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Solar Energy Development in Hong Kong and Its Implications to Energy Market Reform

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ABSTRACT

Solar energy is considered beneficial for application in Hong Kong, but it has not been used significantly in the society at present. The major barriers to large-scale deployment of solar energy systems are not difficult to comprehend. Removal of these barriers, however, will require careful analysis of technical, economic and policy issues. This paper presents an overview of the solar energy potential and development in Hong Kong. The climate and geography are described; the technology options available in the local context are examined. The policy and institutional issues affecting the viability and feasibility of the solar systems are explained. Finally, the implications of wide-scale solar energy application to energy market reform and partnership with the Mainland China are discussed.

KEYWORDS: Solar energy development, renewable energy, Hong Kong, energy market reform and transformation.

1. INTRODUCTION

Many people think that urban cities like Hong Kong are difficult to utilise renewable energy resources because of space limitations and other constraints. However, for achieving sustainable development of the society, it is important to develop the local market potential and promote the use of renewable energy (IEA, 2001b). Most people would agree that the effective use of renewable energy resources will help reduce reliance on fossil fuels, mitigate greenhouse gas emissions and increase energy security. The key question is how to investigate the most appropriate renewable energy technology and build up skills and experience for its development, design and operation.

At present, Hong Kong does not make significant use of renewable energy resources (Hui, 2000). Lack of incentives and shortage of land and space are the key factors limiting the deployment of renewable energy systems (Hui, Cheung and Will, 1997). Obviously, large hydropower, traditional biomass and geothermal energy are not feasible in the territories of Hong Kong. Only a few pilot or demonstration projects, mainly initiated by the Government, have adopted some forms of renewable energy.

With growing concerns about energy and the environment, Hong Kong is trying to develop energy efficiency and renewable energy programmes in recent years. A consultancy study has been commissioned in 2001-2002 to investigate and assess the viability of using renewable energy resources in Hong Kong (CDM, 2002). Taking into account the local characteristics, *solar energy* is considered potentially feasible for wide-scale application.

This paper presents an overview of the solar energy potential and development in Hong Kong. The climate and geography are described; the technology options available in the local context are examined. The policy and institutional issues affecting the viability and feasibility of the solar systems are explained. Finally, the implications of wide-scale solar energy application to energy market reform and partnership with the Mainland China are discussed.

2. CLIMATE AND GEOGRAPHY

The climatic conditions provide an important background for assessing the solar energy potential. Hong Kong is a high-rise and high-density city with a subtropical climate. Figure 1 shows the monthly average data of the general climatic conditions in Hong Kong over the long-term (1960-1990). As for solar conditions, the annual mean daily global solar radiation is about 14.5 MJ/m^2. Compared with a figure of around 9 MJ/m^2 in London, this is not bad at all. If we look at the cloud amount and percentage of sunshine, the data indicates that cloudiness in some months may affect directional solar radiation. Diffuse component of the solar radiation becomes significant, especially in months from February to June.

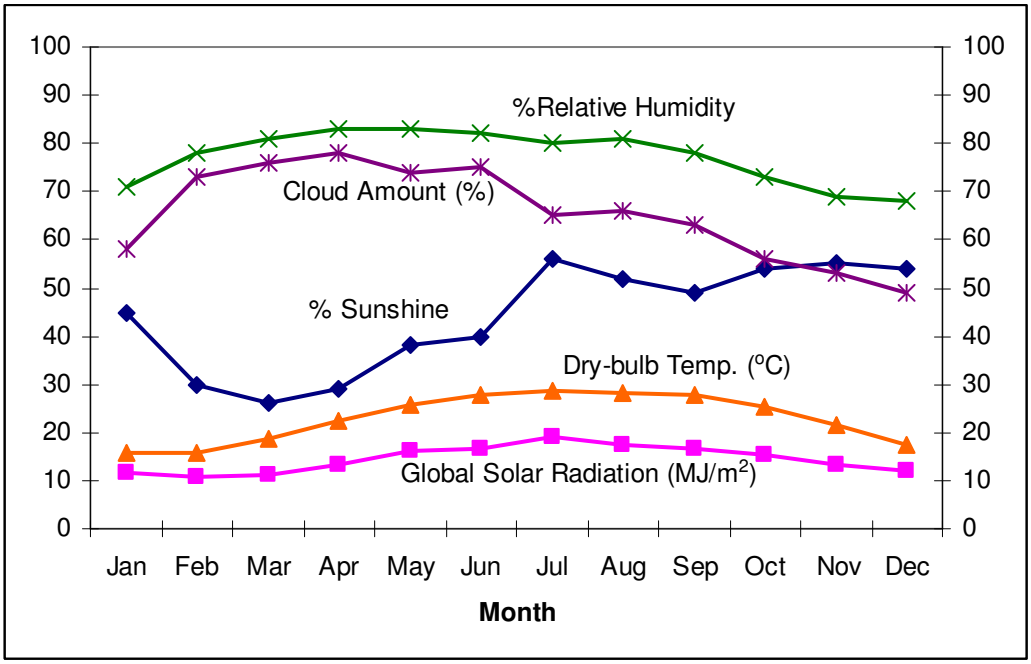

Figure 1. General climatic conditions in Hong Kong (monthly average)

The thermal conditions of ambient air can be evaluated from the average dry-bulb temperature and relative humidity. With an annual dry-bulb temperature of 23.0 °C, the heating demand in most buildings in Hong Kong is not significant and the economic advantage of directly using solar heat is weakened. However, the cooling requirements is large in the summer period from May to October. The humidity level remains high in months from February to September and this presents a need for dehumidification or sufficient

ventilation in most buildings in order to maintain human comfort. On the other hand, the requirement of strong anchorage to withstand high gales during typhoon season may add extra costs to the solar energy installation.

Within the 1,098 km^2 area of Hong Kong's territories, about 184 km^2 (17%) are developed lands and most of Hong Kong is hilly. The land use conditions and building density often present difficulties to the design and installation of solar energy collectors or panels (Hui, 2001). Although the incoming solar radiation is favourable, in practice, the collectable solar energy is affected by specific site conditions, topography and mutual shading.

An examination of the available land on a map of Hong Kong (see Figure 2) shows that in the urban areas like those on Hong Kong Island and Kowloon, it is difficult to find suitable locations for large-scale solar energy projects. However, the countrysides and new towns are potential candidates for developing solar energy systems. Under the Hong Kong's urban context, solar energy technologies that can be integrated into a built environment, such as in high-rise buildings, are more useful.

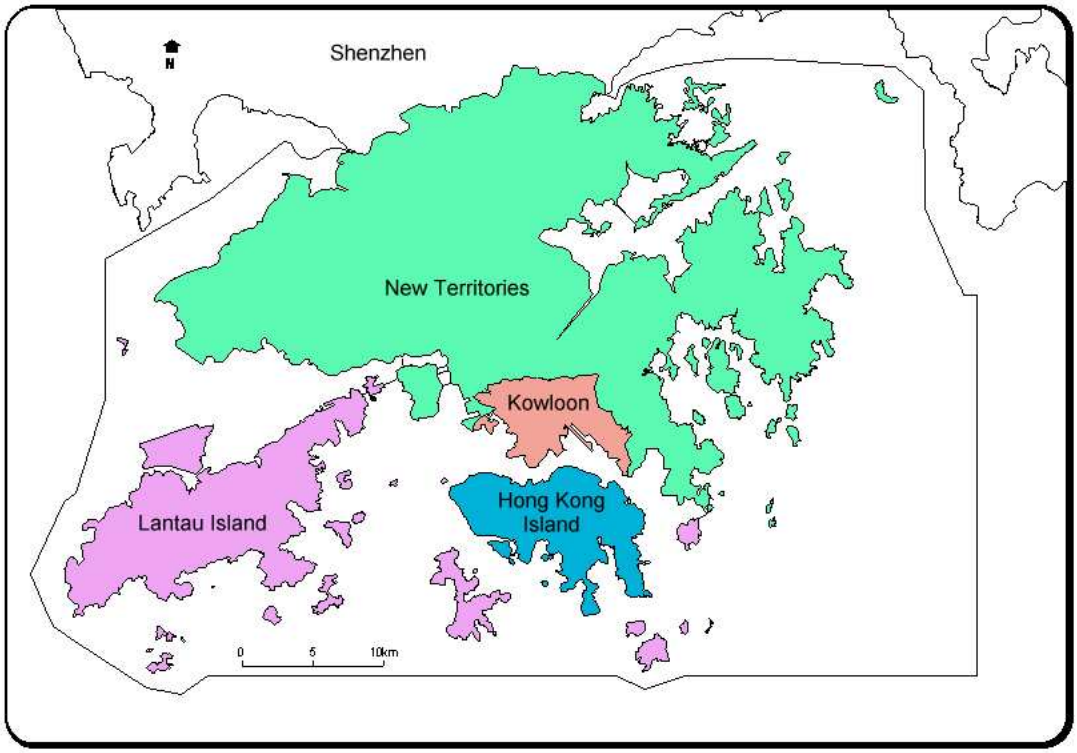

Figure 2. Map of Hong Kong

3. TECHNOLOGY OPTIONS

Solar energy systems, such as solar thermal and photovoltaics (PV), are believed to be the potential areas for further investigation and development in Hong Kong. Besides these two common options, there are also some emerging solar technologies and systems which might be investigated and applied to suit specific requirements in our society.

3.1 Solar Thermal

Solar thermal systems use sunlight to heat water directly or indirectly. In Hong Kong, the present use of these systems is primarily to provide hot water for premises like swimming

pools, slaughterhouse, hospitals, public bathhouses, prison (for kitchen and laundry equipment) and military camp (Hui, 2000). The major functions of hot water produced by solar heating are for bathing, pool heating and pre-heating of boiler feed water. From the past experience, the estimated payback periods vary from 6 to 27 years depending on the usage of the systems.

Experience showed that putting solar thermal installation into a new building usually is more favourable than retrofitting an existing building because the cost of retrofitting in framing and plumbing may be much as the cost of the collectors for a small project. Sizing the pipework and circulating pump accurately can reduce the operating cost. To avoid waste of thermal energy, insulation should be designed properly. Proper operation and maintenance of the installation are critical to generating of energy and cost savings from the system.

To enhance the overall efficiency of the system, other measures or technologies may be use to compliment the solar heat. For example, heat pumps or heat recovery systems can be used to reclaim heat from the air-conditioning plant so as to raise water temperature in the hot water system. An integrated approach to designing of the building energy systems is important for achieving an optimal design solution which minimises total non-renewable energy use. A careful understanding of the cooling and heating demands is necessary for optimising and matching the system components. This will help lower the capacity and initial costs of the systems.

3.2 Photovoltaics (PV)

The use of PV systems to generate electricity is another option now being investigated and tested in Hong Kong. Small-scale PV systems are often used effectively in remote areas to operate lighting and on-site data recording equipment. For example, at present, over 60% of the major battery-operated aids to navigation in Hong Kong waters are powered by solar energy so as to reduce refuelling costs. Many automatic weather stations are using PV cells to support their operation.

Unlike other countries, PV applications on rooftops and open space are limited in Hong Kong, except for a few rural areas. Suitable strategy is needed to apply PV in high-rise buildings and the concept of building-integrated photovoltaic (BIPV) system is believed to be an effective solution. BIPV systems fit solar cells or panels into the building components such as building facade, shading device and roof. By combining the functions of the PV panels, the overall investment of the system can be reduced significantly. A pilot project using PV and BIPV systems has been completed on the government office buildings in North Wanchai area. The electricity from the PV panels will meet part of the electrical energy demands of the buildings.

As the costs and space for battery storage often create difficulties to PV system design, pilot research is being carried out to investigate how grid-connected PV systems can be used in Hong Kong to eliminate the need for battery storage. Connecting PV or other renewable energy systems to the electricity grid requires the cooperation of the power companies. Current electricity regulations and the control scheme between the Government and power companies will have to be reviewed so as to arrange for effective power generation, distribution and purchasing.

3.3 Solar Air-conditioning and Refrigeration

Many people may not realise that solar collectors can be used for air-conditioning and refrigeration. By utilisation of the heat driven technologies, called "absorption" and "adsorption", thermally activated systems can utilise almost any source of heat, including a wide variety of fuels, solar energy as well as waste heat from incineration plants, industrial processes and cogeneration systems (Sumathy, Yeung and Yong, 2003).

Absorption cooling is the first and oldest form of air-conditioning and refrigeration. Rather than using an electric compressor to pressurise the refrigerant, a heat source is used to evaporate the refrigerant liquid (ammonia/water or lithium bromide/water mix). Absorption coolers still need electricity to run a pump which circulates the refrigerant, but this is a fraction of the power used by a compressor in a conventional electric air conditioner or refrigerator. Thermal solar energy can replace or supplement the use of non-renewable heating fuels.

Solar powered air-conditioning is currently only viable for large scale applications that employ absorption style cooling systems. In the future solar collectors that supply hot water and central heating may also be used to run specially designed solar compatible air conditioners for use in domestic applications. This will open up a new era for solar energy application in normal households.

In humid climates like Hong Kong, solar collectors can also work with desiccant-based cooling systems which include a desiccant wheel to dry incoming air. Their system components require electricity to operate, but they use less than a conventional air conditioner. By working together with conventional air conditioners, they can tackle the temperature and humidity loads separately and more efficiently. At present, most desiccant cooling systems are intended for large applications, such as supermarkets and warehouses.

4. POLICY AND INSTITUTIONAL ISSUES

Many institutional and market barriers still exist in the business environment and they will hinder the growth of the solar energy industry. The Government's commitment and policy are critical for stimulating the market and promoting development of the solar energy systems.

4.1 Market Barriers

As the energy price in Hong Kong is low compared with the land and construction costs, the developers and building owners lack the incentive to adopt solar energy systems. Also, the building developments are fast track and demand quick returns on investment. This is certainly not favourable to solar energy systems which often require much time to design and a longer payback period. With a small number of applications and limited market, the possible economics of scale cannot be achieved and the awareness and knowledge for the technology are still relatively low.

The current pricing of power supply has not taken into account the externality and environmental costs associated with combustion of fossil fuel. Thus power generated by solar energy appears to be more expensive than that coming from conventional fossil fuel. In addition, the prevailing regulatory framework tends to drive investment of power companies towards the 'cheaper' conventional method of power generation. It is not easy to have a level playing field for renewable energy to compete with conventional power generation.

The two power companies in Hong Kong are each operating under a Scheme of Control Agreement (SCA) with the Government (which will expire in 2008). The SCAs provide a framework for monitoring the performance of power companies so as to protect the interests of consumers (Lam, 1997). With permitted returns bases on fixed asset value, power companies have no energy conservation incentives and no obligation to consider renewable energy sources or to offer grid access to independent electricity generators. Some people believe that the interim review on the current SCAs scheduled for 2004 will give an opportunity for the Government and the power companies to discuss the issues relating to renewable energy development (FoE-HK, 2003).

4.2 Government Policy

Bear in mind the social and political environment in Hong Kong, it is important to realise that solutions to the energy problems are not simply a matter of applying technology and enforcement through legislation. Government policy settings will help to determine whether markets develop and operate efficiently.

Experience in other countries indicates that the role of utility companies is important for renewable energy deployment. With a world-wide trend for utility deregulation, it is necessary to review and redefine the role of the power companies so that, instead of creating barriers to private renewable generation, they could make active contribution to the "solar business". For example, the terms and conditions for accessing the electricity grid by third party are currently set at the sole discretion of the power companies. It will be beneficial to come up with negotiation methods to allow private generators to sell electricity to the power companies or grid.

It is anticipated that in the near future the Government will continue to take the lead in exploiting renewable energy in public works projects. To encourage the private sector to participate, it is necessary to review the government regulations and various policies in order to identify areas where the barriers can be removed. For example, the scheme to promote changing of water-cooled air-conditioning system in buildings from air-cooled one might help to free up the roof or other exposed space for putting solar energy systems.

Other strategies to stimulate the renewable energy market (such as by taxation and pricing) and promote regional development (such as between Hong Kong and Guangdong) could be considered and discussed in the process of the energy market reform.

5. ENERGY MARKET REFORM

5.1 Promote Competition

Promoting effective and sustainable competition in the energy market requires action on a number of related issues and an overhaul of traditional market structures and regulatory frameworks (IEA, 2001a). This means stimulating competition not only in generation, but also in electricity trading and supply as a service to consumers. At present, the energy market in Hong Kong lacks retail competition and the following methods might help to improve that:

- Introduction of full consumer choice;
- Provide non-discriminatory third-party access to the transmission and distribution

networks;
- Unbundling of transmission; and
- Liberalisation of electricity trade.

For solar energy systems such as PV, because of the significant price difference as compared with a fossil-based generation, additional incentives will be needed to stimulate the initial market.

5.2 Relationship with Mainland China

In pursuit of solar/renewable energy, Hong Kong could collaborate with Mainland China (such as Guangdong) which has abundant renewable energy resources and land. The cross-boundary cooperation would bring about greater benefits to both sides. As the electricity transmission system of Hong Kong is interconnected with the Guangdong Province, it is possible for Hong Kong to make use of the mainland's renewable energy resources to meet its energy need in a more sustainable way.

The recent Hong Kong and Mainland China Closer Economic Partnership Agreement (CEPA), signed on 29 June 2003, establishes a form of free trade area between the Mainland and Hong Kong (TID, 2003). The CEPA has potential to open up many new business opportunities in the Mainland for Hong Kong and the zero import tariff preference may create more opportunities for solar business too. In the absence of a local equipment industry, the majority of the solar energy equipment in Hong Kong now has to be imported from overseas and the price of the equipment is high compared with the potential saving. The partnership will enable the local market to get access to less expensive products and service.

It is clear that China is keen to develop renewable energy. If Hong Kong could play an active role in promoting the renewable energy development, such as by serving as a financial intermediary and an information and technology gateway, then good business opportunities and industrial development could be generated.

5.3 Creating the Markets

Creating markets for the solar energy technologies requires new initiatives (IEA, 2003). Figure 3 shows three main perspectives for designing the market development policy. Firstly, the research, development (R&D) and deployment perspective focuses on the innovation process, industry strategies and the learning that is associated with new technologies (to reduce cost and reach large-scale markets). Secondly, the market barrier perspective applies economic analysis in order to understand the mechanisms impeding deployment of new technologies. Thirdly, the market transformation perspective considers the network of market actors and practical techniques to stimulate technological change. The design and implementation of successful deployment programmes demands vision from all three perspectives.

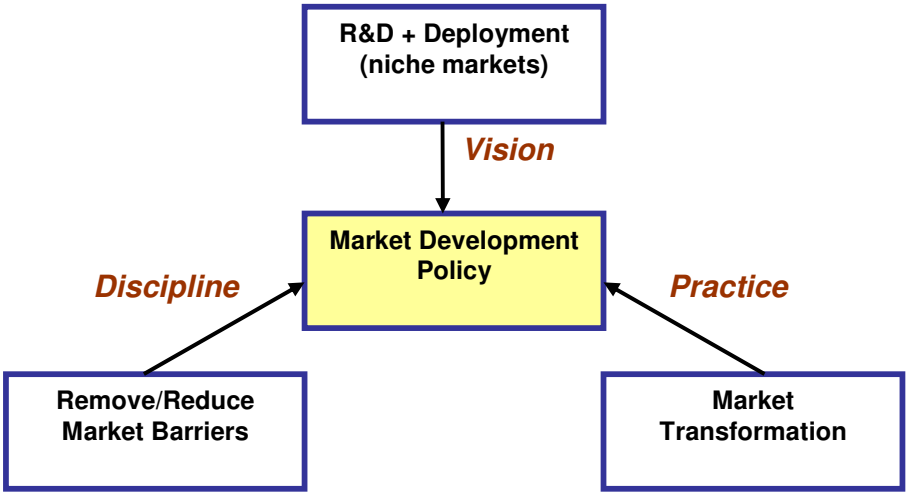

Figure 3. Market development policy for solar energy

The above concept will be useful for Hong Kong to formulate the strategy and relevant policy for solar energy deployment. Hopefully, a renewable energy market could be established so as to satisfy the local demand for green energy and create business opportunities for enhancing the future economic development of Hong Kong.

6. CONCLUSION

Solar energy has definite possibilities in Hong Kong since there is abundant sunlight. High-rise and high-density buildings create difficulties to designing solar energy systems. Current building and business practices do not favour renewable energy, therefore, the Government's role is critical for stimulating the market.

Expanding markets for solar/renewable energy technologies is an effective policy pathway towards reducing greenhouse gas emissions and increasing energy security. But many promising technologies face cost hurdles or other obstacles to commercial deployment. Solar energy technologies require the markets to survive in the long run. Only if they can be made to perform at a level and a cost that society deems acceptable, the solar energy application will not be sustainable in our society.

REFERENCES

CDM (Camp Dresser & McKee International Inc.), 2002. *Study on the Potential Applications of Renewable Energy in Hong Kong: Stage 1 Study Report*, Electrical & Mechanical Services Department, Government of the Hong Kong Special Administrative Region, Hong Kong.

FoE-HK, 2003. *Review and Recommendations for the Study on the Potential Applications of Renewable Energy in Hong Kong and Comments on the Public Consultation Process for the Study*, Friends of the Earth (Hong Kong), Hong Kong, April.

Hui, S. C. M., 2001. Low energy building design in high density urban cities, *Renewable Energy*, 24 (2001): 627-640.

Hui, S. C. M., 2000. Solar Hong Kong - present applications and future prospects, *Renewable Energy World*, 3 (1): 76-83, January 2000.

Hui, S. C. M., Cheung, K. P. and Will, B. F., 1997. Renewable energy in Hong Kong and Mainland China, *Sun At Work in Asia-Pacific*, Number 1, Autumn 1997, pp. 27-30.

Hui, S. C. M., 1997. From renewable energy to sustainability: the challenge for Hong Kong, In *Proc. of the POLMET '97 Conference*, 25-27 November 1997, Hong Kong Institution of Engineers, Hong Kong, pp. 351-358.

IEA, 2003. *Creating Markets for Energy Technologies*, Organisation for Economic Co-operation and Development/International Energy Agency (OECD/IEA), Paris.

IEA, 2001a. *Competition in Electricity Markets*, Organisation for Economic Co-operation and Development/International Energy Agency (OECD/IEA), Paris.

IEA, 2001b. *Towards a Sustainable Energy Future*, Organisation for Economic Co-operation and Development/International Energy Agency (OECD/IEA), Paris.

Lam, Pun-lee, 1997. *Competition in Energy*, City University of Hong Kong Press, Hong Kong.

Sumathy, K., Yeung, K. H. and Yong, L., 2003. Technology development in the solar adsorption refrigeration systems, *Progress in Energy and Combustion Science*, 29 (4): 301-327.

TID, 2003. *Mainland and Hong Kong Closer Economic Partnership Arrangement (CEPA)*, Trade and Industry Department (TID), http://www.tid.gov.hk/english/cepa/.