Demonstration and Promotion of Renewable Energy Technologies in Hong Kong - The Ma Wan Theme Park

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ABSTRACT: In recent years, the most significant change towards renewable energy applications in Hong Kong is that most government officers, property investors, architects and engineers can now consider how to use renewable energy resources in policy making and property development. This paper presents the experience and findings from our research and consultancy projects completed in recent years.

This paper will also present our recent effort for demonstrating and promoting renewable energy applications in the territory: the development of the Hong Kong renewable energy park. A number of solar and wind energy technologies are included for research and demonstration purposes. Besides, ground source heat pump, small hydro power and biomass energy are also shown to the visitors. A teaching programme is developed for school students and public societies. With the joint effort with government departments and private companies, we would like to promote renewable energy applications to the public from education.

Keywords: Solar energy; solar tracker; hybrid lighting; wind energy; hydro power; biomass

1. Introductions

Research and investigation on the application of renewable energy resources such as solar energy, wind energy, hydro power, biomass energy and ground source heat pump system etc. are growing world-wide. And the awareness on developing renewable energy in Hong Kong is ascending in the recent years.

The HKSAR (Hong Kong Special Administrative Region of P.R.C) Government has started to promote the use of renewable energy by conducting feasibility studies and implementing pilot projects in Hong Kong. During the year 2000 to 2005, the Electrical and Mechanical Services Department (EMSD) of the HKSAR commissioned a feasibility study of renewable energy applications in Hong Kong [1]. As revealed by the study, the benefits of using renewable energy technologies are many, mostly because of their virtually inexhaustible nature of resources. A number of renewable energy projects implemented by the government, local tertiary education institutions and major developers were completed in the past few years. Although the projects in Hong Kong only varies from small to medium scale compared with those in foreign countries, the growing trend on
developing renewable energy is rather important.

This paper mainly focuses on our efforts for demonstrating and promoting renewable energy applications in Hong Kong: the development of the Ma Wan Island renewable energy park.

2. Generation information of the park

Ma Wan Island is an island of Hong Kong, located between Lantau Island and Tsing Yi Island. To create awareness and give publicity amongst children, students, teachers and visitors about the use and benefits of the renewable energy systems and devices for education purposes, and to demonstrate the cost-effective applications of renewable energy technologies, a number of renewable energy technologies (including solar energy, wind energy, hydro power, biomass energy and ground source heat pump system etc.) are included for research and demonstration purposes in the renewable energy park constructions (See Figure 1).

A water-proof poster is set up under each renewable energy facility to introduce the principle and knowledge of the renewable energy resources, also some interactive design was incorporated into the systems so that visitors, especially children, can do hand-on practice for using renewable energy resources.

The produced useful energy from solar energy, wind energy and other renewable energy resources are connected to the local utility grid for power supply to the water pumps, other garden lighting systems, air-conditioning systems of the buildings (museum) and hot water supply to the hostels, so that conventional energy resource can be replaced for cost saving and environmental protection. Also some on-site measurements and tests can be carried out on the prototypes. The instant performance of the whole system is monitored by a data collection system, which will collect the system performance data every one second and display them on a 40” LCD monitor to give visitors some illumination about the working states of these renewable energy systems. Besides, the system performance data of the system will be recorded every one minute by the data collection system for research purpose.

3. Wind energy for electric generation

A lot of work has been done on studying the wind power potentials in Hong Kong region. Fung [2] did a preliminary study on the feasibility of wind power using one-year measured data at the Lantau Island. Lu and Yang [3,4] have investigated the wind power potentials at some Hong Kong islands by analyzing the local weather data and wind turbine characteristics. Zhou [5] has statistically analyzed the wind power potentials in the Pearl River Delta region based on hourly measured time-series wind
data of four coastal islands around Hong Kong. The results show that the wind energy in this region were found to be encouraging, however, the wind power at different site varies significantly, so attention should be paid to the wind conditions as well as the site terrains in choosing the wind farm sites.

With the wind turbine tower seated on the peak of a small hill, and the turbine hub 12 m above the ground level, the two 6kW wind turbines (Figure 2) are proposed to be able to provide a good utilization factor for the wind energy applications. The wind turbine’s output DC voltage is 300V, with the help of a grid-connected inverter, AC output of 220V is connected to the local utility grid.

Figure 2. Wind turbines in the park

4. Solar energy for electric generation

The first photovoltaic system in Hong Kong was developed by The Hong Kong Polytechnic University in 1999. It is a remarkable step on the application of photovoltaic system in Hong Kong and has greatly promoted the application of solar energy in the territory.

Several facilities in this park employed the solar photovoltaic technology, such as the PV shelter, solar tracker, and solar-wind hybrid lighting system.

4.1 PV shelter

In order to investigate the technical, operation and maintenance issues of grid-connected photovoltaic (BIPV) applications under Hong Kong weather conditions and demonstrate solar power application to the local industry, a PV system (Figure 3) was incorporated on the PV shelter roof and comprises 18 PV panels with a rate power of 2.97 kWp. In order to increase the DC voltage according to the inverter’s requirement, 9 PV modules are connected in series, so the PV system’s output DC voltage is between 325V and 395V, with the help of a grid-connected inverter, AC output of 220V is connected to the local utility grid. This project is a remarkable step on the application of grid-connected photovoltaic system in Hong Kong and will greatly promote the application of solar energy in the territory.

Figure 3. PV system on PV shelter roof

4.2 Solar tracker

Solar tracker is a device for orienting a solar photovoltaic panel toward the sun. Trackers are helpful at those times when the sun is shining but stationary panels are not producing. In order to show how much a tracker will help under Hong Kong weather conditions, one solar tracker (Figure 4) was
employed in this park. The solar tracker used in this park is active and single axis type. With one PV module amounted, its nominal power output is found to be 165 W, and the operating voltage is 36 V DC. With the help of an electronic load controller, the generated electricity is then utilized to pump a mini fountain to demonstrate the solar fountain application together with the auto tracking technology of photovoltaic arrays.

Figure 4. PV tracker in the park

4.3 Solar-wind hybrid lighting

Solar Lighting is the simplest and safest way of solar energy application for outdoor lighting purpose. Hybrid Solar-Wind Lighting system uses both solar energy and wind energy to provide power for outdoor lighting. Light fixture contains a solar PV panel and a wind turbine to convert sunlight and wind energy to electrical power.

The hybrid lighting systems can provide more reliable lighting service due to the complementary characteristics between solar energy and wind energy. The hybrid solution combines solar and wind energy production into one platform. The strength of one source could overcome the weakness of the other during a certain period of time. Therefore, the hybrid solar-wind lighting system is more likely to produce power when you need it.

Figure 5. Solar-wind hybrid lighting systems

5. Ground Source Heat Pump system

The ground source heat pump (GSHP) system that uses the ground as a heat source can provide buildings cooling, heating and hot water supply. In GSHP systems, heat is extracted from or rejected to the ground via a closed loop through which pure water circulates. The ground heat exchangers (GHEs) used in closed loop system typically consists of some high-density polyethylene (HDPE) pipes installed in vertical boreholes or horizontal trenches. The vertical GHE, which consists of a number of boreholes, each containing a U-tube pipe, is the most popular design of GSHPs currently employed, since it requires less ground area than the horizontal trench systems. The proper design and performance simulation of the GHEs is critical for successful application of these systems in wide variety of climate and building categories. A reasonable design can satisfy building HVAC loads, reduce the power demand and energy consumption, and minimize ground areas used as well.
The ground heat exchangers of the Ground Coupled Heat Pump system used in this park is composed of two vertical and two inclined 30 m depth boreholes. Each borehole containing a high-density polyethylene U-tube, heat is extracted from or rejected to the ground through the U-tube by the circulating water in it.

Figure 6. U-tube in the borehole

6. Small hydro power

To demonstrate small hydro power generation in the park, a 400W hydro power system is constructed for generating electric energy. The water in the high-level water tank is used to drive the small turbine. A small dam (made of concrete) was constructed near the second pedestrian bridge crossing the water channel. A transparent pipe for optical attraction transports the water down to the turbine located about 12m lower in altitude. The outlet of the dam was therefore being situated at 30m altitude. The turbine and generator are situated on a small foundation beside the water canal and near the information platform, at an altitude of 18m.

With an available head of 9m and a water flow of 8.4l/s, the system capable to produce a nominal power of 390W. With the help of an electronic load controller, the voltage can be stabilized to 110V or 220V (or other voltages) for grid connection application.

Figure 7. Drilling of the borehole for GSHP

7. Biomass Energy

Biomass already accounts for about 14% of the world’s total energy supply, and is a steadily increasing in importance for heat and power supply as well as cooking applications (in rural areas of developing countries) all over the world. In China for example, the biomass technologies has a long tradition and the industry is pleased with a booming market, which is estimated to be a
resource of about 5 billion tons of biomass annually.

As 80% of China’s population are living in rural areas and still a large number is living without connection to grid, the heat and power generation by biomass is an attractive solution. Furthermore biomass like straw and stalks etc. are available in all of these regions and are easy to harvest. Except its large potential, biomass has – of course - also the advantage that it is a much cleaner energy resource than fossil fuels.

One gasification system is used for Ma Wan Renewable Energy Park biomass facility. Moreover the produced biogas can be used as a clean fuel for biogas based cooking with a stove. Additionally a storage system for the produced biogas is employed to ensure a regular operation during the visiting hours of the Ma Wan Renewable Energy Park.

8. The Way in the Future

As the pollution problems and the possible shortage of traditional fossil fuel are critical issues on the future energy source, it is believed that the use of renewable energy is a key element in order to achieve sustainable development. The HKSAR Government has put much effort in the development of renewable energy in recent years. The feasibility study report on renewable energy application released by the Government suggested that the renewable energy contribution in year 2012, 2017 and 2022 should be set at 1%, 2% and 3% of annual electricity demand of 1999 respectively [5]. Part of these targets are included officially in the “First Development Strategy for Hong Kong” announced by the Government in 2005 [6]. Further, related construction society gives incentives to building developers to incorporate “green features” into buildings. With the above policies, the development of renewable energy systems would be the way forward for Hong Kong.

It is believed that a rapid growth would be guaranteed if much more support is given by the Government and the power supply companies.

References

[1] EMSD (Electrical & Mechanical Services Department, Hong Kong), 2002. Study on the Potential Applications of Renewable Energy in Hong Kong: Stage 1 Study Report, EMSD, Hong Kong Special Administrative Region.