HANDBOOK FOR PHOTOVOLTAIC (PV) SYSTEMS

10TH SEPTEMBER 2007

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Note:

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1 Introduction

1.1 Solar cells convert sunlight directly into electricity. When the semi-conducting materials of the solar cells absorb sunlight, the electrons become liberated from their atoms and flow through the materials to produce electricity. This process of converting light to electricity is called the photovoltaic ("PV") effect.

1.2 PV systems may be connected to the electrical installation within your (residential or non-residential) premises to generate electricity for your own use. Any excess power may be sold into the wholesale electricity market through the power grid owned by SP PowerAssets ("SPPA"). This Handbook gives an overview of the current licensing, market and technical requirements to ensure safety, reliability and power quality of your electrical installation and of the power grid. You are also advised to refer to the details in the documents listed in this Handbook as you embark on implementing your PV system.

1.3 The contact information for enquiries on matters pertaining to PV systems is summarised in Appendix 1.

2 Electricity Licensing Requirements

2.1 If you generate electricity by means of a PV system *with less than 1 MW generation capacity*:[1]

(a) You are *not* required to hold a Generation Licence to be authorised to generate electricity from the PV system; and

(b) It is *optional* for you to register with the wholesale electricity market, which is called the NEMS (National Electricity Market of Singapore). You need to register with the NEMS *only if you wish to sell and get paid for the electricity you inject into the power grid*. However if you are a residential electricity consumer, please refer to section 7.

[1] A typical PV system in Singapore is not expected to exceed 1 MW in generation capacity. For a generation capacity of 1 MW or above, the licensing requirement is as follows:

(a) For 1 MW or above but less than 10 MW and connected to the power grid, a Wholesaler (Generation) Licence is required.

(b) For 10 MW or above, a Generation Licence is required.

2.2 If you choose to register with the NEMS to sell and get paid for electricity you inject into the power grid, you have to apply to EMA for a Wholesaler (Generation) Licence. The application form is available at the following EMA website:

http://www.ema.gov.sg/doc/licence_application_form_Wholesaler_(Generation).doc

2.3 The Wholesaler (Generation) Licence fee payable to EMA is currently $1,000 per annum.

2.4 The EMA contact person on licensing matters is:

Mr Teo Nan Shing
Deputy Director (Economic Regulation & Licensing)
Email: ema_rs@ema.gov.sg
Tel: 6835 8068

3 Market Participation

3.1 If the generation capacity of your PV system is below 1 MW, it is *optional* for you to register with the NEMS. You need to register (yourself as a Market Participant and your PV system as a Generation Settlement Facility) with the NEMS *only if you wish to sell and get paid for the electricity you inject into the power grid*. However if you are a residential electricity consumer, please refer to section 7.

3.2 The application procedures for Market Participant registration and for generation facility registration, are set out in the "Market Administration Market Manual – Registration and Authorisation" which is available at the following website of Energy Market Company ("EMC"):

http://www.emcsg.com/n393,86.html

EMC administers and operates the NEMS.

3.3 As a Market Participant, you will need to comply with the Market Rules which is available at the following EMC website:

http://www.emcsg.com/n916,12.html

3.4 By selling electricity in the wholesale electricity market, you will be paid the prevailing spot electricity price for the electricity that you inject into the power grid. The spot electricity price varies every half-hour, depending on the demand-supply situation in the wholesale electricity market.

3.5 In selling electricity in the wholesale electricity market, the market has to provide services and system resources to you. You will be subject to market charges (specifically EMC fee, PSO fee, and regulation reserve ("AFP") charges) in respect of the *gross generation output* from your registered PV system for the provision of the market services and system resources. The historical spot electricity prices and market charges can be viewed at the following EMC website:

http://www.emcsg.com/n390,20.html

3.6 The person from EMC to contact if you need more information or help on the Market Rules, market registration process and market charges is:

Mr Poa Tiong Siaw
Senior Economist
Email: tiongsiaw.poa@emcsg.com
Tel: 6779 3000

4 Electrical Safety Requirements

4.1 An *electrical installation* refers to any electrical wiring, fitting or apparatus used for the conveyance and control of electricity in any premises. Any PV system connected to the electrical installation is considered part of the installation.

4.2 Electrical installations are licensed by EMA to ensure they are operated and maintained by *licensed electrical workers (LEWs)*, and are safe to use.

Engaging a LEW

4.3 You are required to engage a LEW to carry out any electrical work on your electrical installation. Your appointed LEW will be responsible for the design, installation, testing, commissioning and maintenance of your electrical installation. This includes installing and connecting any PV system to the electrical installation within your premises.

4.4 There are 3 classes of LEWs: *Licensed Electrician*, *Licensed Electrical Technician*, and *Licensed Electrical Engineer*. The various classes of LEWs are authorised to design, install, repair, maintain, operate, inspect and test electrical installations according to the conditions stated below:

Class of LEW	*Approved Load*	*Voltage Level*
Electrician	Not exceeding 45 kVA	1000V & below
Electrical Technician	Not exceeding 150 kVA (Design); not exceeding 500 kVA (Operation)	1000V & below
Electrical Engineer	No limit	Subject to licence conditions

4.5 The Singapore standard for electrical safety applicable to PV systems is set out in the *Code of Practice for Electrical Installations (Singapore Standard CP5:1998)*, which is published by SPRING Singapore. A summary of the relevant electrical safety standards and requirements are set out in Appendix 2. The LEW whom you appoint to install and connect your PV system will be responsible for compliance with the relevant safety standards and requirements.

4.6 You can search for LEWs and their contact particulars at the following EMA website:

http://elise.ema.gov.sg

4.7 For enquiries on LEWs, you can contact EMA's Electricity Inspectorate Branch at:

Tel: 6835 8060
Email: ema_rs@ema.gov.sg

Applying for Electrical Installation Licence

4.8 Your LEW will advise you on whether you need to apply to EMA for an *Electrical Installation Licence* for the use or operation of the electrical installation within your premises:

(a) If an Electrical Installation Licence is needed, your LEW will submit the licence application to EMA on your behalf.

(b) If you already have an Electrical Installation Licence issued by EMA in respect of the electrical installation within your premises, there is no need to apply for a separate licence for the PV system within the same premises.

4.9 The current electrical installation licence fee payable to EMA is $100 per annum.

5 Connecting to the Power Grid

5.1 If you intend to connect and operate your PV system in *parallel* to the power grid, your appointed LEW will have to consult SPPA's agent, SP PowerGrid ("SPPG") on the connection scheme and the technical requirements.

5.2 A summary of the consultation process to connect your PV system to the power grid, is given in Appendix 3. The following documents set out the detailed consultation process and technical requirements:

(a) the Transmission Code and the Metering Code, which are published at the following EMA websites:

http://www.ema.gov.sg/doc/transmission_code.pdf

http://www.ema.gov.sg/doc/metering_code.pdf

(b) SPPG's handbook entitled "How to Apply for Electricity Connection", which is published at the following SPPA website:

http://www.sppowerassets.com.sg/PDF/howtoapply.pdf

5.3 The SPPG contact person regarding connection of your PV system to the power grid is:

Mr James Goh
Engineer (Distribution Planning Section)
Email: jamesgoh@singaporepower.com.sg
Tel: 6823 8553

6 Buildings & Construction Safety

6.1 There may be safety standards and requirements for buildings and construction applicable to the implementation of your PV system. Please contact either one of the following officers from the Building and Construction Authority ("BCA") to ascertain the standards and requirements applicable to you:

Mr Patrick Poh
Senior Development Officer
Email: patrick_poh@bca.gov.sg
Tel: 6325 1918

Ms Alice Goh
Senior Development Officer
Email: alice_goh@bca.gov.sg
Tel: 6325 8660

7 Further Information for Residential PV Systems

7.1 For electrical safety reasons, a residential electricity consumer is required to have his PV system installed and connected to his electrical installation by an LEW (see section 4.6 on search for LEWs). However, the residential consumer is *not required* to hold an Electrical Installation Licence to use or operate his electrical installation with the PV system connected.

7.2 The residential consumer will have to apply to SP Services ("SPS") by following the application procedure set out in Appendix 3. If the residential consumer will export electricity into the power grid and wants to get compensated for the electricity exported, SPS will make arrangements for the compensation by way of a credit adjustment in the monthly electricity bill to the residential consumer. The credit adjustment will effectively compensate the residential consumer for the amount of electricity he exports into the power grid during that month based on the prevailing low-tension electricity tariff rate less the grid charge. (Note: This scheme to compensate residential electricity consumers for the electricity they export into the power grid is not applicable to those residential consumers whose electricity consumption is metered under the master-sub metering scheme.)

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Appendix 1: Contact Information

For enquiries on the following matters pertaining to PV systems:

(1)	Electricity Licences	*Energy Market Authority (EMA)* Mr Teo Nan Shing Dy Director (Economic Regulation & Licensing) Email: ema_rs@ema.gov.sg Tel: 6835 8068
(2)	Licensed Electrical Workers ("LEWs)	*Energy Market Authority (EMA)* Electricity Inspectorate Branch Email: ema_rs@ema.gov.sg Tel: 6835 8060
(3)	Electricity market rules, market registration process, and market charges	*Energy Market Company (EMC)* Mr Poa Tiong Siaw Senior Economist Email: tiongsiaw.poa@emcsg.com Tel: 6779 3000
(4)	Connection to the power grid	*SP PowerGrid Ltd (SPPG)* Mr James Goh Engineer (Distribution Planning Section) Email: jamesgoh@singaporepower.com.sg Tel: 6823 8553
(5)	Building and construction safety	*Building and Construction Authority (BCA)* Mr Patrick Poh Senior Development Officer Email: patrick_poh@bca.gov.sg Tel: 6325 1918 Ms Alice Goh Senior Development Officer Email: alice_goh@bca.gov.sg Tel: 6325 8660

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Appendix 2: Electrical Safety Standards and Requirements Applicable to PV Systems

A solar photovoltaic power supply system ("PV system") installed within a premises forms part of the consumer's electrical installation and shall comply with the requirements stipulated in the *Electricity Act (cap. 89A)*, the *Electricity (Electrical Installations) Regulations*, and the *Singapore Standard Code of Practice CP5: 1998 for Electrical Installations*.

2 Reference shall also be made to IEC 60364-7-712 or BS 7671 for the technical terms and additional guides for PV systems. These shall be read in conjunction with the following parts of CP5:

Part 3: Assessment of general characteristics

Part 4: Protection for safety

Part 5: Selection and erection of equipment

3 Special attention shall be paid to the following:[2]

(a) The protective measures for automatic disconnection of supply as stipulated in Part 4 shall be complied with. The protective measures of non-conducting location (clause 413-04) and earth-free local equipment bonding (clause 413-05) are not permitted on the d.c. side of the PV system;

(b) PV modules shall comply with the requirements of the relevant equipment standards, for example IEC 61215 for crystalline PV modules. Other accessories such as PV array junction box, PV generator junction box and switchgear assemblies shall comply with the requirements of IEC 60439-1;

(c) Protection by use of Class II or equivalent insulation shall preferably be adopted on the d.c. side of the PV system;

[2] Clause number refers to a clause in CP5 unless otherwise stated.

(d) The PV equipment shall be arranged so as to facilitate its operation, inspection and maintenance and access to each connection (clause 513-01-01L). The provisions made by the manufacturer of the PV equipment for safe maintenance and service work shall not to be affected;

(e) Single-core sheathed cables shall be used for d.c. wiring to minimize the risk of earth faults and short circuits;

(f) Means of isolation for the PV system shall comply with clause 537-02. To allow maintenance of the PV inverter, means of isolating the PV inverter from the d.c. side and the a.c. side shall be provided;

(g) All junction boxes shall carry a warning label indicating that the parts inside the boxes may still be live after isolation from the PV inverter (see IEC 712.537.2.5.1);

(h) For a PV system operating in parallel with the power grid, the power grid supply shall be considered the source, and the electrical installation with the PV system connected shall be considered the load. The PV inverters shall be configured to:

- protect the a.c. side of the PV inverter from being connected out-of-synchronism with the power grid supply; and
- automatically disconnect the PV supply upon loss of supply from the power grid;
- automatically disconnect the PV supply when the direct current injection into the power grid by the PV system exceeds 20 mA. An isolating transformer is preferably installed on the a.c. side of the PV inverter to eliminate the possibility of PV system injecting direct current into the power grid;

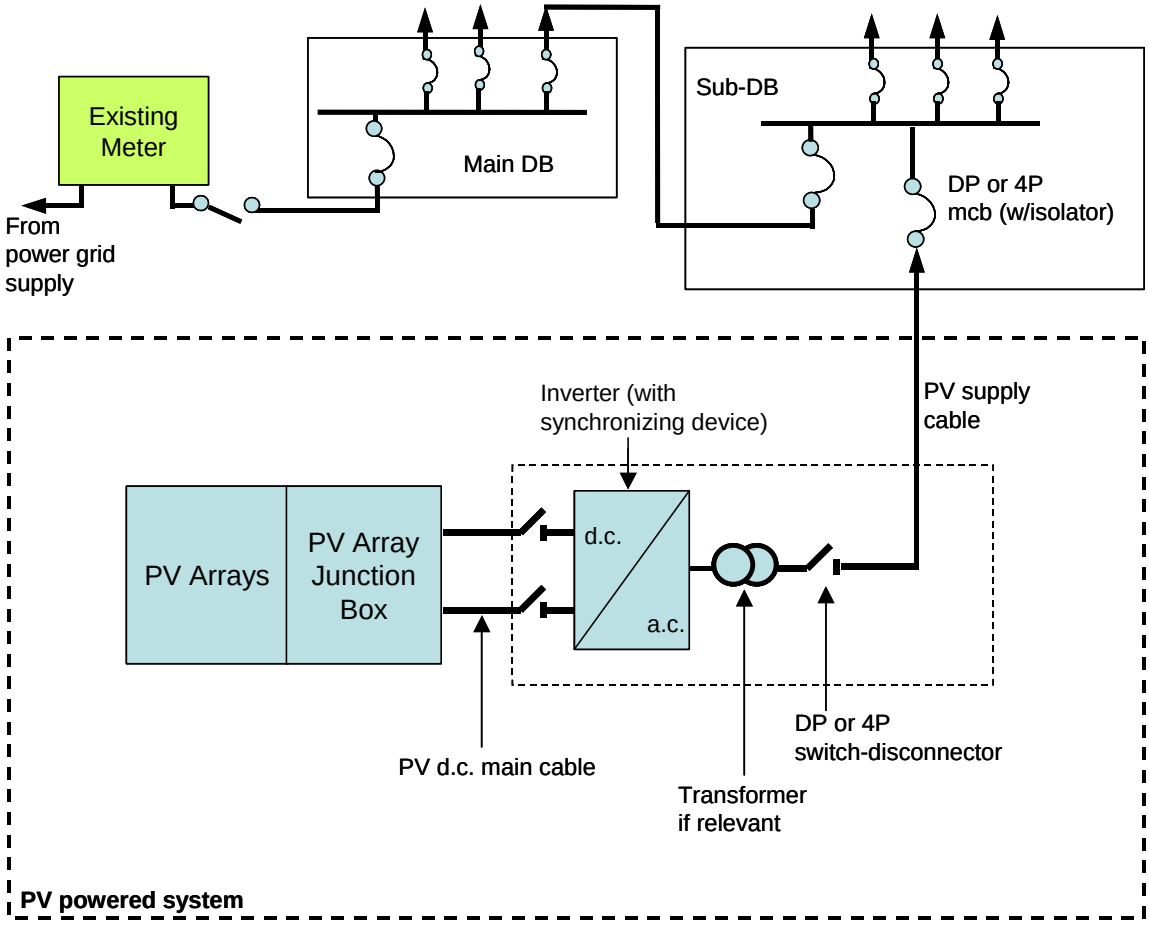
(i) Appropriate protection facilities shall be provided in the PV system to:

- disconnect the PV system from power grid supply in the event of fault occurring in the PV system;
- avoid danger to the PV system caused by transient abnormalities of the power grid supply such as voltage and frequency fluctuation, voltage dip, etc;

(j) The PV system supply cable on the a.c. side shall be protected against short-circuit current by an overcurrent protective device installed at the connection to the a.c. supply (see diagram below); and

(k) It is the responsibility of the consumers to have their PV systems maintained regularly to ensure the safe operation of their PV systems and electrical installations.

Diagram: PV System Forming Part of the Consumer's Electrical Installation



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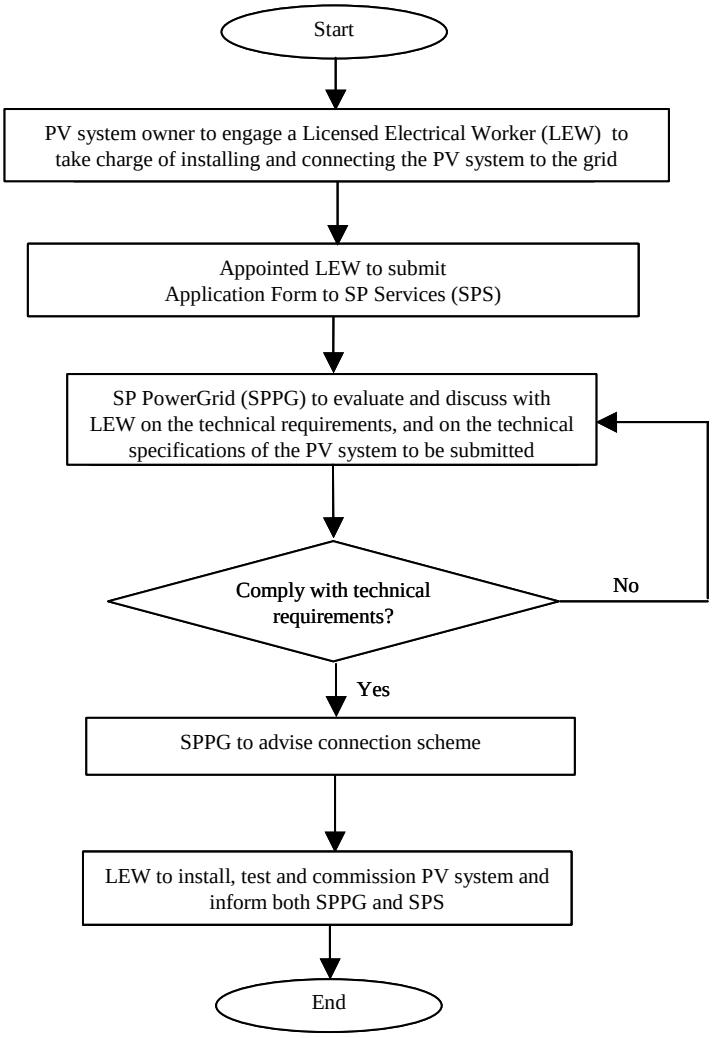
Appendix 3: Consultation Process to Install and Connect PV Systems to the Power Grid



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