were all enacted in 1975. At the end of that year, 756 electrical contractors and 1,456 electrical workers were tested and licensed under the new Act and Regulations.

The Inspectorate also sought to raise the standards of electrical work. In 1984, it introduced a points system to push electrical contractors to raise standards of practice and professional competence. Contractors who were found not complying with the Singapore Code of Practice were given demerit points and repeat offenders could face de-registration.

### **QUALITY OF SUPPLY: THE NEXT FRONTIER**

Once the issues of adequacy, reliability and safety had been addressed, the next dimension was to improve the quality of supply itself.



## Electricity for Traction

After the last electric trolley bus line between Serangoon and Outram was closed in the 1960s, Singapore did not have an electric transport system until the Mass Rapid Transit (MRT) System started operations in 1987.

The three utility departments under PUB – Electricity, Water and Gas – were involved in building the MRT because they had to protect their thousands of kilometres of cables and pipelines from possible damage from the excavation, tunnelling, piling and construction.

The MRT system was set to become one of the biggest consumers of power in Singapore – with most of the power used for moving the trains as well as to power the ventilation, air-conditioning, escalators and lighting, among other features.

Engineer Teo Heng Lam recalled in 2008: “In PUB, there was a special section to handle the few hundreds of diversions from the MRT construction. It’s quite cheap to divert the low voltage cables but if you have to divert the high voltage cables, like the 66 kV ones, it will be quite expensive. If we have to divert the cable, we need to cut the cable and then rejoin the ends. Cable joints are some of the most expensive items. One 230 kV cable joint can cost something like \$200,000, \$300,000. There was one diversion where we helped the Port of Singapore Authority save quite a lot of money when they were expanding the wharf facilities in Pasir Panjang. We decided to try a new method where instead of cutting and rejoining the cables, we manufactured a structure to support the joint for some distance and shifted the whole cable, just like moving a house.”



A case of electricity  
driving progress.

***The Electrical Workers and Contractors Licensing Act, Electrical Workers and Contractors Licensing Regulations, Licensed Installations Regulations, Electricity Supply Regulations, and Electricity Regulations were all enacted in 1975.***

By the 1990s, industries such as shipbuilding, computer building, petrochemicals and pharmaceuticals had moved into using advanced computer control systems. If the voltage for a household drops for a few milliseconds and then recovers, people may see a flicker on their computer screen or not even notice. However, processes heavily reliant on IT and precision equipment are highly sensitive to the quality of electricity supply, and any dip in voltage will be enough to disrupt or “hang” them.

One source of voltage dips in Singapore had been cable damage. Hence, the Electricity Act was enhanced to minimise incidents of cable damage. Contractors were required to inform SP PowerGrid and engage cable detection workers to locate buried cables before any excavation could take place. The enhancements imposed heavier penalties on those who failed to take steps to prevent cable damage. SP PowerGrid also started monitoring closely all earthwork activities and advised contractors on measures to be taken to avoid damaging cables.

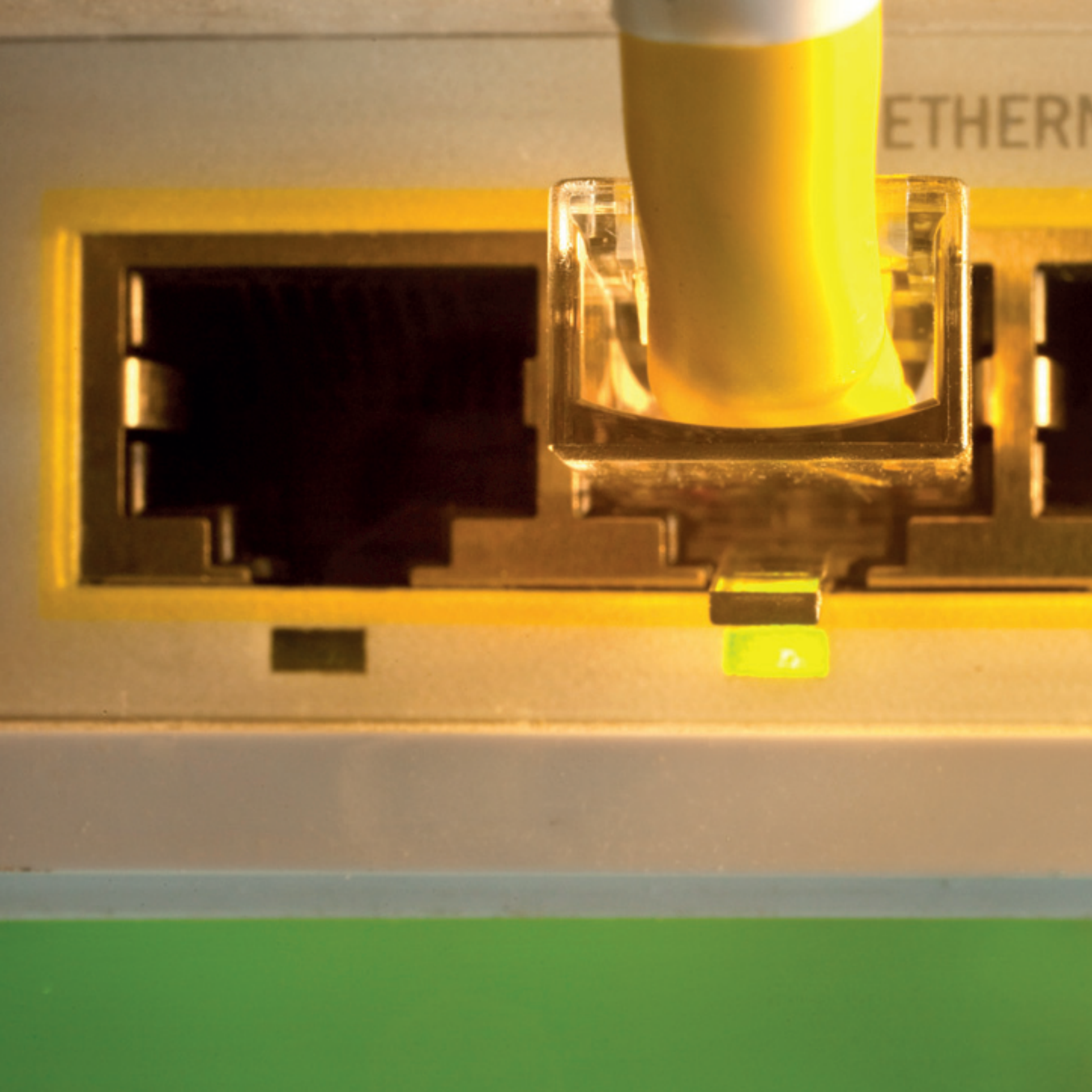
SP PowerGrid put in place a Condition Monitoring System to provide early warning of any impending failure of its transmission and distribution equipment, and underground transmission cable. The system allowed SP PowerGrid to detect incipient faults before they developed into failures that could lead to voltage dips. With the measures in place, the number of dips had fallen from 36 in 1999 to four in 2010.

While measures can be taken to reduce the incidence of voltage dips, such occurrences can never be fully eliminated in any electrical system. Beyond a certain point, measures to reinforce the electricity network will yield diminishing returns in terms of quality of supply, and will lead to increased grid costs to all customers, even those who









are not voltage-sensitive. A more cost-effective solution is to get these voltage-sensitive customers to take measures to protect themselves.

With this in mind, Singapore Power set up a \$150 million Power Quality Solutions scheme in July 2000. Under this scheme, customers received co-funding to invest in solutions that helped improve their power quality.

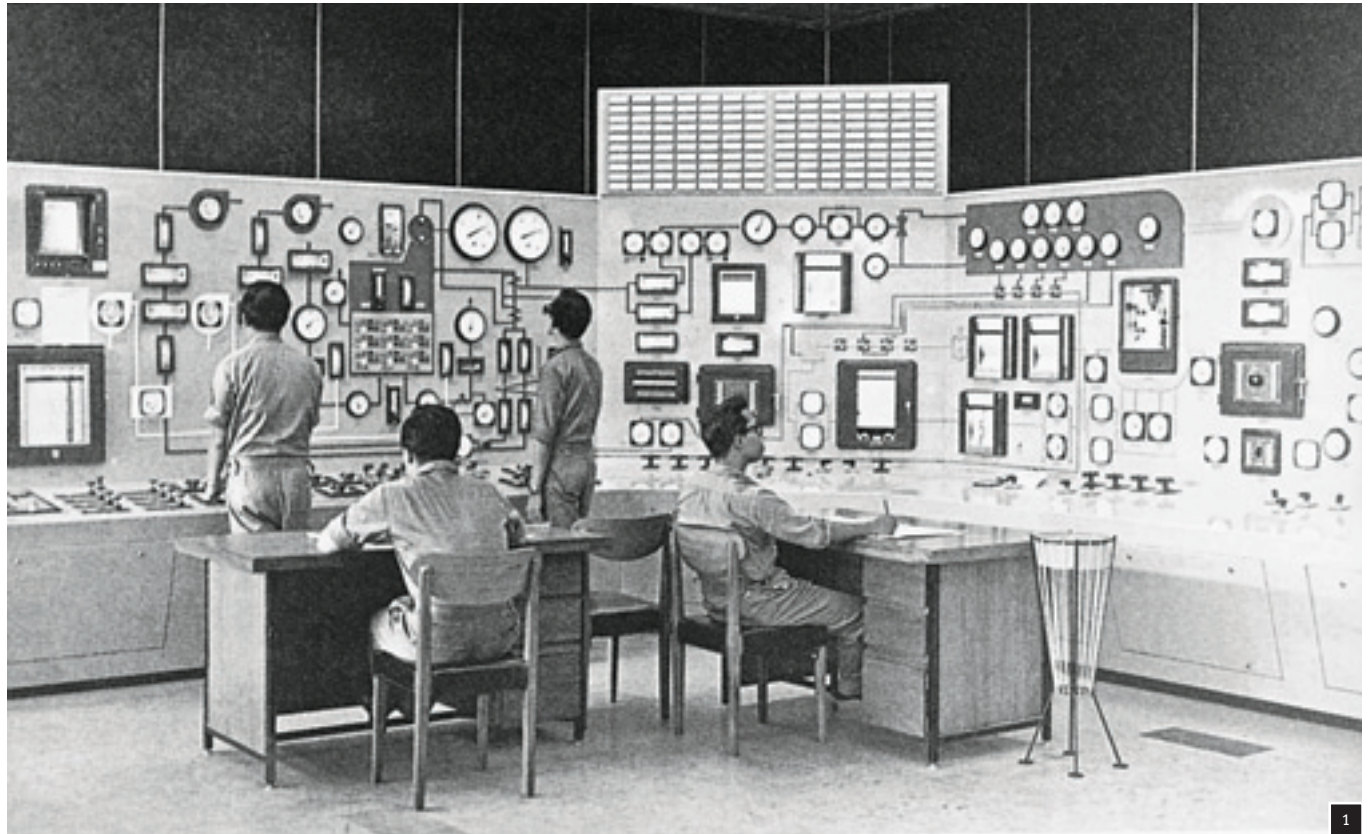
Engineer Soh Siew Cheong recalled that while PowerGrid had a commitment to meet customer needs, the setting up of the scheme made clear that customers also had a role to play in enhancing their own power quality. He said: “If you need a high quality of electricity supply, you have to make improvements to the equipment in your own factory. It is not cost-effective for us to invest in equipment to produce power of such a quality because most of our customers do not need it. The two-year offer put us on moral high ground. The companies also had to show that they were sincere and be willing to put money down.”

The Power Quality Solutions Scheme was in place for two years, but in the end, only \$10 million was spent. Despite the low utilisation rate, the scheme had served its purpose. Complaints about voltage dips soon dissipated. Today, voltage dips are no longer an issue for companies in Singapore. A benchmarking study by PowerGrid showed that the performance of Singapore’s system in terms of the occurrences of voltage dips is among the best in the world.

Such consumer demands reiterated the perennial issue of the right pricing of electricity. These and other concerns were addressed later, on the journey of liberalisation for the electricity market. Key milestones such as the corporatisation of the PUB in late 1995 were to set the stage for the next phase of evolution in Singapore’s electricity sector going into the 21st century.

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1966  
-  
1995



1 A control room in the 1960s.

2 Building a power plant.

3 A power station in the 1990s.

### 1969

- Electricity Department undertook multi-million-dollar project to lay undersea cables from Pasir Panjang B Power Station on the mainland to the oil refinery on Pulau Ayer Chawan.

### 1970

- Jurong Power Station officially opened by the then Minister for Finance, Dr Goh Keng Swee.

### 1972

- Electrical fire broke out at Robinsons Department Store. PUB introduced stricter safety regulations which specified that all lifts must be able to return to the ground floor in the case of a fire and the standby generators must kick in to operate the firemen's lift.



**1975**

- Electrical Workers and Contractors Licensing Act, Electrical Workers and Contractors Licensing Regulations, Licensed Installations Regulations, Electricity Supply Regulations and Electricity Regulations were enacted.

**1977**

- Senoko Power Station was officially opened by then Minister for Foreign Affairs, S. Rajaratnam.

**1979**

- PUB introduced the Supervisory Control and Data Acquisition System (SCADA) for remote control and monitoring of power networks.
- Decision was made to build a power plant on Pulau Seraya.

**1983**

- Senoko Power Station was fully completed with generation capacity of 1,610 MW.
- St James and Pasir Panjang A Power Station was decommissioned.

**1985**

- It became mandatory for all new houses to be fitted with high-sensitivity residual current circuit breakers.

**1988**

- Pulau Seraya became home to the country's first offshore power plant with three 250 MW generating steam plants.

**1992**

- PUB announced plans to build Tuas Power Station.

**1995**

- Electricity and piped gas undertakings of the PUB were corporatised.
- Tuas Power Pte Ltd was formed.



THE

BIG

SWITCH



1996

...

2010









## **THE MARKET OPENS UP**

**SECURITY AND SUSTAINABILITY WERE THE KEYWORDS THAT MARKED THE FIRST CENTURY OF ELECTRICITY IN SINGAPORE. GOING INTO THE 21ST CENTURY AND THE THIRD MILLENNIUM, CHANGE CAME ON “FAST-FORWARD” MODE FOR THIS SECTOR. ■ THE FIRST STEP WAS CORPORATISATION, FOLLOWED BY LIBERALISATION. THE CHANGES, WHILE MAJOR, WERE NOT INTRODUCED AS A “BIG BANG”. THERE WAS CAREFUL THOUGHT AND DELIBERATION BEHIND EACH STAGE OF THE PROCESS.**

## THE LIBERALISATION JOURNEY

The journey towards liberalisation first started when PUB appointed a consultant to look into the feasibility of the privatisation of its electricity and gas undertakings in 1987. This was during a period when other government agencies, in areas such as telecommunications, were also beginning to be corporatised into government-owned companies that would take on more autonomy in their operations.

The initial impetus to open up Singapore's energy sector had come partly from the push factor of high costs of investment in capacity to meet higher demand, and partly from the pull factor of achieving lower tariffs by introducing competition. Deregulation was also seen as a way of promoting more price-responsive consumption behaviour to spread out demand and inject more efficiency into electricity generation.

Shum Siew Keong, a generation engineer at PUB who later in 1995 became managing director of the generation company PowerSeraya, recalled the mood of that time: "The consultants would tell you: 'Too much fat! You must be lean and competitive!'"

And so, with typical Singaporean single-mindedness, the whole electricity sector "went on diet", as it were – the organisational "fat" began to be trimmed, leading up to a privatisation report submitted in 1988. After further study and decision by the government, PUB went ahead with its restructuring to pave the way for the eventual corporatisation of its electricity and piped gas undertakings.

## CORPORATISATION OF PUB

From there, it took a few more years of review and preparation before this phase of Singapore's journey towards liberalisation could be formalised. PUB's electricity and piped gas undertakings were corporatised on 1 October 1995, to introduce competition into the energy market.

With Singapore Power Ltd as the holding company and a wholly-owned subsidiary of Temasek Holdings, the electricity and gas operations of PUB were split into five subsidiary companies: two electricity generation subsidiaries PowerGen (Seraya) Ltd and PowerGen (Senoko) Ltd, an electricity transmission and distribution subsidiary PowerGrid Ltd, an electricity supply and customer services subsidiary Power Supply

## Electricity Generation and Clean Air

Generation of electricity uses a variety of basic fuels: wood, coal, refuse, biomass, fuel oil, diesel oil and gas. All produce pollutants, ranging from waste gas like oxides of sulphur and nitrogen to particulates such as ash, unburnt carbon, grit and dust. In the 1970s, in line with PUB's corporate policy of environmental protection, the power stations took steps to reduce the emission of pollutants. Generation Engineer, Lau Gar Ning, said: "In the old days, you could see dark smoke from the chimneys. After the 1970s, we installed filters called precipitators to arrest the dust. So the smoke became light grey. Now you don't see it because we are using gas. Gas undergoes almost complete combustion."



Controlling pollution in the face of industrialisation.





**“The consultants would tell you: ‘Too much fat! You must be lean and competitive!’”**

Shum Siew Keong, PUB Generation Engineer and subsequent Managing Director of PowerSeraya, reminisces about a cherished ethos.

Ltd, and a gas subsidiary PowerGas Ltd. Prominent businessman Ho Kwon Ping was appointed chairman of the newly-incorporated Singapore Power.

Besides its water authority role, PUB took on the job of regulating as electricity and piped gas industries to achieve its then stated mission: “To ensure that customers continue to enjoy reliable and efficient electricity and piped gas supply at affordable and fair prices.” Another role that PUB kept was its inspectorate function to ensure the safe use of electricity and piped gas.

As former PUB Chairman Lee Ek Tieng said in a 1995 annual report: “This move towards privatisation not only enables the government to lay the groundwork for future distribution of national assets to Singaporeans, it also contributes to Singapore’s participation in regional business opportunities and provides competition in the electricity industry in Singapore, which, in the longer term, will benefit customers with the provision of more flexible and efficient service.”

In December 1996, the PUB issued its Service Standards for Public Licensees, setting out in detail its expectations of the generation and power supply companies. The standards covered aspects such as availability, quality and provision of supply and metering services.

### SHAPING THE MARKET

The first phase of reconstructing PUB’s electricity undertakings effectively split the electricity industry into three sectors.

In the generation sector, power station owners had to compete to sell electricity.





**“This move towards privatisation not only enables the government to lay the groundwork for future distribution of national assets to Singaporeans, it also contributes to Singapore’s participation in regional business opportunities.”**

Former PUB Chairman Lee Ek Tieng extols the merits of privatisation.

The second sector is transmission and distribution, or the “transport service”, generally considered a “natural monopoly”. This was the territory of the power grid, whose job it is to take delivery of power from the power stations through the network of cables to various customers. The last sector of the industry is retailing, to sell electricity to consumers.

To further sharpen the system’s competitiveness, in 1998, the transmission and distribution company, PowerGrid Ltd, taking on the role as the Pool Administrator, started the Singapore Electricity Pool as a wholesale electricity market to facilitate competitive bidding among generation companies.

The Pool commenced operation in April 1998 with PowerSenoko Ltd, PowerSeraya Ltd and Tuas Power Ltd as the generation companies, and with Power Supply Ltd as the only retailer initially. With the breaking up of the electricity industry into three sectors, there was a need to unbundle the costs in the electricity supply value chain. This led to the unbundling of PowerGrid Ltd’s use-of-system charges into three categories: Low Tension (0.4 kV), High Tension (6.6 kV and 22 kV) and Extra High Tension (66 kV and above), and setting the charges to reflect the costs involved and revised tariffs accordingly.

To facilitate the liberalisation process, the Ministry of Trade and Industry (MTI) also learned from similar experiences overseas. Following its study trip to New Zealand in 1996, the eventual market design for Singapore applied learning points from there. Learning points were also picked up from Britain, although the market there is 10 times the size of Singapore’s. PHB Consultants, the New Zealand company involved in the





**“We were acutely aware that we were handling a major undertaking in reforming the whole sector. If this exercise were to fail, a lot of people would be affected.”**

Lee Yuen Hee, then Director of Resource Department at MTI, sheds light on the liberalisation process.

privatisation of the New Zealand electricity market, was then commissioned to review the electricity market framework for Singapore. Lee Yuen Hee, then Director (Resource Development) at MTI from 2000 to 2003, recalled: “We were acutely aware that we were handling a major undertaking in reforming the whole sector. If this exercise were to fail, a lot of people would be affected.”

After the review, PHB Consultants recommended the breakup of the Temasek Holdings-owned Singapore Power, and the retention of the grid by Singapore Power as a monopoly regulated by the government.

### WINNING THE GROUND

The deregulation of the industry was slowly unfolding. In March 2000, then Trade and Industry Minister, George Yeo, announced the government’s decision to further liberalise the electricity and gas industries with greater separation at the ownership level of the contestable and non-contestable businesses. Singapore Power Ltd would divest PowerSeraya Ltd and PowerSenoko Ltd but retain control of PowerGrid Ltd and Power Supply Ltd.

As a politician, Mr Yeo was only too aware of the related challenges of deregulation. He had thought that, as far as change management went, winning the buy-in of members of the Union of Power and Gas Employees (UPAGE) would be tough because of possible retrenchments, but the process turned out instead to be smoother than expected. This was mainly because the union, led by its Executive Secretary, Nithiah Nandan, fully understood what the government was trying to do.

## Divesting the Generation Companies

The long-stated intention to privatise Singapore's power generation companies got off to a good start in March 2008, when Tuas Power, one of the three major gencos, was sold by Temasek Holdings for \$4.2 billion to China Huaneng Group, a leading power company based in Beijing, China. The sale of Tuas Power marked the completion of a competitive and rigorous bidding process which began in October 2007.

At the time of sale, Tuas Power owned businesses in electricity generation, trading and retail services as well as the development and provision of multi-utilities and related services. Its generation assets had a licensed capacity totalling 2,670 MW, comprising 1,200 MW of oil-fired steam plants and 1,470 MW of gas-fired combined cycle plants.

The divestment made by direct sale through tender rather than by public listing (which would have required Temasek to retain some stake) was seen by industry observers as being better able to help meet the objectives of creating a liberalised electricity market in an orderly fashion in phases.

Tuas Power had earlier been carved out of the Public Utilities Board in 1995, and Senoko Power and PowerSeraya from Singapore Power in 2001. Ownership of all three companies was transferred to Temasek, on the understanding that it would eventually divest the companies.

Senoko Power was sold in September 2008 for \$3.6 billion to Lion Power, owned by a Japanese/French consortium comprising Marubeni Corporation, GDF SUEZ S.A., The Kansai Electric Power Co., Inc., Kyushu Electric Power Co., Inc. and Japan Bank for International Cooperation. PowerSeraya was sold in December 2008 for \$3.8 billion to Malaysia's leading power company, YTL Power International Berhad.







Combining efforts and expertise to generate electricity.



## Electricity from Waste

The first incinerator for rubbish was built in Jalan Besar in 1889, with additional ones subsequently built at Tanjong Pagar and Alexandra Road. All the rubbish of the town was burned in the 1920s. The idea of using rubbish as fuel to generate electricity came about in the mid-1970s when the newly-retired Chief Electrical Engineer, Lawrence Estrop, took up a consultancy job at the then Ministry of the Environment to oversee the first incinerator plant to generate electricity. This was the Ulu Pandan Incinerator, which was commissioned in 1979. Subsequently, three incinerator plants to generate electricity were built near the regular power plants: Senoko, Tuas and Tuas South Incineration Plants. In 2009, the Keppel Seghers Tuas Waste-to-Energy Plant (KSTP) came into operation to replace the Ulu Pandan Incineration Plant, which ceased its operations then. In the same year, incineration plants contributed about 2 per cent of existing total capacity.



You don't refuse rubbish when it can generate electricity.

Mr Yeo had offered to speak to union members, but Mr Nandan said no and would handle that task himself. Mr Nandan played the lead role in representing the workforce in these matters, where the livelihood of so many employees was at stake. Among his vital contributions was explaining why the restructuring was necessary for the overall long-term benefit of the whole country. Mr Yeo was very touched by the veteran unionist's sense of duty, responsibility and leadership.

Mr Nandan's leadership continued to be crucial all the way through to the final phase of privatisation. In one of his last acts for the union, Mr Nandan signed a series of agreements, some at his home where he was resting from an illness, including collective agreements with Singapore Power, PowerSeraya and Tuas Power, and a memorandum of understanding with Senoko Power to extend the collective agreement for another three years. The union supported the privatisation exercise for the larger, long-term good, even if there had to be short-term human resource disruptions.

Mr Nandan's pivotal role in this process was also recognised by Prime Minister Lee Hsien Loong who was the Minister for Trade and Industry between 1987 and 1992. When Mr Nandan passed away, PM Lee sent a condolence letter to his wife, in which he wrote: "Nithi... played a pivotal role in rallying workers to support the corporatisation and restructuring of PUB's gas and electricity services. This was a long and complex process, unsettling to both workers and managers, but necessary to make Singapore's infrastructure competitive. Without the union's support and cooperation, the exercise would have been impossible."

## HOW TO UNBLOCK A STALEMATE

The close tripartite relationship between the government, employers and unions was crucial in working out harmonious settlements, especially during this period of structural change.

But union negotiations were not the only issue that needed to be resolved. Dealing with the companies, with their fiercely competing commercial interests, was also a complicated, and sometimes arduous, affair.

In the thick of the action at that time was Yeo Yek Seng, a former PUB engineer who rose to become Deputy Chief Executive of the Energy Market Authority. Debating issues such as the commercial arrangement between PowerGrid Ltd and the generation



**“To enhance economic efficiency through keener competition, attract private investment, produce more accurate price signals to guide production and consumption decisions, spur innovation and widen consumer choice.”**

Jomar Eldoy, a director on the EMC Board, reviews the purpose of introducing market mechanisms into the industry.

companies, the meetings – at the PUB Building in Somerset Road – would at times reach apparent agreement, only for the next meeting to go “right back to square one”.

More than once, Mr Yeo’s perseverance was called for, as was his industry contact base. He recalled one final meeting that started in the afternoon and dragged on until almost 9 pm. The company representatives at the meeting were not CEOs, so he would have these representatives call their CEOs on the phone, speak with the CEOs on the line, and then pass the phones back with the go-ahead. Luckily, many of these CEOs were his former colleagues at the Electricity Department of the old PUB, and he could draw on these longstanding relationships to play this last card to break the deadlock.

### **NEW “REFEREE” EMA IS BORN**

To oversee the further liberalisation of the electricity and gas industries, the Energy Market Authority (EMA) was set up on 1 April 2001. EMA was formed from merging PUB’s regulatory role in energy matters and the power system operation of PowerGrid Ltd.

Speaking in Parliament that year, Peter Chen, then Acting Minister for Trade and Industry, stressed that EMA has to be “a good referee” as well as “a good rule maker”, just like in a game of soccer. He added: “The role of the regulator has... to evolve from one of regulating monopolies to that of regulating competitive markets. In the new regime, EMA will focus on ensuring that there is a good framework for vibrant competitive markets whilst still regulating the monopoly functions of transmission and distribution of electricity and gas.”

At Sembcorp Cogen’s official opening ceremony in November 2001, then Chairman



of EMA, Chiang Chie Foo, said that EMA would “provide the necessary focus to the regulation of the liberalised electricity and gas industries, enhancing competition and maintaining a level playing field”.

The Energy Market Company (EMC) was incorporated in the same year and took over the operation and administration of the electricity market on 1 April 2001. It provides a trading platform for the generation companies to compete in selling electricity. Jomar Eldoy, a director on the EMC Board, recalled that this next stage of introducing market mechanisms into the industry sought to achieve several aims: To enhance economic efficiency through keener competition, attract private investment, produce more accurate price signals to guide production and consumption decisions, spur innovation and widen consumer choice.

### THE “DASH FOR GAS”

In the search for a more competitive and secure way of generating electricity, the math was simple – electricity generated by gas was 10 per cent cheaper than electricity generated using fuel oil.

What sparked the “dash for gas”, the country’s move into natural gas in such a big way and at such speed, were developments in the chemical industry in Singapore, recalled Tan Suan Swee, Managing Director, Investment, at Temasek Holdings since 2003. Previously Assistant Managing Director at the Economic Development Board where he worked for 16 years, he oversaw the investment project that first expanded Singapore’s natural gas supply sources from Malaysia to Indonesia.

In the mid-1990s, when the promotion of Jurong Island as a home for the world’s chemical and petrochemical companies was well underway, the German chemicals company BASF was keen on a project requiring natural gas. Natural gas is the “lifeblood” of the chemical industry, for feedstock and for the cost-effective “embedded generation” of electricity in-house in the chemical plants themselves.

BASF required less than 30 million standard cubic feet per day (mmscfd) of natural gas. However, the usual natural gas contract quantity needed to be around 350 mmscfd for the investment in infrastructure to be viable.

To make the deal with West Natuna in Indonesia happen, there was thus a need





**“In the search for a more competitive and secure way of generating electricity, the math was simple – electricity generated by gas was 10 per cent cheaper than electricity.”**

Managing Director of Investment at Temasek Holdings,  
Tan Suan Swee, on the “dash for gas”.

to “line up” enough demand in the electricity sector too. Mr Tan reckoned that the generation company Sembcorp Cogen was ready to take on some 110 mmscfd. The key was to convince Tuas Power to switch to natural gas for another 150 mmscfd, and also be willing to strand its existing oil-powered steam plants. Persuading Tuas Power took some effort, but once done, the deal was on.

The supply, over 650 km of pipeline, would be worth US\$12 billion for 325 mmscfd of natural gas over 27 years. Terms were first agreed upon broadly in 1997, finalised in 1999, and the building completed remarkably quickly, all less than two years later in January 2001, when Sembcorp Gas started importing the gas for the generation companies and industrial consumers.

While this was Singapore’s second source of natural gas (Singapore first started importing natural gas from Malaysia in 1992 solely for power generation in Senoko Power Station), it marked the first import of natural gas for sale to gas consumers in Singapore.

Following the success of this deal, Singapore’s third source of gas, and the second deal from Indonesia (this time from South Sumatra), was agreed upon in 1999, the agreement signed in February 2001 and building completed in August 2003.

Wong Toon Suan, President of the Gas Association of Singapore who was then Managing Director of PowerGas, worked on this project. He recalled that apart from managing the impact of the political changes, there were two other challenges – working out the market restructuring ahead of time to suit a new regulatory framework for Singapore’s energy market, and the building of staff capability.

The satisfaction of working on this deal, Mr Wong added, was in the knowledge





**“Apart from managing the impact of the political changes, there were two challenges: working out the market restructuring ahead of time to suit a new regulatory framework for Singapore’s energy market; and the building of staff capability.”**

Wong Toon Suan, President of the Gas Association of Singapore, was then Managing Director of PowerGas.

that bringing in natural gas played a key role in supporting the efficiency of the whole restructured and liberalised power market.

For the generation companies, the surge in converting from oil-fired steam sets to more efficient combined-cycle gas turbine plants led to the “dash for gas”.

The next challenge for the gas market was settling disagreements among commercial players. It took from 2000 to 2008 to develop and implement a regulatory framework for the new gas market. Under the new gas industry structure, PowerGas would own and operate the gas pipeline networks in Singapore.

As part of the gas industry restructuring, SembGas was required to transfer its gas pipeline assets to PowerGas. Despite years of negotiation, both parties were unable to agree on the terms of the transfer until the Minister for Trade and Industry, Lim Hng Kiang, had to step in to determine the terms in 2008.

The Gas Network Code, developed by EMA in consultation with industry players, came into effect in September 2008. The Code outlines the use and operation of the gas pipeline network, enabling open and non-discriminatory access to the gas pipeline network.

## **BOOSTING CONSUMER CHOICE**

Contestability, or consumer choice, was implemented in three phases to ensure a smooth transition. About 250 consumers with electricity demand of 2 MW and above became contestable in July 2001 and could choose which supplier to buy their electricity from. These were very large industrial and commercial consumers which together represented 40 per cent of total electricity demand.

Another 5,000 consumers with an average monthly electricity consumption of above 20,000 kWh became contestable starting June 2003. These were large industrial and commercial consumers representing 30 per cent of total demand.

The next 5,000 large industrial and commercial consumers with an average monthly consumption of 10,000 kWh and above became contestable between December 2003 and mid-2004. They represented 5 per cent of total demand.

By 2006, 75 per cent of Singapore's total electricity demand had been opened to competition. What remained was the 25 per cent of the market still to be opened up – comprising mostly households and small businesses.

Progress towards full retail competition for this segment of consumers has been difficult thus far because of the high costs of servicing small accounts.

Soh Siew Cheong, the first managing director of the electricity grid owner and operator, PowerGrid Ltd, and later Senior Advisor at EMA, described it in this way: “The big consumers can buy on the open market from the retailers but for the small consumers to buy electricity from the open market will be a chore.”

This was why SP Services Ltd (formerly known as Power Supply Ltd) took on the role to provide this service for small consumers. It opens accounts, does meter readings, computes bills and bills customers.

SP Services used this role to re-establish its reputation as a reliable and customer-oriented service provider. It learned from the crisis in 2000 and worked hard to reach the top ranks in benchmarking studies on service-level performance among major global utilities. The service achievement was affirmed through a 2009 global survey of expatriates living in Singapore who rated the city-state tops in ease of setting up a household utilities supply.

### **SOME EARLY HITCHES**

Despite all the best efforts, the early years of liberalisation were not without a few setbacks. For example, there were data migration problems when replacing a billing system and these took a long while to put right. There were also occasional blackouts and contention over the setting of electricity tariffs.

The major trigger to ramping up Singapore's energy security was the severe blackout of 29 June 2004. A valve at the gas receiving station operated by ConocoPhillips had

# World Ranking for Quality of Supply

In the Swiss-based World Economic Forum’s 1990 Global Competitiveness Report, PUB was rated as having the best power supply infrastructure in the world, a ranking it kept till 1995 with a rating of 9.58. Its rating reached a peak score of 9.8 out of 10 in 1993. In the 2010/11 Global Competitiveness Report, Singapore’s quality of electricity supply was ranked 9th.

GLOBAL COMPETITIVENESS REPORT  
2010-2011  
Quality of Electricity Supply

| RANK | COUNTRY       |
|------|---------------|
| 1    | Hong Kong SAR |
| 2    | Iceland       |
| 3    | Denmark       |
| 4    | Finland       |
| 5    | Japan         |
| 6    | Germany       |
| 7    | Switzerland   |
| 8    | Austria       |
| 9    | Singapore     |
| 10   | France        |

2010 World Economic Forum



Reliable power supply: up there in world ranking.





**“The big consumers can buy on the open market from the retailers but for the small consumers to buy electricity from the open market will be a chore.”**

Soh Siew Cheong, former Managing Director of PowerGrid Ltd and Senior Advisor at EMA, describes the dynamics of full retail competition.

shut and the natural gas supply from West Natuna, Indonesia, was disrupted. This caused five units of the combined-cycle gas turbines at Tuas Power, PowerSeraya and Sembcorp Cogen to trip and about 300,000 consumers to lose their electricity supply for up to one-and-a-half hours.

Following this incident, an Energy System Review Committee was set up. It made recommendations aimed at improving the reliability of energy supply. This included enhancing procedures for power stations to hot-switch from gas to diesel in the event of a gas supply disruption. The power stations had to continuously monitor the valves at the gas-receiving facilities and immediately commence hot-switching in the event of a valve trip to ensure that they could switch from gas to diesel before the remaining gas in the pipelines ran out.

It was this hot-switch capability that saved the day on 4 November 2008. Natural gas supply from West Natuna was disrupted due to a lightning strike on the gas-receiving facility. Fortunately, a major blackout was averted with the timely hot-switch to the backup diesel for power generation.

### **TARIFFS, FUEL PRICES AND CONSUMPTION**

Ever since a public electricity supply became available, pricing has always been a contentious and difficult issue. Up till 1965, the tariff structure was such that households paid higher tariffs than industrial consumers.

In 1972, the Public Utilities (Tariffs for Electricity) Regulations were instituted to include a fuel price adjustment element for power consumers for the first time.



***Contestability, or consumer choice, was implemented in three phases to ensure a smooth transition. About 250 consumers with electricity demand of 2 MW and above became contestable in July 2001 and could choose which supplier to buy their electricity from.***

Later in 1982, PUB introduced the system of calculating and adjusting tariffs on a quarterly basis. This system replaced the annual revision as it was felt that smaller incremental increases would have a less severe impact on consumers.

Speaking in Parliament in October 2002, then Trade and Industry Minister, George Yeo, explained: “Electricity prices in Singapore are unlikely to be cheaper in absolute terms than in the neighbouring countries because of certain structural characteristics that are unique to a city-state like ours.”

Trade and Industry Minister, Lim Hng Kiang, said at EMA’s “Plugging into Singapore” forum in 2006: “With no natural fuel resources of our own, we are exposed to the ups and downs of the global fuel market. We have no choice but to buy all the fuel that we need. In short, we are a price taker for energy.”

Also, Singapore depended on gas for electricity generation, unlike other countries which have access to cheaper sources such as hydroelectricity. In line with the market practice in the region, the price of gas was tied by long-term contracts to the fuel oil price.

In 2004, a tariff formula was put in place such that the fuel cost component of electricity tariffs for each quarter was established using the average fuel oil price of the first month in the previous quarter. For example, the tariff for October to December 2004 would be based on the average price of fuel oil in July 2004. This formula provided relative certainty and stability in an era of less volatile oil prices.

However, no one could have predicted what happened in 2008. In July, the oil price spiked to its record peak of \$155 per barrel. As a result, the electricity tariff shot up by



***The three large generation companies, Senoko Power, PowerSeraya and Tuas Power, together supply about 80 per cent of Singapore's electricity demand. There is a risk that these companies can exercise market power to drive prices up by withholding supply.***

22 per cent in the fourth quarter of 2008. By then, however, the oil price had started to come down.

Subsequently in July 2009, EMA tweaked the formula and introduced a new system. The fuel cost component of the tariff for each quarter would be pegged to the average fuel oil price in the previous quarter and not just the first month in the previous quarter. The objective was to use more current oil price data to determine the tariff, and thus minimise the likelihood of situations where the oil price and electricity tariff moved in different directions.

### **REINING IN MARKET POWER**

In a further move to fine-tune the market, vesting contracts were introduced on 1 January 2004 to rein in the market power of generation companies.

The three large generation companies, Senoko Power, PowerSeraya and Tuas Power, together supply about 80 per cent of Singapore's electricity demand. There is a risk that these companies can exercise market power to drive prices up by withholding supply. Conversely, these companies may also drive prices down to such low levels that would not attract new generation companies to invest in new power plants.

Vesting contracts are bilateral electricity contracts between generation companies and SP Services, and place an obligation on the companies to sell a specified minimum quantity of electricity at a vesting price, reviewed by EMA every two years.

The vesting contracts were imposed on the three big generation companies to remove the incentive for them to exercise their market power by manipulating generation



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R80







capacity. The smaller generation companies which were already licensed – Sembcorp Cogen, Keppel Merlimau Cogen and Island Power Company – were given the option to take up vesting contracts.

### **KEEPING OPTIONS OPEN**

Looking back on the heady early days of deregulation, Khoo Chin Hean, former Chief Executive of PUB and EMA, and now CEO of OpenNet, saw infrastructure as the key factor in managing electricity supply. “The cost is very lumpy,” he said, noting that any investment decision is something that has to be lived with for the next 20 to 50 years.

As Singapore sustains its search for security and sustainability in sourcing for energy, the key is to keep all options open, even more so than in decades past.



1996  
-  
2010



1

- 1 Lighting up the streets.
- 2 A small but powerful success story.
- 3 Tending a gas-receiving facility in Singapore.
- 4 Regularly maintaining our street lights.

1996

- PUB issued the Service Standards for Public Licensees, setting out in detail its expectations of the generation and power supply companies.

1998

- PowerGrid Ltd started the Singapore Electricity Pool.



2

|                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                         |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p><b>2000</b></p> <ul style="list-style-type: none"><li>■ Then Trade and Industry Minister George Yeo announced the government’s decision to further liberalise the electricity and gas industries.</li></ul> | <p><b>2001</b></p> <ul style="list-style-type: none"><li>■ Sembcorp Gas started importing gas from Indonesia.</li><li>■ Energy Market Authority was set up on 1 April.</li><li>■ Energy Market Company was formed and took over the operation and administration of the electricity market.</li><li>■ About 250 companies with electricity demand of 2 MW and above became contestable consumers.</li></ul> |  <div>3</div>                                                                                                                                                                        |
|  <div>4</div>                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                             | <p><b>2004</b></p> <ul style="list-style-type: none"><li>■ Vesting contracts were introduced.</li><li>■ A blackout occurred on 29 June, which caused about 300,000 consumers to lose their electricity supply for up to one-and-a-half hours.</li></ul>                 |
|                                                                                                                                                                                                                | <p><b>2006</b></p> <ul style="list-style-type: none"><li>■ Large consumers comprising business and industries, which formed 75 per cent of total electricity demand, became contestable.</li></ul>                                                                                                                                                                                                          | <p><b>2009</b></p> <ul style="list-style-type: none"><li>■ EMA introduced a new system of pegging the fuel cost component of electricity tariffs to the average fuel oil prices in the previous quarter and not just the first month in the previous quarter.</li></ul> |





BOUNDBLES

REPAIR

2017 AND BEYOND









## **THE RACE CONTINUES**

**AS THE WORLD CONFRONTS THE TWIN ISSUES OF DECLINING FOSSIL FUEL SUPPLIES AND CLIMATE CHANGE, SINGAPORE IS READYING ITSELF FOR A NEW ENERGY FUTURE. DELIVERING THE SINGAPORE ENERGY LECTURE IN NOVEMBER 2010, PRIME MINISTER LEE HSIEN LOONG SAID: “IN SINGAPORE, WE ARE PREPARING OURSELVES FOR A NEW ENERGY FUTURE. THE UNCERTAINTIES ARE MAJOR AND THERE ARE THREE QUESTIONS WHICH WE ASK OURSELVES: WILL FUTURE ENERGY PRICES RISE SIGNIFICANTLY? WHAT WILL BE THE GLOBAL REGIME ON CLIMATE CHANGE? AND WHAT NEW TECHNOLOGIES WILL EMERGE?”**



## TOWARDS A SUSTAINABLE FUTURE

The key national energy objectives focus on the challenge termed by EMA as “the energy trilemma”: how to have energy that is competitive, secure and sustainable at the same time. In response, Singapore is investing in knowledge and capabilities to build a smart energy economy – one that is innovative, resilient and sustainable. Singapore is also developing a long-term masterplan to guide the evolution of its energy landscape, based on three strategies.

The first strategy for Singapore is to continue to promote competitive markets and apply economic principles to influence corporate and consumer behaviour, achieve efficient outcomes and tackle issues such as energy efficiency and carbon emissions. The second strategy is to diversify Singapore’s energy supplies, secure access to resources and provide safeguards against supply disruptions. The third strategy is to develop a dynamic energy sector, focusing on the development and test-bedding of energy technologies and promoting the growth of energy businesses in Singapore.

## LIBERALISATION’S OUTCOMES AND BENEFITS

A decade on, what outcomes has a liberalised electricity market produced? The evidence so far suggests that market competition is working. Since the liberalisation of the electricity market, the price of fuel oil has increased by 196 per cent from April 2001 to April 2011. In comparison, the tariff for households has increased by just 29 per cent.

This has been mainly due to higher operational efficiencies in the power sector and keen market competition among the power companies here. Competition has strengthened following the government’s divestment of the big three generation companies to new foreign owners: PowerSeraya (under Malaysia’s YTL Power), Tuas Power (owned by China Huaneng) and Senoko Power (under Japanese/French consortium Lion Power). The generation companies have also embarked on expansion projects, further boosting electricity supply.

Like a conductor of a finely-tuned orchestra, EMA has to constantly keep an eagle eye out to spot unexpected problems that could crop up in a dynamic market, and to adjust, whenever needed, to bring the market back into a delicate balance. This is one



that delivers competitive prices for consumers, while also enabling the licensees to earn reasonable returns so they will continue to invest in new capacity and to upgrade their existing infrastructure.

### THE GOVERNMENT'S "VISIBLE HAND"

At the same time as market competition continues to be nurtured, electricity supply is too critical to Singapore's economy to be left entirely to market forces. This calls for the intervention of what can be termed the government's "visible hand", which complements the "invisible hand" of the market economy.

In 2010, the Economic Strategies Committee's Subcommittee on Ensuring Energy Resilience and Sustainable Growth, co-chaired by S. Iswaran, then Senior Minister of State for Trade and Industry, and Jen Kwong Hwa, Managing Director of Micron Semiconductor Asia Pte Ltd, said in its report: "The market, on its own, may not help with diversification as it will gravitate towards the lowest-cost solutions. Hence, government intervention may also be necessary to balance our energy portfolio on account of security and environmental concerns or where large capital investments are required."

This "visible hand" of the government is most significant in the area of energy security. For example, EMA has contingency planning and stockpiling requirements to maintain system security. Every power station is required to maintain at least 90 days of fuel reserves, with at least 45 days' worth of reserves kept onsite.

After the 2004 blackout caused by the disrupted gas supply from Indonesia, Singapore placed greater priority on importing liquefied natural gas (LNG) from any source. Thus, the next milestone towards a secure and sustainable gas and electricity supply system is Singapore's LNG terminal, so that Singapore can secure LNG from other suppliers around the world.

In 2005, Tokyo Gas Engineering, a unit of Japan's biggest gas distributor, conducted an LNG study which validated the economic viability of such a terminal in Singapore. Singapore Power's subsidiary, PowerGas, was appointed to build the LNG terminal in April 2008. PowerGas partnered France-based energy company GDF Suez to jointly develop the LNG terminal.



***The evidence so far suggests that market competition is working. Since the liberalisation of the electricity market, the price of fuel oil has increased by 196 per cent from April 2001 to April 2011. In comparison, the tariff for households has increased by just 29 per cent.***

But with the global economic downturn and credit crunch in 2008, the venture was not commercially viable and had to be delayed. The Singapore government decided to take over the project. In June 2009, the EMA set up Singapore LNG Corporation to build, own and operate Singapore's first LNG terminal.

The terminal will be Asia's first open-access multi-user terminal capable of importing and re-exporting LNG from multiple suppliers. Located on Jurong Island, the terminal will be completed by 2013. It will not only help to meet Singapore's growing energy needs, but also catalyse the development of a robust gas market to underpin Singapore's industrial growth.

During the groundbreaking ceremony for the LNG terminal in 2010, Mr Iswaran said: "One possibility is to develop Singapore as a centre for LNG trading in Asia. Singapore's central geographical position, between LNG demand in North-east Asia and LNG supply from the Middle East and Australia, offers a key competitive advantage."

He added: "To further diversify our energy portfolio, the government is also prepared to consider other energy sources such as clean coal and electricity imports in the medium term. We expect these to be undertaken on a market basis with appropriate safeguards to maintain the reliability of supply and to meet environmental considerations."

### **SMART ENERGY ECONOMY**

The energy constraints that Singapore faces are tremendous. In this serene seaport of calm waters, there are no powerful tides, no geothermal effusions, and winds are seldom strong. In sunny Singapore, solar power might seem to have bright potential but the reality

***The energy constraints that Singapore faces are tremendous. In this serene seaport of calm waters, there are no powerful tides, no geothermal effusions, and winds are seldom strong.***

is that it does not have enough land to host the massive solar panels often seen in overseas solar farms, and also has many cloudy days in a year. With technological improvements, we can expect solar panels to be deployed in Singapore in future. However, the above factors will limit the extent of solar energy as part of Singapore's overall energy mix.

Faced with important constraints of natural geography, EMA has to stay on top of the latest technologies and encourage new players with new technology to enter the power generation industry. In the Economic Strategies Committee's report on energy resilience and sustainable growth, the committee said that to achieve Singapore's vision of becoming a smart energy economy, the country should stay "technology-agnostic", open to all sources.

### **GLIMPSE INTO THE FUTURE**

In a speech in Parliament in 2002, then Trade and Industry Minister George Yeo had imagined a future in which "all kinds of new products would be possible". In New Zealand, for example, consumers have a menu of electricity suppliers that offer various service packages. Customers willing to accept interruptible supply could get lower rates, while others may opt for bundled packages.

The potential for quantum-leap change has been further boosted with the advent of IT into the electricity grid infrastructure. In the not-so-distant future, electricity, like telecommunications, will become a smarter, more flexible and responsive system that enables plug-and-play options that allow users to connect to a larger ready-to-use system.

Some of these exciting glimpses into the energy systems of the future in Singapore are being developed with public- and private-sector partnerships.





## Alternatives to Gas for Power Generation in Singapore

About 80 per cent of Singapore's electricity is generated using piped natural gas from Malaysia and Indonesia. The security and reliability of our gas supply will be enhanced with the arrival of liquefied natural gas (LNG) after the completion of the LNG Terminal in 2013. Other than gas, can Singapore consider other sources of power generation?

### COAL

A cost-competitive baseload option, though there are environmental concerns. Pollution can be mitigated with modern technology to control emissions of particulate matter and sulphur dioxide, with ash being recycled for construction. Globally, research and development is also ongoing to develop carbon capture and sequestration or utilisation, which has the potential to lower carbon emissions when used in conjunction with new coal technologies.

### MUNICIPAL WASTE AND BIOGAS

Waste incineration plants contributed about 2 per cent of the power generation fuel mix in 2009. Biogas can be produced from any organic waste including food waste. The total extent of deployment is limited by the amount of waste generated and collected within Singapore.

### SOLAR

A renewable, abundant and carbon-free source of energy, though intermittency and land constraints limit its total deployment in Singapore compared with other countries. While still more expensive than electricity from conventional sources, costs of solar photovoltaic systems have been declining steadily and the deployment of building integrated photovoltaic systems is expanding.



Exploring solar energy as a feasible way to generate electricity.







***With better information flow, energy providers will know how much electricity is being used and fed into the grid to better optimise generation and grid operations.***

EMA's Intelligent Energy System pilot project, which kicked off in 2009, will enable two-way data flow between energy providers and consumers, leveraging on smart meters and related communications technologies. With better information flow, energy providers will know how much electricity is being used and fed into the grid to better optimise generation and grid operations. In turn, customers can monitor and control their consumption in real time. During the Smart Grids Conference in 2009, former Chief Executive of EMA, Lawrence Wong, said a smart grid "will provide the platform for new products and services, spur energy innovations, and completely transform the shape of the energy industry in future".

Singaporeans could benefit from the implementation of home automation systems riding on smart metering technologies. For example, households could set washing machines to do laundry automatically overnight when electricity is cheaper, and therefore save on their electricity bills. Electric cars could be plugged in at night to recharge their batteries.

EMA and the Land Transport Authority (LTA) are also leading a pilot for electric vehicles. Singapore will be the first location outside Germany to try out an integrated electric vehicle charging infrastructure solution. At the launch of the Electric Vehicle Test-bed in 2009, Mr Wong said: "Worldwide, there is a growing concentration of resources to improve the performance and costs of electric vehicles, in preparation for a lower carbon future. Singapore is happy to play a part in this global endeavour to push out the frontiers of possibilities for electric transport, and to help develop the technology that will make these vehicles a success."

***The potential for quantum-leap change has been further boosted with the advent of IT into the electricity grid infrastructure. In the not-so-distant future, electricity, like telecommunications, will become a smarter, more flexible and responsive system that enables plug-and-play options.***

To encourage more of such developments, the Singapore government has embarked on a clean energy programme. The Inter-Ministerial Committee on Sustainable Development initiated the Sustainable Blueprint in 2008. Some \$680 million have been set aside to build new capabilities in clean energy and water technologies. In 2010, the government announced a new \$1 billion fund for research to tackle long-term national challenges such as energy and environmental sustainability. The research will focus on ways to enhance Singapore's energy resilience by increasing its energy options, reducing carbon emissions and improving energy efficiency.

### **THE RACE CONTINUES**

It has been an exciting journey since 1906, when electricity officially started in Singapore. The story began with an open market system striving to overcome the energy scarcity of those earlier times. The system then developed into a vertically integrated power supply set-up comprising power generation, transmission and distribution in the 20th century, as energy stability was established after World War II and before independence in 1965. This was followed by phased restructuring and liberalisation in the next three decades.

Looking ahead, the electricity system in Singapore will continue to evolve against the backdrop of a rapidly changing global energy landscape. Worldwide, energy issues have increased in priority as governments grapple with the concerns of energy security and climate change. Similarly in Singapore, the balance between market forces and government will continue to adjust in the unending quest to harness market forces effectively, while ensuring energy security and sustainability.







At the same time, the system is advancing – much further than anyone could have imagined before – into new directions that carry as many challenges as there are exciting possibilities. Indeed, the race for competitive, secure and sustainable energy options is intensifying. The technology revolution unfolding in energy over the coming decades will take many forms. Nobody can predict exactly which new technologies will work best. But it is certain that the energy landscape several decades from now will be different from what can be seen today. For Singapore, the work continues to prepare for a new energy future that is competitive, secure and sustainable.





# LOOKING BEYOND



1

- 1 Singapore's first LNG terminal.
- 2 Seeing the bigger picture in energy resilience.
- 3 Towards a smarter energy grid.
- 4 Balancing developmental and environmental conservation.

## 2008

- The Inter-Ministerial Committee on Sustainable Development initiated the Sustainable Blueprint. One key area of focus is to develop capabilities to improve the way resources such as energy and water are used and optimised.



2





3

## 2009

- EMA set up Singapore LNG Corporation Pte Ltd in June to build, own and operate Singapore's first LNG terminal.
- EMA's Intelligent Energy System pilot project kicked off, representing a first move towards an integrated smarter grid in Singapore.
- EMA and LTA co-chair a taskforce set up to oversee the Electric Vehicle (EV) test-bedding programme, to assess the viability of EVs in Singapore.
- EMA and the National Environment Agency lead the Energy Efficiency Programme Office to drive energy efficiency improvements in Singapore.

## 2010

- The Economic Strategies Committee's Subcommittee on Ensuring Energy Resilience and Sustainable Growth recommended that the government balance Singapore's energy portfolio on account of security and environmental concerns or where large capital investments were required.
- The groundbreaking ceremony for Singapore's first LNG terminal took place on Jurong Island.



4

## 2011

- EV test-bed launched with outdoor and indoor charging stations by Bosch and Greenlots, and EVs by Mitsubishi and Daimler.
- Singapore's LNG terminal will have three tanks, thereby enhancing Singapore's energy security by being able to access LNG worldwide.
- EMA and EDB co-chair the Energy Innovation Programme Office, formerly known as Clean Energy Programme Office, to promote research and development in the energy sector.
- EMA and the National Research Foundation co-chair the National Innovation Challenge in Energy Resilience for Sustainable Growth (or Energy NIC) Sub-Committee to promote the development of cost-competitive energy solutions for deployment to help Singapore improve energy efficiency, reduce carbon emissions and increase energy options.



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