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WONG Yuk Sum

Development of Renewable Energy in Singapore

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ABSTRACT

Singapore is a diamond-shaped island with several surrounding smaller islets. It has a relatively flat coastline with a land area of 710 km². Situated south of the Straits of Malacca on a major shipping route, the city-state is well-located for the energy industry with regard to international oil refining and trading.

Singapore does not have any hydro or geothermal energy resources but is aiming to incubate renewable energy. Much of the maritime territory is used for ports, anchorage and shipping lanes. This limits the application of ocean energy technologies domestically and Singapore's wind speed is too low to generate power efficiently. Because of its strong capabilities in electronics, precision engineering and chemicals sectors, the viable REs in Singapore are solar and biofuels.

This article discusses objectives of Singapore's national energy policy and the latest developments of renewable energy in Singapore.

KEY WORDS

Biofuels, Energy Policy, Photovoltaics

1. Singapore is a diamond-shaped island with several surrounding smaller islets. It has a relatively flat coastline with a land area of 710 square kilometres. Situated south of the Straits of Malacca, a major shipping route, Singapore is ideally positioned for the energy industry with respect to international oil refining and trading. The Government aims to incubate renewable energy (RE) in the energy industry.

3. Singapore does not have any hydro or geothermal energy resources. Much of the coastal areas are used for ports, anchorage and shipping lanes, which limit the application of ocean energy technologies domestically. Singapore's wind speed is too low to generate power efficiently. However, due to the strong capabilities in electronics, precision engineering and the chemicals sector, the viable REs in Singapore are solar, fuel cells and biofuels.

4. The experience with the semiconductor industry provides Singapore with the industrial infrastructure and workforce familiar with silicon technologies. Silicon is the dominant material used in photovoltaics (PV). Singapore is ideally placed to serve the countries of Southeast Asia, which have about 50% more solar irradiation than the temperate countries. Singapore's urban landscape also provides opportunities to develop capabilities in system integration and building integrated PV (BIPV).

5. Wind and solar energies generate power intermittently. Hydrogen works as the medium to store the energies from these REs. It will be used to generate electricity by fuel cells. Singapore's experience with clean energy and innate capabilities in managing complex industrial equipment manufacturing put the country in good stead to develop fuel cells.

6. Singapore is close to Malaysia and Indonesia, which account for 80% of the world's palm oil supply. Biofuel companies such as Peter Cremer, Continental and Natural Fuels, have invested in production capacity on Jurong Island since 2005, with a yield of 650,000 tonnes of biodiesel by 2005.

7. The core objective of Singapore's national energy policy is to secure energy for growth by maintaining a balance among economic competitiveness, energy security and environmental sustainability. Research and development (R&D) in clean energy technologies allows Singapore to capture global economic opportunities and develop solutions for domestic change.

8. The Government has initiated the development of REs by building energy R&D infrastructure and test-bedding platforms, establishing energy R&D programmes and putting strategic energy R&D funding in place.

Clean Energy Programme Office (CEPO)

9. The Clean Energy Programme Office (CEPO) was set up in April 2007 to implement and coordinate various research and test-bedding programmes.

10. The Strategic Research Programme on clean energy at the National Research Foundation (NRF) aims to develop Singapore into a global clean energy hub where clean energy products and solutions are developed then exported globally. While the clean energy industry comprises a broad range of areas, solar energy has been identified as the main focus area domestically. Technology development will be a key driver to grow the clean energy industry. Singapore also intends to establish world-class R&D centres and groom specialist manpower for this industry through

graduate scholarships.

Clean Energy Research Programme (CERP)

11. The NRF has set aside $170 million to boost clean energy R&D with a focus on solar research as a start. The funding will be used to provide competitive grants for clean energy projects undertaken by both the public and private sectors. It also supports the establishment of world-class clean energy R&D centres to create the necessary critical mass and establish global linkages to other centres of excellence and incubates clean energy start-up companies by helping them to commercialise their technologies.

12. The Clean Energy Research Programme (CERP) within the NRF aims to kick-start the R&D activities in clean energy in Singapore. This programme helps the development of the technological capabilities to accelerate the growth of the clean energy industry in Singapore. The first CERP call for proposals was in the solar technologies domain. A total of S$10 million was awarded to eight research teams. The proposed studies include research on thin-film PV and high-efficiency concentrator cells.

13. The second grant call was focused on novel roof-mounted solar-harvesting devices and systems for the tropical region. A total of S$15 million was awarded to eight research teams. Singapore's location in the tropics, coupled with the highly-urbanised landscape, gives rise to the opportunity to harness solar energy through roof-mounted solar energy systems suited for the tropical climate. There are many urbanised environments similar in size to Singapore throughout Southeast Asia, Southern China, India, South America and Africa. There is also a vast market potential for successful products to be exported. The eight awarded proposals span

a range of areas such as solar-driven cooling systems, hybrid PV thermal systems and optimisation of the performance of solar systems under the diffuse sunlight conditions typically experienced in the tropics.

Experimental Power Grid Centre (EPGC)

14. The EPGC was established to provide the technical infrastructure for the development of clean energy technologies and sustainable energy solutions. It will be equipped with micro-grid and command and control facilities. Microgrids will enable researchers to test-bed novel power generating, storage, and integrated power/thermal systems and study their performance in a grid environment. These systems can be harnessed to work in concert with one another in main grid-isolated (islanded) mode as well as in main grid-paralleled operations. They can also utilise a variety of conventional and alternative fuels such as natural gas, biofuels, hydrogen and batteries. The command and control facilities serve as the control centre for the assets on the microgrid and provide access to other systems and assets operated by collaborators. The facility will have technology to enable real-time information exchange, remote and intelligent monitoring, diagnosis, decision-making, control and management. Such capabilities are important for the operation of physical energy and power systems and to facilitate energy markets.

15. The EPGC will work with independently-funded research groups from both the public sector and industry. Through research collaborations, the centre is expected to develop in-house expertise in systems integration, testing and evaluation of technologies. In time, the centre may offer this expertise in the form of consultancy services to address issues such as grid management, energy efficiency and fuel management, both locally and overseas.

Market Development Fund (MDF)

16. The Energy Market Authority (EMA)'s Market Development Fund (MDF) allocated $5 million to facilitate test-bedding of non-traditional generation technologies, such as solar, wind, marine, hydrogen and fuel cells, that have significant value in the electricity market.

Clean Energy Research and Test-bedding Programme (CERT)

17. CERT was launched in August 2007 to stimulate research in the application of clean energy in Singapore. A $17 million fund was allocated to support test-bedding projects involving the buildings and facilities of various government agencies. CERT helps the Government in studying the feasibility of distributed generation as a possible component in the strategy for energy diversification. Table 1 lists the solar test-bed projects funded by CERT.

Table 1: Solar Test-bed Project funded by CERT

Public Sector (CERT)	Phase	System Size (kWp)
BCA Zero Energy Building	1	190
HDB Sembawang & Serangoon North	1	146
NParks Gardens by the Bay	1	TBC
PUB Marina Barrage	1	70
Singapore Polytechnic	1	47
Changi Airport Budget Terminal	2	250
Khoo Teck Puat Hospital	2	150
Ngee Ann Polytechnic	2	14
NEA Meteorological Services Building	2	25

Solar Capability Scheme (SCS)

18. Solar Capability Scheme (SCS) encourages innovative design and integration of solar technologies into energy efficient buildings. SCS offsets 30-40% of the total capital cost of solar technology, capped at $1 million per project. It caters to new building developments in the private sector, which meet a minimum Green Mark Gold standard with a minimum system size of 10 kWp. Table 2 lists the solar test-bed projects by the SCS.

Table 2: Solar Test-bed Project funded by SCS

Private Sector (SCS)	Building Type	System Size (kWp)
Applied Materials Manufacturing Facility	Industrial	366
CDL Tampines Grande	Commercial	108
Lend Lease Retail 313@Somerset	Commercial	76
Lonza Biologics Manufacturing Facility	Industrial	181
Robert Bosch SEA HQ Building	Commercial	88

Private Sectors

19. International companies also invest in Singapore. Figure 1 shows the Government initiatives and investments for different phases of RE. Norway's Renewable Energy Corporation ASA (REC) will build the world's largest integrated solar manufacturing complex in Singapore. REC plans to incorporate wafer, cell and module production facilities and has the potential to reach 1.5 Gigawatts in production capacity, roughly three-quarters of the total global output in 2006. There are also solar panel manufacturing investments by Solar Energy Power and Eco-Solar. Solar World and Conergy set up Asia-Pacific headquarters in Singapore.

20. Denmark's Vestas Wind Systems has set up its Asia-Pacific headquarters in Singapore. Vestas will invest up to S$500 million over the next 10 years in R&D in Singapore. Rolls-Royce and a consortium of Singapore companies, EnerTek Singapore Pte Ltd, signed an agreement to invest S$164.7 million to develop a commercially viable power system based on fuel cell technology for stationary application. Peter Cremer (Nexsol), Continental and Natural Fuels (CNF) have set up biodiesel production facilities in Singapore. Finland's Neste Oil is investing $1.2 billion in building the world's largest renewable diesel NExBTL plant in Singapore.

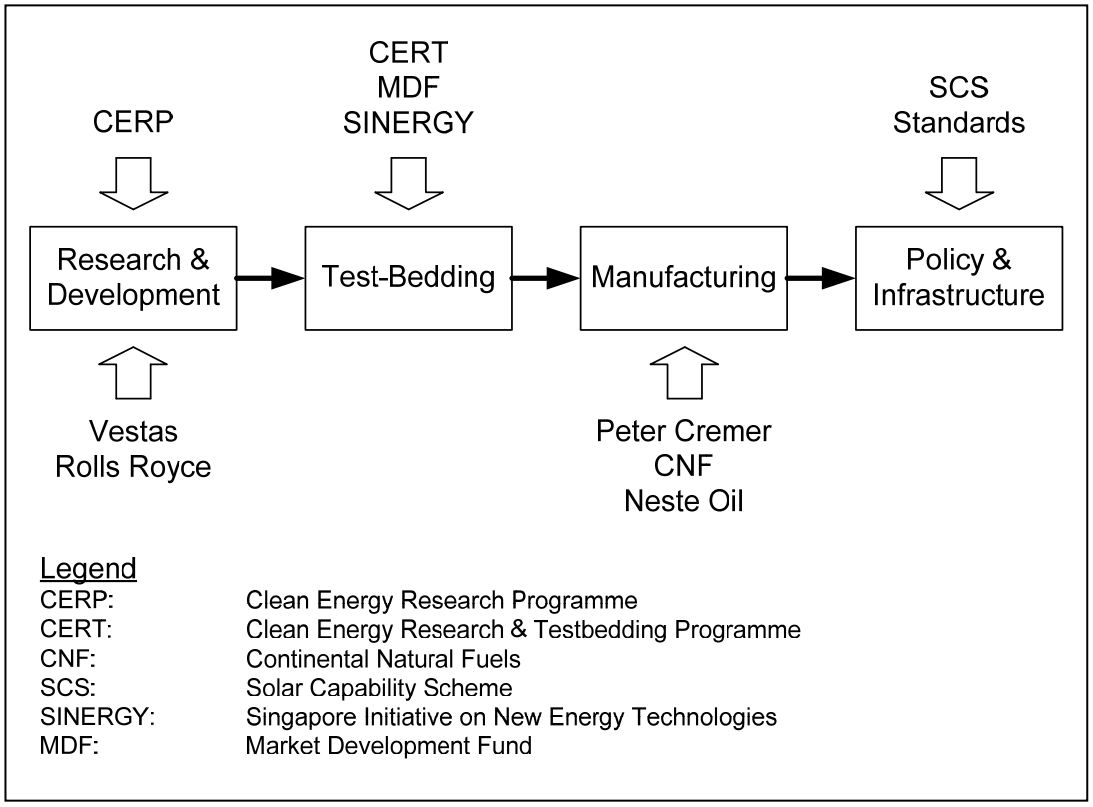

Figure 1: Government Initiatives and Investments

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About the Author

WONG Yuk Sum is a Fellow with ESI. He received his BEng, MPhil and PhD degrees all in Electrical and Electronic Engineering from The University of Hong Kong. His research projects covered optimization of energy management systems for electric, fuel cell, hybrid and plug-in hybrid vehicles and battery modelling. From 2007 to 2008, he was a postdoctoral researcher at the National University of Ireland, Galway, where he developed a temperature compensated battery charge regime for standby applications.

Dr Wong has obtained one patent, published 8 peer-reviewed journal articles and won the Environmental Excellence in Transportation Award for Education, Training and Public Awareness by the International Society of Automotive Engineers (SAE) in 2007. Dr Wong's current research interests include energy efficiency potential studies, assessments of policy options to improve efficiency and economy-wide energy efficiency performance monitoring.

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Energy Studies Institute
National University of Singapore
29 Heng Mui Keng Terrace, Block A #10-01
Singapore 119620
Tel: (65) 6516 2000 Fax: (65) 6775 1831 Http://www.esi.nus.edu.sg