Technical Guidelines on Grid Connection of Small-scale Renewable Energy Power Systems

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***Abstract*—EMSD published a Technical Guidelines on Grid Connection of Small-scale Renewable Energy Power Systems in May 2005. This paper outlines the main provisions in the Technical Guidelines with respect to safety considerations, equipment protection, reliability, and power quality aspects of such grid-connected renewable energy installations. The grid-connected PV installations at Wanchai Tower and the new EMSD Headquarters are also briefly described.**

***Index Terms*—Building Integrated Photovoltaic System, Grid Connection, Renewable Energy, Small-scal Renewable Energy Power System.**

I. Introduction

Hong Kong does not have any indigenous fossil fuel resources. The only natural resources available for energy production are the renewable energy (RE) resouces. While renewable energy resources, mainly solar and wind resources, are available to us, they can only fulfill a limited extent of our energy needs. In spite of this, it is important that we do harness renewable energy wherever possible, in order to supplement fossil fuel-based power generation and protect the environment.

Depending on the scale, there are two types of RE installations – utility-scale (or commerical-scale) installations and small-scale installations. In Hong Kong, the power companies have committed to build two commercial-scale wind turbines. We expect to see one of those in operation in 2006.

On the other hand, quite a number of small-scale RE installations have been built by the private sector and by the government, mainly photovoltaic (PV) installations at a few kW to tenths of kW capacity, and solar water heating installations. Among the PV installations, most are standalone systems serving dedicated loads, while a few are directly connected to the electrical distribution system within the site or the building. The latter are the so-called grid-connected RE installations as they operate in parallel with the electricity grid to serve the electricity needs of the respective sites or buildings.

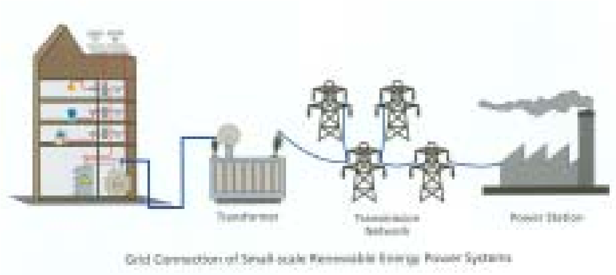

Fig. 1. Grid-connected Small-scale Renewable Power System

Due to the intermittency of renewable energy resources, the power output from a standalone RE installation fluctuates according to the available solar or wind energy. In contrast to this, a grid-connected RE installation on one hands supplements the grid supply, and on the other hand is supplemented by the grid supply when the solar or wind energy is curtailed by weather.

In late 2002, EMSD installed a grid-connected building-integrated photovoltaic (BIPV) system at Wanchai Tower. The whole BIPV system consists of three separate sub-systems – a rack-mounted installation on the roof, a glass-embedded installation forming shading screens outside the windows of office floors, and another glass-embedded installation forming the entrance atrium. Total installed capacity of the whole system is 55kW.

The purpose of installing the system is to gather actual performance data of BIPV installations under Hong Kong's climatic conditions, and to gain hands-on experience in the installation and operation of such systems.

II. The Technical Guidelines

With the experience gained from the Wanchai Tower BIPV project, it became obvious that there are a number of technical considerations which are very important to the successful implementation of a grid-connected RE project, namely: safety, equipment protection, supply reliability, and power quality.

In this connection, EMSD convened a Working Group on Grid Connection of Small-scale Renewable Energy Power Systems (SREPSs) with representatives from professional institutions, trade associations, utilities, and other stakeholders, to produce a set of technical guidelines. The *Technical Guidelines on Grid Connection of Small-scale*

Renewable Energy Power Systems was finalised and published in May 2005.

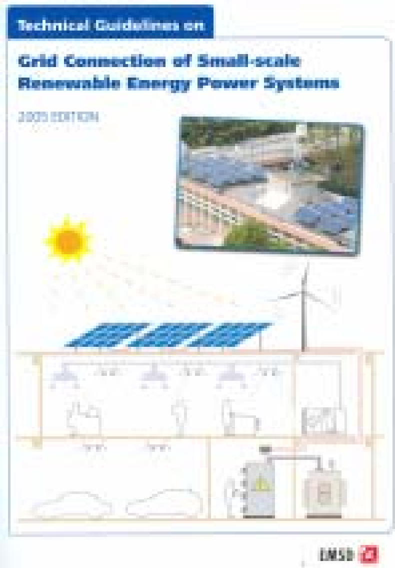

Fig. 2. Cover of the Technical Guidelines

The Technical Guidelines are applicable to grid-connected SREPSs of aggregated power ratings of up to 200kW. The Guidelines cover only the technical aspects of the SREPS's connection to the electricity grid. The Guidelines do not purport to be a design manual. The owner of the SREPS should ensure that the system complies with all prevailing statutory requuirements and best engineering practices.

III. Safety Considerations

If the SREPS remains connected to the electrical distribution system of a site in the event of an interruption in the electricity supply from the grid, switchboards may continue to remain energised, and the distribution system within the site operates like an "island" detached from the main continent of the electricity grid. Besides technical problems that may arise (such as collapse of voltages when the grid supply is absent), it poses a danger for electricians.

Therefore, an "anti-islanding" protection function should be incorporated into the design of the SREPS. This function can automatically disconnect any grid-connected SREPS from the electrical distribution system in the event that the grid supply is interrupted for whatever reasons.

When the grid supply is restored, the SREPS can either be re-synchronised to grid under manual control, or it can be automatically re-synchroised to grid after certain time delay.

IV. Equipment Protection

When a SREPS is added to an existing electrical distribution system, the original short-cirucit current levels (i.e. fault levels) of the distribution system will be elevated. It is important during design stage to re-assess the fault levels of the distribution system due to the introduction of the SREPS into the system, and to re-adjust the protection device settings within the distribution system where necessary.

The anti-islanding time setting should be suitably chosen according to utility company's requirements. Very often, grid supply interruption occurs only for a very brief period of time due to automatic restoration features of the utility power system. At the time the grid supply is restored and if the SREPS still remains connected to the distribution system, the output of the SREPS may be out-of-synchroism with the grid supply and damage may occur to the equipment. Proper choice of the anti-islanding time setting can minimize the occurrence of such undesirable situations.

By the same token, facility should be provided to ensure that the SREPS is in synhcronisim with the grid supply (i.e. their voltages, frequency, and phase angles are within limits) before connecting the SREPS to the distribution system.

Some other features recommended for the SREPS include:

(a) Facilities to automatically disconnect the SREPS from the distribution sytem when a fault occurs in the SREPS;
(b) Facilities to disconnect the SREPS from the distribution system when sustained voltage and frequency fluctuations/deviations are detected in the distribution system;

In case (b) above, it is recommended to incorporate facilities to autoamtically re-connect the SREPS back to the distribution system when voltage and frequency in the distribution sytem are back to normal. There are reoccmendations in international standards regarding the time delay setting before re-connection can take place.

V. Reliability

It is important that the electricity suppy to existing loads would not be adversely affected by the introduction of a grid-connected SREPS. One of the key components affecting reliability of the SREPS is the inverter, in the case of PV installations. An inverter with long MTBF (mean time before failure) and of proven design should be chosen.

The protection device settings in the distribution system should be carefully chosen so as not to cause improper disconnection of parts of the system under fault conditions (bearing in mind the elevated fault levels due to the introduction of the SREPS).

VI. POWER QUALITY

Good power quality for the electricity supply is important for proper operation of elecrical and electronic equipment.

An inverter is often included as part of a SREPS. Power conditiioning function should be incorporated in the inverter to reduce harmonic currents injected into the system and to raise the power factor of its output. An isolation transformer on the output side of the inverter can eliminate the possibility of injection of direct current into the distribution system. Excess direct current injection will cause voltage distortions in the system.

When the distribution system is a three-phase one, use a three-phase inverter to provide a balanced output to all the phases.

VII. UTILITY LIASON

When an owner of a building or site decides to install a SREPS, it would be advantageous for the owner to contact the utility company serving his/her area at the very beginning of the project. This ensures that the utility compay can provide advice on the grid-connection aspect of the SREPS.

The owner and the utility company should then come to an agreement on the most suitable connection arrangement of the SREPS. Both parties should also discuss and reach an agreement on the terms and conditions of the grid connection. A list of information to be submitted with the grid connection application to the utility company is given in Appendix (II) of the Technical Guidelines.

A list of local and overseas standards, codes and best practices relating to grid-connected RE installations is also given in Appendix (III) of the Technical Guidelines. The designer of the installation can make reference to these documents.

VIII. SREPS AT NEW EMSD HEADQUARTERS

The Electrical and Mechanical Services Department has installed the largest roof-mounted PV installation in Hong Kong, in its new headquarters in Kowloon Bay. A wind turbine has also been installed on the roof.

The 350 kW PV installation involves a solar array made up of almost 2400 PV modules which together has a total area of about 8,000 m2, and a smaller building-integrated photovoltaic (BIPV) system.

Each PV module in the solar array is constructed in the form of a rectangular panel and consists of 72 series-connected mono-crystalline silicon PV cells. The panels are mounted on supporting racks in an inclined manner and facing southwards so as to receive maximum solar irradiation in the course of a year.

In addition to these PV panels, BIPV laminates are also installed on the glass-enveloped viewing gallery on the roof of the building. There are totally 20 sets of BIPV laminates, each consisting of 100 series-connected mono-crystalline PV cells.

The d.c. output of the installation is converted into a.c. by a number of inverters. The a.c. power generated by the PV installation supplements the electricity supply from the power company to meet the electrical power requirement of the building.

IX. CONCLUDING REMARKS

It is hoped that through the publication of the Technical Guidelines, more building owners will consider to install SREPSs in Hong Kong.

X. REFERENCES

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XI. BIOGRAPHY

Joseph K. C. CHAN is currently a Senior Engineer serving in the Energy Efficiency Office of the Electrical and Mechanical Services Department. He has been actively promoting the application of renewable energy in Hong Kong. He is a Fellow of several professional institutions.