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Information Sheet

Paper Title:

Construction of the First Offshore Wind Monitoring Station in Hong Kong

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CONSTRUCTION OF THE FIRST OFFSHORE WIND MONITORING STATION IN HONG KONG

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Abstract

HK Electric is committed to promote renewable energy development in Hong Kong and has already launched successful renewable projects including the Lamma Winds and the Thin Film Photo Voltaic (TFPV) system in Lamma Power Station. In the meantime, preparation for development of a 100MW offshore wind farm at Southwest Lamma is in progress with the Environmental Permit of this project granted by the Authority in June 2010. The estimated annual generation from the offshore wind farm accounts to around 1.6% of the total generation of HK Electric system in 2012, which is adequate for consumption of 50,000 Hong Kong families. It can supplant the use of around 62,000 tonnes of coal per annum, hence a reduction of 150,000 tonnes of carbon dioxide.

On-site meteorological and oceanographic data collection is crucial for the offshore wind farm design. An offshore wind monitoring station has been set up at the proposed wind farm site for conduction of the required wind monitoring campaign. Despite of its offshore in nature, the wind monitoring station is a classified as a building where all building codes have been followed on its design and construction. Wind data is collected by a Light Detection & Ranging (LiDAR) unit installed in-situ of the offshore wind monitoring station. This represents the first of its kind being deployed in Asia for capturing wind speed and directional data in an offshore

environment.

This paper serves to share HK Electric's experience on the design and construction of the offshore wind monitoring station, with emphasis on the green initiatives inherent in the development.

KEYWORDS: Renewable Energy, Wind Monitoring Station

Project Background

As one of the major suppliers of electricity in Hong Kong, HK Electric is committed to promoting the development of renewable energy for power generation. As part of this commitment, HK Electric pioneered the development of wind and solar power systems in Hong Kong with the launching of Lamma Winds (Figure 1) in February 2006 and TFPV system (Figure 2) in July 2010 respectively.

Fig. 1 – Lamma Winds

Fig. 2 – TFPV in Lamma Power Station

These projects were backed with tremendous supports from the government and the general public which has enabled HK Electric to gain valuable experience in development of renewable energy in Hong Kong. It also laid a solid foundation for the subsequent exploration of other large scale renewable energy projects in the territory.

Offshore Wind Farm

Development of a commercial scale wind farm in Hong Kong can contribute to improvement of the local air quality, and to the fulfillment of the Government's proposed target of having 3-4% of the total power generation in Hong Kong coming from renewable energy sources in the next decade as revealed in the public consultation on Hong Kong's Climate Change Strategy & Action Agenda in September 2010.

An Environmental Impact Assessment (EIA) with comprehensive site selection study on identifying potential wind farm sites was conducted since 2006. The study which covered both onshore and offshore site throughout the entire Hong Kong territory concluded an offshore area 3.5km southwest of Lamma Island is the best option for the project with the least physical and environmental impacts to the surrounding environment.

The planned capacity of the offshore wind farm is around 100MW. The site boundary occupies an area of about 600 hectares with water depth ranges between 17 and 23m. The preliminary layout is shown in Figure 3 below.

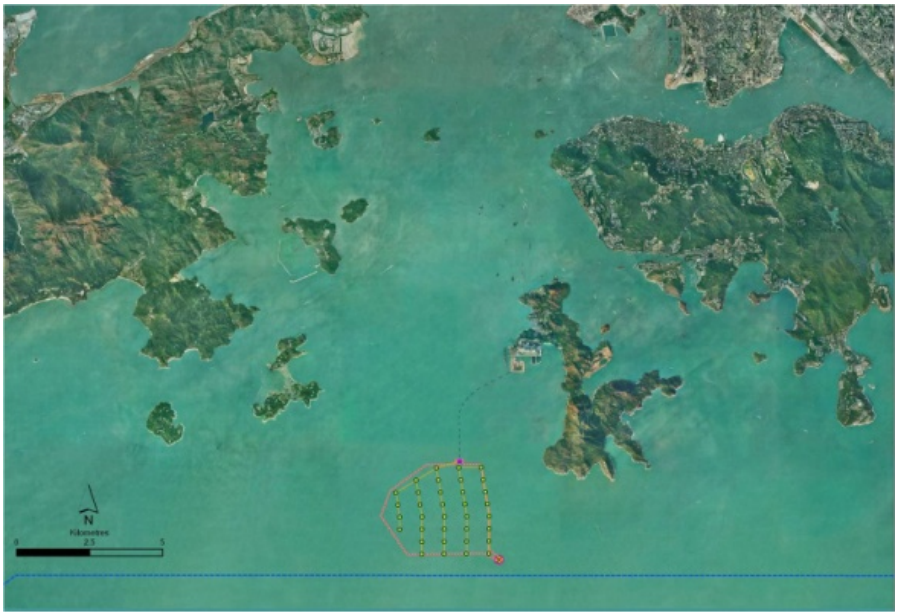

Fig. 3 – Proposed Location for Wind Farm

The estimated annual generation from the wind farm accounts to about 1.6% of the total generation of HK Electric system in 2012, which is adequate for consumption of 50,000 Hong Kong families. It can supplant the use of around 62,000 tonnes of coal per annum, hence a reduction of 150,000 tonnes of carbon dioxide.

Wind Monitoring Station

In-situ meteorological data collection is crucial towards determination of the project viability. This is so not only because of the need to predict energy yield that the wind farm can produce, but also to provide fundamental information that may be required for the wind turbine design in the subsequent stage. In view of this, HK Electric has set up a wind monitoring station on a dedicated offshore platform within the proposed wind farm site to pursue with a 12-month data collection campaign. The 12-month span was required to capture the seasonal variation that may occur throughout the whole year period. Apart from meteorological measurement,

oceanographic data is also collected using an Acoustic Doppler Wave and Current Profiler deployed onto the seabed to capture the wave, tidal and current behaviors at the proposed wind farm site.

Although this wind monitoring station is a temporary structure in nature, it is classified as a building under the Buildings Ordinance where all building codes have been followed on its design and construction. Despite the platform is designed for unmanned operation offshore, Fire Services Certificate and Occupation Permit have been granted by the Fire Services Department and Building Department respectively same as other ordinary buildings existed in the local territory.

Operation of the wind monitoring station has commenced since early March 2012 and the 12-month wind monitoring campaign has been completed in end February 2013.

Green Initiatives

To demonstrate HK Electric's commitments to environmental protection and effort rendered for resource optimization towards its design and construction, two key initiatives have been adopted in the design of the wind monitoring station.

LiDAR System

A Light Detection & Ranging (LiDAR) system has been utilized in the wind monitoring station for collection of the meteorological data. This installation represents the first LiDAR deployment for offshore wind measurement in the Asian region. Unlike other conventional met masts comprising of a tower structure mounted with layers of cup anemometers and wind vanes, the LiDAR system is a

relatively new technology that makes use of the principle of Doppler shift of laser beam scattered by microscopic airborne particulates to capture meteorological data (Figure 4). The collected data is then fed into a processor that can generate three-dimensional views on wind speed and wind direction. The application of LiDAR can substantially reduce the overall height and weight of the wind monitoring station, leading to a drastic reduction in the static load as well as the structural requirement such as the steel tonnages of foundation piles and lattice tower, hence effectively maximize the resource utilization of the installation.

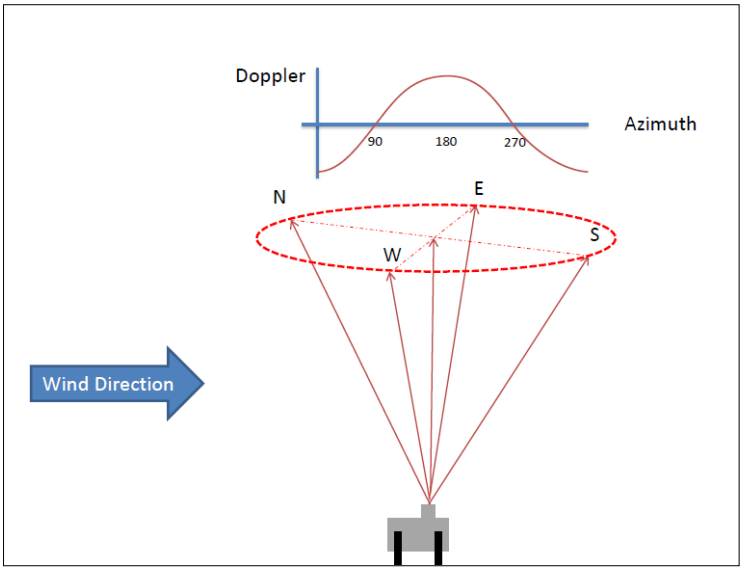

Fig. 4 – LiDAR Technology

The LiDAR system is now receiving more attention from developers and consultants in the field in recent years as it has several technical advantages when compared with conventional met masts. Apart from its advantages of the substantial reduction in foundation construction effort, the high portability of the LiDAR system allows the convenient transportation and easy dismantling of the associated equipment makes it particularly suitable for temporary installation in an offshore environment.

Fig. 5 – Wind Monitoring Station (WMS)

Fig. 6 – Top View of WMS

Foundation of the wind monitoring station platform consists of 4 conventional steel raking piles each of 965mm diameter driven down into 60m below seabed by percussive piling using hydraulic hammer. The foundation design represents a saving

of roughly 25% of steel tonnage compared with a foundation designed to support conventional met mast. A 5m diameter concrete landing platform was constructed to sit on the marine piles at +5mPD to further support a 4m x 4m main station platform at +12.5mPD via a steel hollow column with diameter of 1.5m. The wind monitoring station is shown in Figure 5 & 6 with its basic design parameters tabulated in Table 1 below.

Location	**3.5 km Southwest of Lamma Island**
Pile Cap Level	**+5 mPD**
Platform Level	**+12.5 mPD**
Total Height	**22.5m**
Platform Area	**4m x 4m**
Platform Installations	**Galion LiDAR** **10m reference met mast** **3 small wind turbines** **14 solar PV panels** **Civil aviation lights** **Marine navigational lights** **Fog horn** **CCTV** **Radar reflector** **Bird repelling system**

Table 1 – General Information of WMS

Renewable Energy Installation

The second initiative inherent in the wind monitoring station design is the maximization on the use of renewable energy. Three small wind turbines of 600W each and fourteen solar photovoltaic (PV) panels of 95W each have been installed on the wind monitoring station serving as the primary power supply to sustain operation of the wind monitoring station.

This wind/solar hybrid system with battery storage provides a reliable power supply as the two renewable energy sources can supplement each other to cater for both the strong wind season in winter and the high solar illumination season in summer. Instead of setting the inclination angle for the solar PV panels at 22° to maximize the solar capture for all year round output, tilt angle for the solar PV panels has been optimized at 15° for the summer months when the wind speed is expected to be at its lowest.

Electricity generated from the wind/solar hybrid system is sufficient to power all electrical installations on board of the platform including the LiDAR as well as its associated data logging & transmission facilities. The power supply system is also designed adequate to sustain the continuous and reliable operation of all safety installations such as marine navigation lights, aviation warning lights, fog horn, CCTV and a bird repelling system. The annual electricity consumption of the above electrical equipment onboard of the wind monitoring station is around 3,500kWh, which is totally supplied by the renewable energy installations in situ at the platform. As such, operation of this offshore building structure can be considered as electrically self-sustained with a zero emission associated with its power consumption.

Environmental Considerations

Due considerations in environmental concerns with regard to the construction of the wind monitoring station have been undertaken. An Environmental Team (ET) responsible for implementation of the Environmental Monitoring & Auditing (EM&A) programme has been established before commencement of construction of the wind monitoring station. In addition, an Independent Environmental Checker (IEC) has

been engaged responsible for auditing the overall EM&A performance before, during and after the wind monitoring station construction stages. The IEC has taken prudent steps in verifying the environmental acceptability resulted from all permanent & temporary site works. Site audits were carried out at least twice per month by the ET in consultation with the IEC to assess the environmental performance of all concerned parties involved in the construction activities. It is worth noting that the ET team comprises of both HK Electric engineers as well as external consultants of relevant field of expertise.

The EM&A programme associated with the wind monitoring station construction covers visual monitoring of marine mammals during piling and those related to good site construction practices. HK Electric understands the potential disturbance that may cause to marine mammals due to marine piling works. As such we have adopted the principle of avoidance as means of mitigation measure. No percussive piling activities have been conducted during the peak sighting season of finless porpoises between the periods from December to May. Moreover, a marine mammal exclusion zone has been set up to ensure the area of works is clear of marine mammals before piling is allowed to commence. A qualified marine mammal observer has been engaged full time at site during the piling operation to supervise the piling work not to jeopardize the marine mammal that may exist at the vicinity. Other best construction practices such as adoption of ramp-up piling procedures and carrying out of piling only during daytime when any nearby marine mammals can be visually detected by the marine mammal observer have been adopted aiming to ensure any impact to the marine mammals due to construction of the wind monitoring station is reduced to an absolute minimum.

Noise and water quality are not expected to be impacted by the construction work and hence monitoring of these parameters is not statutorily required. Nevertheless, HK Electric has volunteered to carry out additional measures aiming at taking prudent steps to avoid impact to the environment. This also demonstrates HK Electric's commitment in implementing the development in a sustainable mean.

Effort for minimizing noise impact during piling work has been demonstrated by adoption of bubble curtain. Bubble curtain can effectively serve as noise barrier to avoid propagation of underwater noise beyond the sound source. Underwater noise level has been monitored during the piling work to ensure the sound power level generated will not exceed the threshold level for those concern mammals. In addition, monitoring points at Lo So Sing and Cheung Chau has been set up to monitored the airborne noise to ensure no disturbance to the nearby residents.

Apart from the above, HK Electric has conducted water quality monitoring, also on voluntary basis, during the piling operation aiming to ensure the construction will not cause any unacceptable deterioration to the nearby water quality. These additional measures that HK Electric have volunteered to implement has effectively eased the concerns of the local fishermen and is generally welcomed by the green groups and our major stakeholders.

The overall environmental performance during construction of the wind monitoring station has been satisfactory. In line with the EIA predictions, the construction work has not caused any adverse impact to the environment as well as disturbance to the nearby sensitive receivers.

Construction Challenges

Construction of the wind monitoring station posed a challenge to our project team. This is primarily due to our lack of previous experience in offshore marine construction, in particular the need for competing with time to complete the construction work within a short window amid a unpredictable sea state.

From the period of November to February which is the monsoon season in Hong Kong, over half of the calendar days were overridden by the rough sea conditions such that the derrick barge could not be safely anchored to provide a workable condition for the construction team. Under these circumstances, the offshore team had to station at barge and wait until the arrival of a favorable sea condition that could allow work resumption. To ensure smooth pursuance of the offshore installation in the limitedly available marine workable window, advance preparation and testing were carried out onshore as far as practicable to minimize the extent of offshore work. This measure is of particular importance towards chasing up any delayed progress due to inclement weather, and yet this help minimizing the retention time of workers staying offshore hence reducing the risk that may expose to them. This experience provides our project team valuable reference towards planning for the future offshore wind farm erection.

Measurement Results

Since commissioning of the wind monitoring station in March 2012, promising results have been collected indicating the actual wind resources at the proposed wind farm site are in line with our previous in-house prediction.

With the advancement of new wind turbine models of longer rotor blades for better output performance in particular for areas with medium wind speeds such as that in Hong Kong, it is envisaged that the annual average energy production from the proposed offshore wind farm will likely be higher than that predicted from previous desktop studies. Nonetheless, the wind data collected from the wind monitoring station is being consolidated for conduction of a Measure-Correlate-Predict analysis making reference with the long term weather available from suitable local meteorological stations before we can accurately predict the annual wind farm output available at the proposed site.

Concluding Remarks

HK Electric has been taking initiatives to develop renewable energy projects in recent years in response to the public's expectations for sustainable development. This is also in line with the Government's proposed renewable energy target. An offshore wind farm of around 100MW capacity at 3.5km southwest of Lamma Island is being planned. The estimated annual generation from the offshore wind farm accounts to around 1.6% of the total generation of HK Electric system in 2012, which is adequate for consumption of 50,000 Hong Kong families. It can supplant the use of around 62,000 tonnes of coal per annum, hence a reduction of 150,000 tonnes of carbon dioxide.

To pave way for the offshore wind farm development, a wind monitoring station adopting LiDAR technology has been launched since March 2012 to collect the in-situ meteorological and oceanographic data within the wind farm boundary. All building codes have been followed on the design and construction of the wind

monitoring station which is classified as a building under the Buildings Ordinance.

Green initiatives have been inherent in the design of the wind monitoring station. The use of LiDAR technology instead of a conventional met mast has effectively optimized the use of resource in particular the extent of piling effort hence reducing the construction impact. Maximization on the use of renewable energy on board of the platform has allowed operation of the wind monitoring station throughout the entire 12-month period to be electrically self-sustained without the need for fossil fuel consumption. The voluntary implementation of environmental monitoring measures during the construction stage has demonstrated HK Electric's commitment in taking every prudent step to avoid impact caused to the environment associated with the development, despite the construction challenges that we have faced during the marine construction work.

The wind monitoring campaign has come to an end in end February 2013. The wind data collected is being consolidated for conduction of further analysis as part of the overall feasibility studies of the proposed wind farm project. HK Electric is confident this offshore wind farm project can gain the support from our local community, thereby allowing us to make a contribution to sustaining a blue sky in Hong Kong.

Acknowledgement

This paper is issued with the permission of the management of The Hongkong Electric Company Limited.

Reference

[1] ERM (HK) Ltd., “Development of an Offshore Wind Farm in Hong Kong – EIA Report”, 2010

[2] Frank Lau & Y.L. Kwan, “Development of an Offshore Wind Farm in Hong Kong”, HKIE Electrical Division Annual Seminar, 2011

[3] Frank Lau, “Road Map to Sustainable Future”, HKIE Environmental Division Annual Seminar, 2012

[4] Frank Lau, Norman Chan & Henry Chan, “Development of an Offshore Wind Farm in Hong Kong”, The 19th Conference of the Electric Power Supply Industry, 2012

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