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# THE SINGAPORE ENGINEER

COVER STORY:  
POWER GENERATION  
An environment-conscious power generation company





## An environment-conscious power generation company

Senoko Energy Pte Ltd (Senoko Energy) is currently the largest power generation company in Singapore, having a licensed capacity of 3,300 megawatts (MW) and providing about one quarter of the nation's electricity needs. Its subsidiary, Senoko Energy Supply Pte Ltd is a major electricity retailer.



Er. Eu Pui Sun.

Senoko Energy's ongoing efforts are aimed at producing electricity using processes with lower carbon emissions, and marketing it at competitive prices.

'The Singapore Engineer' meets with Er. Eu Pui Sun, Managing Director, Senoko Energy Supply Pte Ltd and Mr Kwong Kok Chan, Vice President (Environment & Quality), Senoko Energy Pte Ltd, and obtains more details.



Mr Kwong Kok Chan.

### Senoko Energy

Senoko Energy, formerly known as PowerSenoko Limited, commenced operations in 1976, as part of the generation division in the Electricity Department of the Public Utilities Board (PUB).

On 1 October 1995, as part of the corporatisation of the Electricity and Gas Departments of the PUB, PowerSenoko was established as a public company limited by shares and became a subsidiary of Singapore Power Limited (Singapore Power), to hold both Senoko Power Station and Pasir Panjang Power Station.

On 1 April 2001, Singapore Power divested its interest in PowerSenoko to Temasek Holdings and PowerSenoko was renamed Senoko Power Limited.

In September 2008, a consortium comprising GDF Suez of France and Japanese organisations Marubeni Corporation, The Kansai Electric Power Company, Kyushu Electric Power Company, and Japan Bank for International Cooperation, acquired Senoko Power Limited for S\$ 3.65 billion.

Senoko Power Limited was renamed Senoko Energy Pte Ltd in 2010. Senoko Energy was granted a generation licence to operate its plants at Senoko Power Station and Pasir Panjang Power Station. The operations of Senoko Energy have been certified to international standards ISO 9000, in 1998; OHSAS 18001, in 2003; and ISO 14001, in 2004.

### Plant portfolio

Senoko Energy's plant portfolio is split between its main site at Senoko Power Station and a separate site at Pasir Panjang

Power Station. The portfolio comprises a mix of oil-fired steam turbines, gas-fired combined cycle plant, and diesel-fired open cycle gas turbines.

Stage Two which was completed in 1979, comprises three oil-fired steam thermal plants, each with a capacity of 250 MW (for a total of 750 MW). Stage Two is currently undergoing repowering which involves the conversion of its three steam thermal plants into two combined cycle gas turbine units, each with a capacity of 430 MW (for a total of 860 MW). The gas turbines are supplied by Mitsubishi Heavy Industries. The repowering project is scheduled for completion in 2012.

Stage Three, which was completed in 1983, comprises two steam thermal plants, each with a capacity of 250 MW. The turbines are from Hitachi.

In the 1990s, Senoko Energy started experimenting with the use of gas turbines using natural gas. In 1992, Senoko Energy became the first power generation company to import clean natural gas for power generation.

After three years of evaluating the viability and reliability of gas turbines, Senoko Energy became the first power generation company to adopt the combined cycle concept. The combined cycle plants CCP 1 and 2 were completed in 1996. Each of the plants uses Siemens turbines, and has a capacity of 425 MW.

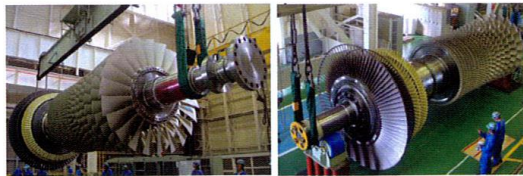
The combined cycle plants CCP 3 to 5 became fully operational in 2004, and involved the repowering of the former Stage One oil-fired steam thermal plant. Each of the three combined cycle plants, with Alstom turbines, has a capacity of 365 MW.



CCP 1 & 2 overlooking the Johor Straits with Johor Bahru at a distance. CCP 1 & 2 was Senoko Energy's and Singapore's first repowering project and involved the conversion of four open cycle gas turbines into two blocks of combined cycle gas turbines.



Chimney stacks of Stage 3 (middle) and CCP 3 - 5 (right). The repowering of CCP 3 - 5 involves the conversion of the old Stage 1 oil-fired steam units into combined cycle gas turbine units. The picture also shows that the Stage 2 chimney had already been dismantled as part of the Stage 2 repowering project which is now nearing completion.



The 701F4 gas turbine at the Takasago Machinery Works of Mitsubishi Heavy Industries (MHI). The gas turbine, the most advanced and most efficient F-class turbine from MHI, is part of Senoko Energy's Stage Two repowering programme.

PPGT which is located at Pasir Panjang Power Station comprises two oil-fired gas turbine generators, using Siemens gas turbines, one of which is still operational and has a capacity of 105 MW.

#### Energy efficiency and environmental impact

Since 2000, Senoko Energy has been converting its steam plants to combined cycle power plants which has an efficiency of 40% to 50%. The cost savings are passed on to consumers and industries.

'Senoko Energy embraces a different kind of repowering with combined cycle power plants. We reuse much of our existing equipment. Also, by building within the existing facility, we have reduced the footprint required for a power generation plant. As a result, we have a commercially viable power generation system', said Mr Kwong.

The replacement of steam generating plant with a combined cycle power plant on the same footprint, without additional land area, is an engineering feat, because an 860 MW plant has to be accommodated on an area where a 750 MW plant is sited.

An important feature of using the combined cycle power plant is the reduction in the carbon dioxide emissions by 2.5 million tons annually. The new repowering plant contributes to a further reduction of 1 million tons of carbon dioxide emissions.

'Totally, the 3.5 million tons is a significant contribution towards carbon dioxide reduction by a single company', said Mr Kwong.

In the past, CO<sub>2</sub> emitted / KWh of power produced by the company was 0.71 Kg CO<sub>2</sub> /KWh. With the installation of the combined cycle power plants, this has been reduced to 0.43 Kg CO<sub>2</sub> /KWh which is below the average for the Singapore grid, of 0.45 Kg CO<sub>2</sub> /KWh. With the new repowering (which will result in a further reduction of 1 million tons of CO<sub>2</sub> per annum) this figure will be lowered to 0.36 Kg CO<sub>2</sub> /KWh.

#### Commitment of shareholders

Senoko Energy's repowering programme was announced around the time of the onset of the global financial crisis in 2008.

The company's shareholders decided to go ahead with the capital-intensive exercise, because they believe that Singapore has a great future and it was the right time to give the republic vote of confidence. Also, they are sure that Singapore's electricity market will continue to embrace new power generation concepts.

'Stage Two repowering actually gave a lot of impetus to the Singapore's electricity market', said Mr Kwong.



Operations staff working in front of a console in the control room where most of the operation of the plant takes place.

#### Water efficiency

By replacing steam turbines with combined cycle power plants, the water requirement for power generation is reduced.



Furthermore, Senoko Energy has built a seawater desalination plant to supplement the NEWater the company is already using.

'We desalinate water and use it for boiler feed water for the steam plant or for even the heat recovery steam generator', said Er. Eu.

'In the past, potable water was used for boiler feed water. There was therefore the need to remove the minerals in the potable water to make it to boiler feed quality. By using NEWater and desalinated water, potable water is reduced as it is now required only for use by the staff', he added.

Around one-third of the requirement of process water is met by desalinated water, complementing the use of NEWater which meets two-thirds of the requirement.

Senoko Energy is the first power generation company in Singapore to build a desalination plant.

### The Smart Grid

All over the world, different countries are developing different solutions for the application of the Smart Grid. In Singapore, the Energy Market Authority (EMA) is looking at what can be adapted to Singapore, when it starts the Smart Grid Pilot in 2013.

Senoko is one of the many market participants in this initiative, and is currently working with EMA on what can be adapted for a viable Smart Grid.

Looking at the energy consumption, the Smart Grid will benefit commercial and industrial customers more than residential customers.

'However, this will involve people willing to shift their loads from peak periods to off-peak periods, and also improving the efficiency of their operation, that is, using less KWh' said Er. Eu.

All images by Senoko Energy.



The Senoko Energy Electric Vehicle on the road, with Er. Eu and Mr Kwong.

### Senoko Energy Electric Vehicle

Senoko Energy recently purchased an i-MiEV (Mitsubishi innovative Electric Vehicle), as part of EMA's Pilot Project to test out this greener mode of transport.

The i-MiEV uses a 16 kilowatt-hour lithium ion battery pack. Its 47 kW motor gives 63 horsepower and a high torque of 180 Nm (equivalent to a 2-litre car) for a maximum speed of about 130 km/h, with a cruising range of approximately 150 km.

### PERFORMANCE DATA

#### Good torque from standstill (due to motor)

A small size does not have to equal a small performance. The lightweight, highly efficient permanent magnet synchronous motor delivers strong and linear acceleration and surprising passing power with a maximum 180 Nm of torque which is equivalent to that for a two-litre vehicle. Due to its low centre of gravity, the i-MiEV has good handling performance.

The EV also has a feature, under various driving modes, to regenerate power while in motion, to charge the battery during braking or downhill driving. This helps to extend battery life and the distance covered by the EV.

#### Single charge cruising range

The EV has a cruising range of about 150 km. The Mode2/3 charge system can be used to charge the EV from an empty state to 80% charged in 30 mins, and fully charged in 6 hours. The Mode4 quick charge system can be used to fully charge the EV in 15-30 mins.

#### Zero drive-time CO<sub>2</sub> emissions

The i-MiEV is a zero-emissions vehicle (ZEV) which produces no CO<sub>2</sub> emissions while being driven. Even when the CO<sub>2</sub> gas emitted at power generating stations is taken into consideration, the i-MiEV generates approximately one-third of the CO<sub>2</sub> produced by the petrol "minicar".

#### Driven 100% by electrical power

The i-MiEV is economical because it uses only electricity as its power source. Depending on the electricity rate structure, the running cost can be reduced further by off-peak charging of the battery if that rate is lower.

#### Charging station

There is a Mode3 Bosch Charging Station at the Senoko Power Station, capable of charging two EVs simultaneously as well as transmitting EV usage data remotely via 3G for analysis. The car parks at the power station are also EV-ready, with 16 amp power supply points to connect the OEM-supplied Mode2 cable for safe indoor charging. Bosch was appointed by EMA to install the charging infrastructure across Singapore for the EV Pilot Programme. There would be about 63 charging stations island-wide when the pilot infrastructure is fully rolled out.