Installation of Solar PV Systems

Guidance Document

January 2017
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Guidance Document

Issued by
the Regulation and Supervision Bureau
for the water, wastewater and electricity sector in the Emirate of Abu Dhabi
www.rsb.gov.ae
Foreword

The Regulation and Supervision Bureau (the Bureau) is established under Abu Dhabi Law No (2) of 1998 to regulate the electricity, water and wastewater sectors and to oversee the technical and economic activities of the Persons that are licensed to undertake Regulated Activities in the Emirate of Abu Dhabi.

This document provides further guidance on the technical requirements of Solar PV Systems already established in the Electricity Wiring Regulations (Third Edition). It also provides further guidance to the requirements for the design, specification, installation, commissioning, operation and maintenance of grid-connected solar photovoltaic (PV) systems in the Emirate of Abu Dhabi.

These Guidance and Regulations come in support to the Government of Abu Dhabi drive for promoting clean and sustainable energy. In addition, they will provide the Producers with the framework that will both ensure the successful installation of their small scale solar PV systems and connection to the Distribution Network.

This guidance document is also available for download from the Bureau’s website at www.rsb.gov.ae.

Saif Saeed Al Qubaisi
Director General
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(a) Abu Dhabi Water and Electricity Authority  
(b) Abu Dhabi Urban Planning Council  
(c) Abu Dhabi Distribution Company  
(d) Al Ain Distribution Company  
(e) Abu Dhabi Quality and Conformity Council  
(f) Abu Dhabi Future Energy Company (Masdar)  
(g) Abu Dhabi Housing Authority  
(h) Department of Municipal Affairs & Transport
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Words which are defined under this section are used in the document beginning with capital letters. For example, “all PV Modules shall be ...”.

Terms in common use are not defined here and normal dictionary definitions apply (e.g. circuit-breaker, plug, and conduit).

Class II Equipment: equipment which does not include a means for connection to an Earth Conductor, and which provides supplementary insulation in addition to the basic insulation of the equipment such that a breakdown of the basic insulation will not present a dangerous Voltage on Exposed-Conductive-Parts (also known as Double Insulated Equipment).

Bureau: the Regulations and Supervision Bureau for the Water, Wastewater and Electricity Sector in the Emirate of Abu Dhabi, as established under Law No (2) of 1998.

Connection Point (CP): the point which defines the boundary between the Owner’s Electrical Installation installed at a Premises and the main cable or equipment owned by the Distribution Company.

Customer: any person, corporate body, or company who has an agreement with a Distribution Company for the supply of electricity.

Distribution Company: a company or body holding a distribution licence, granted by the Bureau, pursuant to Law No (2) of 1998. Currently there are two companies, Al Ain Distribution Company (AADC) and Abu Dhabi Distribution Company (ADDC).

Earthing or Earthed: a general term used to describe the connection of conductive parts of an Electrical Installation or an appliance to earth.

Electrical Installation: an Electrical Installation comprises any fixed or temporary cable, switchgear or other electrical equipment or apparatus within a Premises or other place where there is an electricity supply (including outdoor locations). Fixed or portable electrical appliances are not considered part of the Electrical Installation.

Electrical Installation Certificate: a certificate in accordance with the Electricity Wiring Regulations used by the Licensed Contractor after completion of work on an Electrical Installation and provided to the Customer or Owner of the Premises.
Electrical Installation Work: work performed on an Electrical Installation by a Licensed Contractor and may involve the design, construction, installation, operation or maintenance of an Electrical Installation.

**Electricity Distribution Code:** a code prepared and maintained by the Distribution Companies detailing technical parameters and other requirements relating to the connection and the use of the distribution networks owned and operated by the Distribution Company.

**Licensed Contractor:** a person, entity or company which has been assessed by the Distribution Company as competent to work on Electrical Installations and issued a Competency Licence by that Distribution Company.

**Low Voltage (LV):** an a.c. voltage between 1000V between phases, or below 600V between any phase and earth or; a d.c. voltage below 1500V between conductors, or below 900V between any conductor to earth.

**Main Distribution Board (MDB):** the Distribution Board which accepts the main incoming LV supply from the Distribution Company or Owner’s transformer;

**Owner:** the legal owner of the Premises in which an Electrical Installation is installed.

**PV:** Photovoltaic. The following are related definitions:

**a.c. side:** part of a PV installation from the a.c. terminals of the PV Inverter to the point of connection of the PV supply cable to the Electrical Installation;

**Array:** mechanically and electrically integrated assembly of PV Modules, and other necessary components, to form a d.c. power supply unit;

**Array Junction Box:** enclosure where PV Strings of any PV Array are electrically connected and where devices can be located;

**Array Cable:** output cable of a PV array;

**Cell:** basic PV device which can generate electricity when exposed to light such as solar radiation.

**d.c. side:** part of a PV installation from a PV cell to the d.c. terminals of the PV Inverter;
**d.c. main cable**: cable connecting the PV generator junction box to the DC terminals of the PV inverter;

**Inverter**: device which converts d.c. voltage and d.c. current into a.c. voltage and a.c. current; PV supply cable connecting the AC terminals of the PV inverter to a distribution circuit of the electrical installation;

**Module**: smallest completely environmental protected assembly of interconnected PV cells;

**Open Circuit Voltage, Voc**: voltage under standard testing conditions across unloaded PV String, PV Array, or on the d.c. side of the PV Inverter.

**Short Circuit Current, Isc**: short circuit current of a PV Module, PV String, PV Array or PV generator under standard test conditions.

**Solar PV Integrator**: a registered entity with the Distribution Company carrying out Electrical Installation Work specific to solar photovoltaic (PV) systems.

**String**: circuit in which PV Modules are connected in series, in order for a PV Array to generate the required output voltage.
Introduction

2.1 Scope and purpose

2.1.1 This document provides further guidance on the technical requirements of Solar PV Systems already established in the Electricity Wiring Regulations (Third Edition). It also provides further guidance to the requirements for the design, specification, installation, commissioning, operation and maintenance of grid-connected solar photovoltaic (PV) systems in the Emirate of Abu Dhabi.

2.1.2 The scope of this guidance document covers:

a) Solar PV installations for residential, commercial and industrial type Premises. Typically, the PV system would connect to the Premises’ Main Distribution Board (MDB) which means that all electricity generated will be consumed internally in the first instance. In most cases, the PV generation would only offset a portion of the Premises’ power demand;

b) LV connections and components (400/230V)

c) Solar PV systems with an open circuit d.c. voltage below 1500 V d.c.

(Note: the scope of this guidance does not cover HV connections and battery storage.)

2.1.3 The purpose of this document is to:

a) Provide guidance to Customers, Owners, Licensed Contractors, or any other person involved in the design, construction, installation, maintenance and operation of solar PV systems in the Emirate of Abu Dhabi.

b) Provide an overview and an understanding of solar PV systems, the process to be followed in the installation and connection of such systems to the distribution network in the Emirates of Abu Dhabi; and

c) Provide Licensed Contractors (in particular Solar PV Integrators) with suitable information so as to ensure that a grid connected solar PV system meets the current regulations, standards and best practices.

2.1.4 Solar PV systems intended for standalone operations (not connected in parallel with the Low Voltage distribution system are not covered in this document). Furthermore, Mechanical and civil design of the solar PV array are not within the scope of this document.
2.1.5 For larger Embedded Generator connections, the provisions of the Electricity Distribution Code would apply and advice should be sought from the relevant Distribution Companies in the Emirate of Abu Dhabi.

2.2 Regulations and standards

2.2.1 The following documents are of a particular relevance to the design and installation of solar PV systems, where referenced throughout the guide the most recent edition should be referred to:

a) Electricity Wiring Regulation issued by the Regulation and Supervision Bureau in the Emirate of Abu Dhabi (all parts—but in particular Regulations 9.10 – Solar photovoltaic systems);

b) Small-Scale Solar Photovoltaic (PV) Energy Netting Regulations (First Edition) issued by the Regulation and Supervision Bureau in the Emirate of Abu Dhabi;

c) Abu Dhabi Emirate Environment, Health and Safety Management System (AD EHSMS);

d) The Electricity Distribution Code;

e) Engineering Recommendation No.1 of the Electricity Distribution Code – Limits for Harmonics in the Electricity Supply System;

f) Engineering Recommendation No.3 of the Electricity Distribution Code, Connection of Embedded Generating Plant up to 5MW;

g) Engineering Recommendation No.10 of the Electricity Distribution Code, Limits for Voltage Unbalance in the Electricity Supply System;

h) Engineering Recommendation No.7 of the Electricity Distribution Code, Limits for Voltage fluctuations in the Electricity Supply System;

i) BS 7671 - Requirements – Solar photovoltaic (PV) power supply systems; and

j) BS EN 62446 - Grid connected photovoltaic systems - Minimum requirements for system documentation, commissioning tests and inspection.
3.1 General overview

3.1.1 Solar photovoltaic (PV) power systems work by converting sunlight directly into electricity.

3.1.2 Photovoltaic (PV) cells or solar cells are the building block of solar Modules or solar panels. They take advantage of the photovoltaic effect to produce voltage or current upon exposure to light. PV Cells come in many sizes and shapes, from smaller than a postage stamp to several centimetres across.

3.1.3 When light shines on a PV Cell, it may be reflected, absorbed, or pass right through. It is the absorbed sunlight by these PV Cells that generate electricity.

3.1.4 The main application of solar PV in Abu Dhabi is grid-connected; the PV system would typically be installed on the roof of Premises and would connect to the Premises’ LV Main Distribution Board (MDB).

3.1.5 PV systems are reliable and pollution-free. They make use of the renewable source of energy from the sun. Such systems work best in an energy-efficient building. As such, it would be sensible to firstly ensure that the overall electricity consumption in your Premises is at the optimum level by minimizing any wastage and utilising energy efficient air conditioning, lighting, appliances and windows before investing in a PV system.
3.2 Types of solar PV systems

3.2.1 There are two main types of solar PV systems:

a) Grid Connected Solar PV systems: Solar PV systems connected in parallel with the Low Voltage distribution system; and

b) Off-Grid or standalone Solar PV systems not connected in parallel with the Low Voltage distribution system.

3.2.2 The majority of solar PV systems installations in the Emirate of Abu Dhabi are grid connected type. The Solar PV System would typically be installed on the rooftop of Premises and connected to the Premises’ main electrical distribution board.

3.2.3 Typically all electricity generated will be consumed internally in the first instance. In most cases, the PV generation would only offset a portion of the Premises’ power demand. If the Solar PV system supply exceeds the Premises demand at any given time, then the excess electricity generated will be exported to the grid.

3.3 Photovoltaic (PV) Systems Components

3.3.1 A PV Cell is the basic element of a PV Module; each Cell typically produces around 1 or 2 watts of power. To make use of these Cells they are interconnected to form Modules that can produce more power (e.g. 250 Watts/Module).

3.3.2 Larger units can be formed by interconnecting Modules in series and parallel. These will dictate the PV system output capacity in terms of kWp to meet a certain electricity demand for various types of Premises.

3.3.3 Typical PV systems comprises of the following:

a) Solar Cell which forms a Module which when interconnected using cables and connectors they form Strings and Arrays.

b) These Strings and Arrays are then connected to Inverters to convert the d.c. output of these Strings and Arrays into a.c. current so that it can be used within the Premises electricity demand.

c) Electrical cables, switchgears, control gears, monitoring and metering systems, and protection/interface modules.

d) Mechanical structures that hold the modules and point them toward the sun.
3.4 **Solar PV Cell materials**

3.4.1 Solar Cells use the energy in sunlight to produce electricity. However, the amount of electricity produced depends on many factors such as ambient temperature, orientation of the PV Modules, PV Cell material, quality of the light available and the performance of the PV Cell.

3.4.2 Crystalline silicon PV Cells are the most common photovoltaic Cells in use today. They are also the earliest successful PV devices. Therefore, crystalline silicon solar cells provide a good example of typical PV Cell functionality.

3.4.3 Although crystalline silicon cells are the most common type, photovoltaic (PV), or solar Cells, can be made of many semiconductor materials. Each material has unique strengths and characteristics that influence its suitability for specific applications. For example, PV Cell materials may differ based on their crystallinity, band gap, absorption, and manufacturing complexity.

   a) **Silicon (Si)**—including single-crystalline Si, multi-crystalline Si, and amorphous Si.

   b) **Thin Films**—including copper indium gallium selenide (CIGS), cadmium telluride (CdTe), and thin-film silicon.
c) **Single-Crystalline Thin Films**—including high-efficiency material such as gallium arsenide (GaAs).

Common PV Modules types

### 3.5 Solar PV Modules

3.5.1 Solar PV Cells are typically interconnected in series and parallel to form PV Modules. Modules, in turn, can be combined and connected to form PV Arrays of different sizes and power output. The Modules of the Array make up the major part of a PV system, which can also include electrical connections, mounting hardware, Inverters or power-conditioning equipment.
3.5.2 Solar PV Modules are typically configured in two options as follows:

a) Connected in Parallel where the Module current is the sum of all module currents; and the Output voltage remains as the Module voltage.

b) Connected in Series where the output voltage is the sum of the all modules voltages and the output current remains as the module current.

3.5.3 Solar PV Modules when connected in series they form a PV String and the parallel aggregation of PV Strings will form a PV Array as shown below.
3.5.4 Solar PV Modules typically comes in three safety classes as per IEC 61730:

a) Class A modules meet the safety class II, these are mandatory.

b) Class B modules meet the safety class 0, these are not permitted.

c) Class C modules meet the safety class III, these are not permitted.

3.5.5 Consideration should be given to Modules installed in coastal environments, in such locations compliance with IEC 61701 is required for salt mist corrosion testing of PV Modules.

3.5.6 Solar PV Modules must be in compliance with the international standards stated below. Evidence of compliance to these standards will need to be presented to the relevant Distribution Company when applying for a connection.

<table>
<thead>
<tr>
<th>PV Modules</th>
<th>BS EN</th>
<th>IEC</th>
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<tbody>
<tr>
<td>Thin-film terrestrial</td>
<td>61646</td>
<td>61646</td>
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<tr>
<td>Crystalline silicon terrestrial</td>
<td>61215</td>
<td>61215</td>
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<td>PV modules safety qualification</td>
<td>61730-1</td>
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<tr>
<td>Ammonia corrosion testing of PV Modules</td>
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<tr>
<td>Junction boxes for PV Modules</td>
<td>50548</td>
<td></td>
</tr>
</tbody>
</table>

3.5.7 Solar PV Modules must be protected by the use of class II insulation as defined under the Electricity Wiring Regulations. Class II protection provides supplementary insulation in addition to the basic insulation such that a breakdown of the basic insulation will not present a dangerous voltage on exposed conductive parts.
3.5.8 It is recommended that manufacturers of solar PV Modules to submit the required compliance documentation to the relevant Distribution Company to be listed on their pre-approved product database.

3.5.9 For the purposes of electrical connections, each PV Module should be provided with a pair of connecting cables (positive (+) and negative (-) terminals) existing from a junction box located at the rear side of the panel.

3.5.10 Each PV Module should have a label located at the rear side of the panel. Such labels typically include information and values at standard testing conditions, such as model type and number, maximum system voltage $V_{sys}$, power rating ($W_p$), Open Circuit Voltage ($V_{oc}$), Short Circuit Current ($I_{sc}$), voltage at maximum power point ($V_{mpp}$), current at maximum power point ($I_{mpp}$), protection class, and voltage temperature coefficient. Reference can be made to BS EN 50380 for compliance to datasheet and nameplate information for PV Modules.

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
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<tbody>
<tr>
<td>$P_{mpp}$</td>
<td>Nominal Power at Maximum Power Point (STC)</td>
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<tr>
<td>$V_{mpp}$</td>
<td>Voltage at Maximum Power Point (STC)</td>
</tr>
<tr>
<td>$I_{mpp}$</td>
<td>Current at Maximum Power Point (STC)</td>
</tr>
<tr>
<td>$V_{oc}$</td>
<td>Open Circuit Voltage (STC)</td>
</tr>
<tr>
<td>$I_{sc}$</td>
<td>Short Circuit Current (STC)</td>
</tr>
<tr>
<td>$V_{sys}$</td>
<td>Maximum System Voltage</td>
</tr>
<tr>
<td>Nominal Operating</td>
<td></td>
</tr>
<tr>
<td>Cell Temp</td>
<td>In Celsius</td>
</tr>
</tbody>
</table>
3.5.11 Modules used in a single solar PV system should have the same manufacturer and model numbers with similar rated electrical characteristics.

### 3.6 Solar PV Inverters

3.6.1 Inverters work by converting d.c. voltage and current into a.c. voltage and current to be used to meet electricity demand for various appliances. The most common types of Inverters are:

a) Stand-alone Inverters are used in isolated or decentralised systems not connected to the utility grid, where the Inverter receives its d.c. current and voltage from batteries that are charged by PV Strings and Arrays.

b) Grid connected Inverters regulates the amount of voltage and the current that is received from d.c. Strings and Arrays and then converts it into an alternating current by ensuring that the power will be in phase or synchronised with the grid-power. This will allow the exportation of any excess power generated by the PV system to the utility grid.

3.6.2 Grid connected inverters, in addition to its basic functionality of d.c./a.c. conversion should perform the following functions:

a) Synchronise its output voltage and frequency with the a.c. mains.

b) Disconnect from the grid if the voltage and frequency deviate from the allowable limits or there is a loss of grid.

c) Ensure the output a.c. waveform is within the specified harmonic and flicker limits.
d) Adjust the PV array operating voltage to ensure maximum power is extracted from the PV Array.

e) Monitor earth and isolation faults on the d.c. side of the solar PV system.

3.6.3 Inverters come in a variety of configuration and sizes. The choice of inverters will depend on a number of factors such as connection voltage, cost, warranty, installation location, monitoring options etc. Some are small units such as micro inverters typically mounted directly at the rear of the modules, some are standalone units meant for residential applications, commercial applications. In addition Inverters may be single-phase or three-phase and may come with a single or multiple maximum-power point tracking (MPPT).

3.6.4 Inverters typically come in two classifications that will have an impact on the design process of the Solar PV System. These are:

a) Isolated inverters with at least simple separation between the a.c. and d.c. sides; and

b) Non-isolated inverter without at least simple separation between the a.c. and d.c. sides, also known as transformer-less inverter.

3.6.5 Solar PV Inverters must be in compliance with the international standards stated in below. Evidence of compliance to these standards will need to be presented to the relevant Distribution Company when applying for a connection.

<table>
<thead>
<tr>
<th>PV Modules</th>
<th>BS EN</th>
<th>IEC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar PV inverters degree of protection</td>
<td>60529</td>
<td>60529</td>
</tr>
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<td>Solar PV inverters protection class</td>
<td>60664-1</td>
<td>60664-1</td>
</tr>
<tr>
<td>Solar PV inverters characteristics of the utility interface</td>
<td></td>
<td>61727</td>
</tr>
</tbody>
</table>
3.6.6 Solar PV inverter are typically configured in many ways, the most common two arrangements used in the Emirate of Abu Dhabi are shown in the below diagrams.

a) Single String connected to a single Inverter

![Diagram of Single String connection](image)

b) Multiple Strings connected to a single Inverter with multiple MPPT

![Diagram of Multiple String connection](image)
4.1 **General requirements**

4.1.1 To ensure the safety of solar PV systems, all involved parties should ensure the following:

a) Selection of the correct system components that conform to the appropriate international standards as required by the Electricity Wiring Regulations (i.e. Modules, Inverters, cables, connectors, junction boxes, isolators etc.);

b) Correct installation of the solar PV system; and

c) Correct operation and maintenance of the solar PV system.

4.1.2 The design should consider the potential risks during the installation, operation and maintenance of such systems. The design should also consider the assessment of the installation constraints including wind and structural loading.

4.1.3 The PV owner shall ensure that only a Licensed Contractor and/or Solar PV Integrator experienced in PV installations are used for the design, installation, operation and maintenance of its system.

4.1.4 Where products containing hazardous materials are used in a Solar PV System Installation, the solar PV system provider should provide recycling and/or disposal information for the PV Modules, Inverters and other components as applicable.

*Note: Consideration must be given to the relevant HSE and waste management requirements in the Emirate of Abu Dhabi.*

4.1.5 Typical safety issues are:

a) The supply from PV modules cannot be switched off, so special precautions should be made to ensure that live parts are either not accessible or cannot be touched during installation, use and maintenance. A String of solar PV Modules can produce a voltage in excess of 1000 V d.c. in which case access should be restricted to only competent, skilled or instructed persons;

b) Due to the potential presence of high voltage d.c. in solar PV systems, a risk of arc faults resulting in a high energy discharge that may lead to fire;

c) Risk of electric shock due to direct and indirect contact with live parts.
d) Knowledge may be lacking in working with d.c. wiring in solar PV systems; and

e) Risk of falling and injury due to working at height and manual handling during the installation of solar PV systems.

4.2 Risk Assessment

4.2.1 A risk assessment should be performed prior to carrying out Solar PV installation and maintenance work in accordance with the requirements mandated by the relevant authority within the Emirate of Abu Dhabi (i.e. Municipality, OSHAD, Civil Defence etc.).

4.2.2 The aim of the risk assessment is thoroughly examine the installation of Solar PV systems on roof tops in order to:

a) Identify hazards

b) Identify who can be harmed or what can be damaged and how

c) Evaluate the risk and select additional control measures where required.

d) Implement the selected control measures in the installation location.

e) Monitor the control measures.

4.2.3 It is critical that every person involved in the installation work is made aware of the risks associated with the installation work including (contractors, consultants, material suppliers, maintenance companies, and the Distribution Company staff).

4.3 Main Hazards

4.3.1 The following is a summary of some of the main hazards that may be encountered during the construction, operation and maintenance of a Solar PV System:

a) PV Modules produce electricity during daylight and cannot be turned off. Therefore, it is expected that during installation work, installers will be working on live panels and a risk of direct or indirect contact with electricity will be high. Measures should be taken to inform installers of such risks and use of proper insulating materials (e.g. gloves, insulated shoes, proper harness etc.) to minimise the risk of electric shock.
b) PV Modules are current limiting devices with the short circuit current being not much higher than the operating current which in turn may not be detected by the overcurrent protection used; as such minor faults may remain undetected for a long period of time which can develop into a fire hazard.

c) PV Modules are typically installed on roofs, which in the case of a high wind may increase the risk of flying objects. As such, the mounting structure holding the PV Modules should take into consideration such risks during the design and installation phases.

d) The majority of Solar PV systems would be installed at premises roof tops, the risk of falling becomes very high, as such measures should be taken to reduce such risks by using the appropriate scaffolding, suitable access provisions, safe lifting procedures, and suitable labelling and warning signs.

e) Electric shock from PV Modules, cables, combiner boxes, and termination points. As indicated above Modules will produce electricity when subjected to sunlight, as such measures should be taken to eliminate the risk of exposed/damaged wires, cables and connections.

4.4 Labelling and warning signs

4.4.1 All labels must be clear, easily visible, constructed and affixed to remain legible for as long as the enclosure is in use and written both in Arabic and English. PVC engraved labels must be used.

<table>
<thead>
<tr>
<th>Location</th>
<th>Required Label</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Intake Room</td>
<td><img src="image" alt="WARNING PHOTOVOLTAIC SYSTEM DUAL POWER SUPPLY" /></td>
</tr>
<tr>
<td>Inverter</td>
<td><img src="image" alt="WARNING - before carrying out work." /></td>
</tr>
</tbody>
</table>
4.5 Structural Safety

4.5.1 To ensure safety, there are measures and steps that need to be taken or considered when installing a solar PV system onto a new or an existing building. The design of the structure must take into consideration the loading of the solar PV system installation, just like any other equipment mounted onto a building structure, all relevant building codes and safety codes of Abu Dhabi must be followed (e.g. Abu Dhabi International Building Code).

4.5.2 For existing buildings, a professional competent structural engineer or consultant may be required for calculation of the structural loading. Check if the roof is able to withstand the loading of the solar PV system. Architectural and Structural documents need to be submitted to the relevant municipalities in the Emirate of Abu Dhabi for approval before commencement of installation works.
4.5.3 The environmental conditions within the Emirate of Abu Dhabi is considered to be corrosive in nature and particularly in coastal areas, as such all mounting structures and fixings must be made from corrosion resistant materials that are suitable for the lifetime of the solar PV system (e.g. galvanised steel, zinc coated steel etc.). Also possible galvanic effects from the bolting of dissimilar metals needs to be considered.

4.5.4 The design of a solar PV system mounting structure should allow for thermal expansion and contraction (e.g. thermal breaks and gaps). This is particularly important for large mounting structures.

4.5.5 The design and installation of a solar PV system should take into consideration the rain water drainage from the roof top, this is to avoid creation of any pools of water on the roof during heavy rain fall. Also the location of rain fall drainage should be considered in relation to the location of the modules to avoid overloading the drainage system during heavy rain fall.

4.5.6 Safe access to the mounting structure should be considered during the design of a solar PV system, this is particularly important for future access for maintenance, testing, troubleshooting and emergency purposes.

4.5.7 The solar PV system should be designed and installed taking into consideration the maximum expected wind speed encountered in the Emirate of Abu Dhabi, reference to local building codes must be made.

4.6 Fire Prevention Consideration

4.6.1 The following are some of the main causes that are known to increase the risk of fire in a solar PV system:

   a) Poor installation practices.
   b) Use of incorrect equipment,
   c) Use of faulty and defected equipment.
   d) Wrong wiring and design specification.
   e) As a consequence of Lightning strike.

4.6.2 The most likely cause of a fire on a grid connected solar PV system is the development of a d.c. arc as a result of poor connections (module connectors, combiner boxes) creating high resistance junctions or faulty d.c. disconnector switches or damaged cables resulting in a short circuit.
4.6.3 The design and installation of solar PV system should aim to minimise the risk of the system being the source of fire and minimise the risk to occupants or emergency services (consideration must be given to the relevant UAE fire code requirements). The following are some measures for consideration:

a) Specifying and installing the proper d.c. overcurrent protection.

b) Properly securing d.c. cables in containments.

c) Segregation between the positive and negative conductors along their path and at connection terminals.

d) Use of enclosures made from insulating materials with self-extinguishing properties.

e) Ensuring the correct ratings are used for the d.c. cables, combiner boxes and switch disconnectors etc.

f) Ensuring all connections are tightened and torqued in accordance with manufacturer specifications.

g) Ensuring that used inverters have a built–in d.c. arc detection capabilities, otherwise standalone detectors should considered.

h) Ensuring that double insulation is used throughout the d.c. circuit to greatly minimise the risk of parallel arcs between conductors, or via an earth path.

(Note: d.c. arcs can be extremely hot and capable of melting glass, as such it is easily capable of causing a fire.)
i) Smoke and fire alarms should be considered where a PV room is provided to house the Inverters and PV switchgear/panels (adherence to the local fire codes should be followed).

j) Minimise as much as possible the length of the d.c. cables from the inverters, and avoid installing d.c. cables in walls or hidden in the building structure.

k) Ensure that premises with solar PV system are properly identified with clear label at the main electricity intake room to notify emergency personal of the existence of such system.

l) The owner of a solar PV system should have a regular maintenance contract with a specialised entity to ensure regular maintenance and system condition tests are always carried out to prevent any potential hazards from developing into a fire risk.
5.1 General Overview

5.1.1 Ensure that the location, tilt, size and orientation of the PV array provide the best output in terms of annual energy.

5.1.2 Ensure the roof area is enough for the expected installed capacity kWp with adequate area for maintenance along with the verification that the roof is capable of handling the load.

5.1.3 Sunlight and weather resistant equipment and materials are recommended for outdoor use.

5.1.4 Locate the PV Array to minimize shading effect from vent pipes, high rise buildings and adjacent structures.

5.1.5 Design the system in compliance with all applicable electrical and building codes.

5.1.6 Design the system in a way to reduce losses due to wiring length, fuses, switches, and inverters.

5.1.7 Ensure the design meets local utility interconnection requirements. [Note: Refer to Design and Installation Checklist in Annex 4.]

5.1.8 PV Modules are current-limiting devices, therefore, the short circuit current expected (i.e. shorting the output terminals of the PV Module) would be only slightly higher than the operating current of the Module.

5.1.9 Depending on the operating conditions (i.e. irradiance, temperature, module age etc.), the output voltage and current of PV arrays varies considerably, therefore it is critical to consider designing the PV system based on the maximum voltage and current that may occur.

5.2 d.c system design

Solar PV d.c. System voltage and current ratings

5.2.1 The rating of all d.c. components of Solar PV system must be rated in consideration of the highest d.c. voltage and highest d.c. current the circuit will be subject to. This will include but not limited to all cables, switch disconnectors, and connectors used on the d.c. side of the Solar PV System.
5.2.2 An assessment of the highest d.c. voltage and highest d.c. current need to be made based on the PV Modules Open-Circuit-Voltage (Voc) and Short-Circuit-Current (Isc). These information are typically provided by the PV Module manufacturer under standard test conditions (stc).

5.2.3 Standard test conditions (stc) refer to the following testing conditions:

a) Irradiance of 1000 W/m²;

b) 25°C cell temperature; and

c) Air mass of 1.5.

5.2.4 In Abu Dhabi ambient temperature can typically vary between 5°C to more than 50°C for unshaded areas. The temperature rise due to solar gain must be calculated for the relevant equipment (typically 10°C above ambient temperature), and this will have an impact on the output voltage and output current of PV Modules. Therefore, it is critical perform system design calculation taking into consideration the minimum/maximum temperatures that can occur where the system is being installed.

5.2.5 Typically Module manufactures provide the required technical data sheets that will include temperature coefficients for Voc and Isc respectively and may include other information on the operation of modules during the first week of exposure to sunlight these must be taken into consideration (soaking-in periods).

(Note: The Voc and Isc temperature coefficients are typically indicated as volts per °C or as a percentage per °C. For example the temperature coefficient for Voc will be listed as a negative %/°C to represent the amount of module’s voltage increase for every degree °C decrease below the standard test conditions (stc).)

<table>
<thead>
<tr>
<th>Temperature coefficient $\beta$ (Isc)</th>
<th>+0.057%/°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature coefficient $\chi$ (Uoc)</td>
<td>-0.346%/°C</td>
</tr>
</tbody>
</table>

**Example:** A module has a Voc of 30.4V and a temperature coefficient of -0.346% per °C resulting in the following:

- For each °C below 25°C the module voltage will increase by 0.105 volts. (30.4 × 0.00346 V = 0.105V).
5.2.6 PV Modules connected in series must consider the maximum allowed operating voltage of the PV Module and the PV Inverter, whichever is lower.

5.2.7 The minimum current rating of the d.c. circuit must be based on the short circuit current (Isc) seen by the module at STC conditions multiplied by 1.25 as shown below for an Array formed of single PV string.

5.2.8 Solar PV Inverters that are able to feed d.c. fault currents to the a.c. side of the electrical installation, a type B RCD in accordance with IEC 62423 must be provided for the automatic disconnection of supply.

**d.c. Cables**

5.2.9 The cables used for wiring the d.c. side should be selected to ensure that they can withstand the environmental conditions at which they may be expected to operate especially in hot climate like Abu Dhabi. This will include heating effects of both current and solar irradiation gain.

5.2.10 Solar PV d.c. Cables should be selected and installed to minimise the risk of earth faults and short-circuits. This is accomplished by reinforcing the protection on the cables by the use of double insulated cables.
5.2.11 Double insulation of the solar PV d.c. circuit (d.c. wiring, connectors etc.) greatly minimises the risk of creating accidental shock current paths (e.g. via damaged cable coming in contact with PV frame) and the risk of fire. It is recommended that these cables not be hidden in the building structure or buried in walls as this will make it very difficult to identify damaged cables and increase the risk of electric shock and fires. If it is absolutely required for d.c. cables to be installed in such manner then the use of cable trunkings or conduits in accordance with the requirement of the Electricity Wiring Regulations must be followed.

(Note: Purpose designed “Solar PV d.c. cables” are readily available in the market. These are simple to use, comply with the relevant international standards and allow a simple and safe connection via purpose made PV plug and socket connectors. Currently the following standards may be referenced UL 4703, TUV 2 PfG 1169/08.2007, VDE PV 01:2008-02 and BS EN 50618.)

5.2.12 Solar PV d.c. cables should be sized in accordance with the requirements of the Electricity Wiring Regulations. The current carrying capacity for cables shall be at least 1.25 times the Isc under standard test conditions (STC). Furthermore, cable derating factors must be included in the calculation.

5.2.13 d.c. cables must be rated for the voltage maxima calculated for the circuit.

5.2.14 d.c. cables temperature rating must be taken into consideration. Cables routed behind PV array must have a temperature rating of at least 80°C.

5.2.15 External cables should be UV stable, water resistant, and it is recommended that they be flexible (multi-stranded) to allow for thermal/wind movement of arrays/modules.

5.2.16 In Abu Dhabi PV cables must be black in colour mainly to assist in UV resistance.
5.2.17 All d.c. cables should be appropriately labelled to indicate their polarity and the associated dangers. Such labels are required to be fixed every 5 to 10 meters.

Solar d.c. module connectors

5.2.18 PV modules are typically provided by the manufacturers with fitted connectors as shown in the figure below. Such connectors must comply with the requirements of BS EN 50521. These connectors will make the installation work much faster and safer in addition to providing a secure, durable and effective electrical contact.

5.2.19 The rating of all d.c. connectors must be in consideration of the highest d.c. voltage and highest d.c. current of the PV system.

5.2.20 Connectors must be selected so as to withstand external influences such as rain, temperature and solar radiation, this will include the appropriate IP, UV, temperature rating, and compatible with the cable they are connected to.

5.2.21 Connectors must be fixed and secured in a location that is easily accessible for trouble shooting purposes. See figures below of a good and bad ways of installation.
5.2.22 Connectors must be clearly labelled as “Do Not Disconnect – DC Plugs Under Load – Turn off AC and DC Isolators First”.

**PV Junction boxes**

5.2.23 If there is more than one string, the solar PV d.c. junction box is normally the point at which they are connected together in parallel. Junctions need to be made using high quality connectors, typically screw terminals. The box may also contain string fuses or d.c. rated disconnection device, MCB, MCCB inside the box shall be provided to isolate individual strings. Isolation shall be provided in both positive and negative string cables.

*(Note: A solar PV system cannot be switched off and components of the d.c. system will be live during daylight.)*

**Solar PV d.c Switch Disconnector**

5.2.24 A switch disconnector must be provided on the d.c. side of the PV System Inverter with the following requirements as per the Electricity Wiring Regulations:

a) It must isolate all live parts (the positive and negative conductors);

b) It must be located in a prominent position and clearly labelled as shown in the figure below;

c) It must clearly show the “On” and “Off” positions; and

d) It must be rated for d.c. operation at the system voltage and current maxima as calculated.
5.2.25 The load break switch disconnector can be either:
   a) Physically separate and located adjacent to the Inverter as shown below; or

b) Integral to the inverter, if the inverter includes a means of isolation only operable when the switch-disconnector is in the open position (e.g. plugs only accessible once the switch disconnector handle is removed);

**Solar PV system insulation faults**

5.2.26 The design of a Solar PV system should take into account the possibility of insulation faults detection on the d.c. side. Such faults can result in shock voltages and provide a path for fault currents.

5.2.27 The most common causes for insulation failures are damaged cables due to amongst other causes direct impact, wind, and water ingress into junction boxes.

5.2.28 The most common way to detect such faults is through conducting earth insulation resistance tests and use of residual current monitoring systems. Most small scale PV systems will have those features already built in within the Inverter according to BS EN 62109-2, otherwise separate devices must be considered.
5.2.29 Earth insulation resistance tests must be carried out and verified in accordance with the requirements indicated in IEC 61446 clause 5.4.7.

5.2.30 Residual current monitoring devices are provided for PV systems that use functional earthing or use an inverter without at least simple separation otherwise it is not required. For such cases the inverter must shut down and isolate the PV array from the grid when a fault is detected.

5.2.31 In cases where the earth insulation resistance or the residual current monitoring detects a fault, the inverter should have both a local alarm on the inverter and a means of remote signaling in accordance with the requirements of IEC 62109.

**Earthing requirements**

5.2.32 Earthing is defined as a general term used to describe the connection of exposed conductive parts of an Electrical Installation to Earth. These exposed conductive parts can be touched by persons and which is not normally live but may become live due to a fault condition. Exposed conductive parts are required to be connected to Earth Main Terminal (MET) of the Electrical Installation by the use of Circuit Earth Conductors (CEC).

5.2.33 The connections of Exposed-Conductive-Parts are typically done for accessories and appliances that are classified as Class I Equipment in which the equipment includes a means for the connection of Exposed-Conductive-Parts of the equipment to the Earth Conductor, thus providing protection against electric shock in case of failure of the basic insulation of the equipment by the use of automatic disconnection of the supply.

5.2.34 Since the Electricity Wiring Regulations mandate the use of Class II Equipment on the d.c. side of a PV system (e.g. modules, cables, Junction boxes, connectors etc), no connection to Earth between the PV Modules or frame and the MET is required.

*Note: If it is found that any electrical apparatus are classified as ‘Class I’ then earthing of the Array frame is required in accordance with the requirements of the Electricity Wiring Regulations.*
5.2.35 The decision to connect or not connect the Array frame with earth is a complex one, however, it is recommended that the PV Array frame is connected to earth in all circumstances, mainly for the following reasons:

a) Current inverters come with built in d.c. fault detection systems that are able to isolate inverters in case of fault detection (e.g. earth insulation resistance, and residual current monitoring).

b) Removing any risk of electric shock from leakage currents from transformless inverters.

c) Alignment with IEC requirements.

**Bonding requirements**

5.2.36 Equipotential bonding is a protective measure used where the connection of Extraneous-Conductive-Parts within Premises using designated conductors such that potential touch voltages are kept to safe value during the passage of earth fault current.

5.2.37 Since the Electricity Wiring Regulations mandate the use of Class II Equipment on the d.c. side of a PV system, no equipotential bonding is required.

*Note: to determine if an equipment is classified as an Extraneous-Conductive-Part, a simple resistance test can be carried out (e.g. between the PV Module frame and the MET), if the value recorded are greater than 22kΩ then the equipment is considered to be sufficiently isolated from the installation and not an Extraneous-Conductive-Part, if the reading is less than 22kΩ, then equipotential bonding is required in line with the requirements of the Electricity Wiring Regulations. For the avoidance of doubt bonding of the Array frame is recommended in all circumstances.*

**Lightning and surge protection**

5.2.38 The design of a PV system must take into consideration the susceptibility of the system to be damaged due to a lightning strike. Damaged caused by lightning typically occurs due to a direct strike or due to surges from a nearby strike.

5.2.39 It is recommended that a specialist entity in lightning protection be consulted to determine the appropriateness of installing a lightning protection system. It must be noted that for villas with roof top mounted PV systems the risks may be very small for a
direct lightning strike. However, this will depend on the physical size of the installation, location of the system (e.g. on top of a high rise building or in remote areas), proximity of the PV system frames from the lightning protection system and if the PV System is the tallest structure in a building.

5.2.40 Where it is deemed necessary to install a separate lightning protection system then all exposed conductive parts of the Solar PV System must be bonded to the lightning earthing system. In addition all wiring loops should be as small and as short as possible.

5.2.41 The use of surge protected devices must be considered in such cases. Consideration must be given to protect the a.c. and d.c. side of the PV system. On the a.c. side surge protected devices must be used at the Connection Point typically installed at the Main Distribution Board in line with the requirements of the Electricity Wiring Regulations. On the d.c. side surge protection devices may be installed at the Inverter d.c. cabling end or at the PV Array.

5.3 **Solar PV a.c. system**

5.3.1 The a.c. side of the solar PV system would need to fully comply with the requirements of the latest edition of the Electricity Wiring Regulations.

5.3.2 Each solar PV system connected to the Distribution Company(s) network must be designed, installed and tested to be compatible with distribution network performance requirements with respect to frequency, voltage, control capabilities, protection coordination requirements, and phase voltage unbalance.

5.3.3 The technical data regarding the solar PV system that is intended for connection to the distribution system should be made available to the Distribution Company to enable an assessment to be carried out so as to identify and mitigate against any effect the solar PV system may have of the distribution system.
5.3.4 The solar PV system shall automatically disconnect from the public grid supply in the event of loss of grid or deviation of the electricity parameters at the supply terminals. A suitable device (interface protection) must be installed to provide means of disconnection. Such devices monitor the grid voltage and frequency, and in the case of a loss of grid, it will disconnect the PV system from the grid.

5.3.5 Depending on the maximum capacity of the solar PV system the interface protection may be installed as a separate unit or integrated into the inverter. The interface protection may be located between the solar PV system and the connection to the grid or at the Connection Point. The form and location of the interface protection needs to be agreed with the Distribution Company.
Factors Affecting Performance of the Solar System

6.1 PV Array orientation, tilt angle and cleaning frequency

6.1.1 The location, tilt, size, orientation and cleaning of the PV array are the key factors in determining the best power output of the PV System throughout the year.

6.1.2 Based on various pilot projects on roof top installations in Abu Dhabi, the following is recommended:

   a) PV Modules should always be installed to face true south. However, variations by +/- 35° away from south have minimal effect (<1%) on the total power output of the system;

   b) A tilt angle between 10°-20° towards south is found to be optimum; and

   c) A cleaning frequency of once every 4 weeks during normal operational conditions.


6.1.3 Typically PV modules are installed with a fixed angle throughout the year. This will typically not yield the optimum output as the position of the sun changes with changing seasons. It is therefore recommended to adjust the tilt angle twice a year where possible to get more power out of the PV system. It must be noted that adjustable systems will be more costly than fixed ones.

6.2 Shade effect

6.2.1 Shading can play a significant role in degrading the power output of the PV System. Therefore, it is vital to locate the PV Array to minimize shading effect from other modules, vent pipes, trees, adjacent high rise buildings, and adjacent structures.
6.2.2 A small degree of shading on part of an array can have a very significant impact on the overall Array output. Shading is one element of system performance that can be specifically addressed during system design – by careful selection of array location and layout and in the electrical design (string design to ensure shade effects only one string).

6.3 Temperature effects

6.3.1 The performance of PV Modules is inversely proportional to module’s temperature. For example a 1°C increase in a crystalline module temperature above its standard testing condition (STC) will typically result in a decrease in its performance by 0.5%). Therefore, ventilation behind PV Modules is important in reducing or limiting this decrease in performance.

6.3.2 Inverters dissipate heat and should be provided with ventilation. Clearance distances as specified by the manufacturer should also be provided. Failure to follow this can result in a loss in system performance as the inverter will de-rate when it reaches its maximum operating temperature. This should be highlighted within the O&M manual and perhaps with a label – not to block ventilation next to the inverter. It is also important to ensure that inverters are installed away from direct sunlight (e.g. shaded areas or inside a room) to avoid being subjected to high temperatures especially in the summer.

6.4 Module cleaning

6.4.1 The weather in the Emirate of Abu Dhabi is considered to be mainly sunny, occasional fog (causing condensation on outdoor equipment), frequently dusty with occasional sandstorms causing dust accumulation on PV modules. This can greatly decreases the efficiency of these modules.
6.4.2 It is recommended that PV Modules are mounted with a tilt angle between 10°-20° to allow for easier cleaning.

6.4.3 A cleaning frequency of once every 4 weeks during normal operational conditions is recommended.

6.5 Annual energy performance warranties

6.5.1 As a best practice, owners of the solar PV system could insist on the annual performance warranties and energy yield study for their specific roof top installation. An energy performance warranty guarantees that the system will perform consistently over a period of time. This is particularly helpful in ensuring that the customer receives the savings that they expect. Adequate metering to verify the system power output and energy generation is necessary to help the system owner understand whether the system is operating properly, or has warranty-related performance issues.

6.5.2 The solar PV system performance should be conducted in accordance with IEC 61724 Part 1-4 (General guidelines for the monitoring and analysis of the electrical performance of solar PV systems).

6.5.3 PV power project developers should maintain technical information on the performance of system, solar radiation availability, hours of sunshine, duration of plant operation and the quantum of power fed to the grid. The project developer should install suitable instruments, meters and data loggers for this purpose.

6.5.4 It is expected that a Solar Roof Top in Abu Dhabi can typically generate an expected yield of 1600 kWh/kWp/Annum to 1700 kWh/kWp/Annum.
6.5.5 Loss of performance over the life time of a PV module (typically manufactures guarantee performance up to 25 years) must be taken into consideration. Manufacturers typically guarantee an efficiency of 90% after 10 years and 80% after 25 years.

6.6 Remote Monitoring System (Typically > 20kWp)

6.6.1 The Solar PV System designers and installer should cater for the installation of suitable instruments and make adequate arrangements to remote monitor the performance and ensure satisfactory operation of the grid connected Solar PV System.
7.1 Relevant Sector Entities – Roles & Responsibilities

Regulation & Supervision Bureau (Bureau)

7.1.1 The Regulation and Supervision Bureau (Bureau) is the independent regulatory body for the water, wastewater and electricity sector of the Emirate of Abu Dhabi.

7.1.2 In essence the Bureau enforces the relevant laws through the licensing of activities to various ‘persons’ who undertake a ‘Regulated Activity’ in the sector. Regulated Activities include; generation, transmission, distribution and sale of electricity and the production, transmission, distribution, sale and treatment of water including wastewater products.

7.1.3 With respect to solar PV systems, The Bureau is responsible for the following:

a) Issuance of Self-Generation (Solar PV) License or Exemption Order Confirmation.

b) Issuance of the Electricity Wiring Regulations, in particular Electrical Installation requirements for solar PV systems.

Abu Dhabi Water and Electricity Authority (ADWEA)

7.1.4 The Abu Dhabi Water & Electricity Authority researches and develops ways to efficiently produce, distribute and consume water and electricity. Abu Dhabi needs water and electricity to live, grow and thrive. The Abu Dhabi Water and Electricity Authority was established in 1998 to oversee all business related to the formation, development and implementation of Government policies related to the sector.

7.1.5 The immediate aim of ADWEA is to focus on setting up an enabling and supporting environment for renewable energy in particular, to promote solar energy penetration in distribution grid both at centralized and decentralized levels.

Distribution Companies

7.1.6 Al Ain Distribution Company (AADC) is a wholly owned subsidiary of ADWEA with a fully paid capital. AADC is the sole distributor of water and electricity in the Eastern Region of the Emirate of Abu Dhabi (Al Ain city and its surrounding rural areas). This includes the ownership, operation and maintenance of the water and
electricity distribution network assets, meter reading, and services for the supply of water and electricity. AADC provides services to the population living in the East Region of Abu Dhabi (Al Ain Region).

7.1.7 Abu Dhabi Distribution Company (ADDC) is responsible for distributing high quality water and electricity services to all customers in the emirate of Abu Dhabi, excluding the Al Ain region. ADDC’s core business is the planning, design, construction, and operation of the Abu Dhabi water and electricity distribution network.

7.1.8 The Distribution Companies are responsible for:

a) Reviewing and approving the connection applications for solar PV generation connected to the distribution network.

b) Enforcing the requirements of the Electricity Wiring Regulations, which include:

- Pre-qualification of solar PV equipment.
- Licensing of Electrical Contractors.
- Approval of solar PV Electrical Installations (i.e. review of technical details, inspection and testing).

Department of Municipal Affairs & Transport

7.1.9 The Department of Municipal Affairs & Transport (DMA&T) was established in May 2007, and replaced the Department of Municipalities and Agriculture to act as the main focal point of all municipal planning and to oversee public works projects in the Emirate of Abu Dhabi. The DMA&T aims to produce efficiencies and higher customer satisfaction in accordance with the national Policy Agenda which will represent a new era in municipal services to the general public. As a regulatory body, the DMA&T supervises the three regional municipal councils and municipal administrations; Abu Dhabi Municipality (ADM), Al Ain Municipality (AAM) and Western Region Municipality (WRM).

7.1.10 AAM and ADM are responsible to issue permits that will include both the architectural and structural approvals for the rooftop solar PV installation in Al Ain and Abu Dhabi respectively.
7.2 Steps in connecting solar PV systems

Step 1: Selection of Solar PV Integrator

7.2.1 The Owner of an Electrical Installation wishing to install solar PV systems should select a Solar PV Integrator to carry out solar PV system Electrical Installation Work.

7.2.2 The Solar PV Integrator must be approved as a Licensed Contractor to carry out Electrical Installation work by the Relevant Distribution Company.

[Note: A register of Licensed Contractors are kept up-to-date by the Distribution Company and provided on request to any person. Refer to Annex B for a summary of the licensing requirements of Solar PV Integrators]

7.2.3 It will be prudent for the project proponent to consider the following points during discussions with the Solar PV Integrator:

a) The mechanical structure, Electrical Installation work including power conditioners/inverters/charge controllers/ other DC equipment’s etc. and overall workmanship of the solar PV power plants/ systems in general must be warranted against any manufacturing/ design/ installation defects for a minimum period of 5 to 10 years (preferably 10 years).

b) A separate Operation & Maintenance contract to be prepared covering all parts in details by the Solar PV System Integrator.

c) PV Modules used in solar power plants/ systems must be warranted for their output peak watt Capacity, which should not be less than 90% at the end of 10 years and 80% at the end of 25 years.

Step 2: Self-Regulating Generation License:

7.2.4 Application for Self-Regulating Generating (Solar PV) Licence from the Regulation and Supervision Bureau to be made by the Owner or Solar PV System Integrator on behalf of the Owner.

7.2.5 Rooftop solar PV installations on residential and commercial entities referred to in this guide are typically small-scale and self-supply generation which is an activity regulated by the RSB through licensing or exemption.
7.2.6 Any company/person/entity considering the installation and operation of privately owned solar PV systems must contact the RSB to obtain the necessary application forms. Further details can be found on the website www.rsb.gov.ae or email Licence@rsb.gov.ae.

7.2.7 The licence application process will require amongst other things, details of the person/company undertaking O&M works, risk assessment/measures carried out to comply to with Health and Safety requirements and compliance with the Electricity Wiring Regulations. Refer to Annex A for the process flow chart.

7.2.8 To reduce the current regulatory burden on small-scale solar PV generators, the Bureau will develop a two tier system of Exemptions which allows small-scale solar PV generators to seek an Exemption Order Confirmation rather a Self-Regulating Licence:

(a) Solar PV installations of capacity less than 50 kW; and

(b) Solar PV installations of capacity more than 50 kW but not exceeding 5MW.

Step 3: Building Permit Application

7.2.9 AAM and ADM has a permit application for licensing activities concerning the installation of PV systems, called the “Rooftop Solar PV Panel Permit”. The permit typically takes some 2-1 weeks to issue.

7.2.10 Applications can be made through any of the consultants or contractors registered with the municipality via the AAM or ADM websites.

7.2.11 All information required are available on line but in summary, the applicants have to complete the Rooftop Solar PV panel information on line and upload a site plan, elevation, owner authorization, and a copy of the consultant or contractor license and NOC from AADC or ADDC.

7.2.12 Finally, the AAM or ADM permit will include both the architectural and structural approvals.
Step 4: Generation Connection Application

7.2.13 A generation connection application has to be made to either AADC or ADDC. Further details can be found on the websites or customer services centres.

7.2.14 In general, the connection process would involve:

a) Submittal of the relevant PV system details alongside the submittal of the Load Demand Notification “LDN application”. As a minimum, details of the type of PV modules (mono crystalline, thin film etc.), PV modules make/model, total generation output (kWp), Inverter kW rating, Inverter make/model, location of PV system (rooftop, car park shade etc.), details of the Solar PV Integrator/Licensed Contractor etc.

b) Submittal of the relevant PV system schematic diagram when submitting the Drawings Approval application. The PV system schematic diagram should clearly show all details of both the complete DC and AC systems and connection to the distribution network.

(Note: Refer Annex E for the complete process flowchart.)
8.1 Inspection and Testing

8.1.1 Inspection and testing of the a.c. system is covered under the Electricity Wiring Regulations.

8.1.2 The a.c. system inspection and testing documentations consist of the following (refer to Annex F):

a) Electrical Installation Certificate;
b) Electrical Inspection report; and
c) Electrical Installation testing report.

8.1.3 Inspection and testing of the Solar PV d.c. circuits shall be carried out in compliance with the requirements of the Electricity Wiring Regulations and documented by a Licensed Contractor under the supervision of a solar PV system Integrator.

8.1.4 The d.c. system inspection and testing documentations consists the following (refer to Annex F):

a) Solar PV test report; and
b) Solar PV system inspection report.

8.2 Documentation requirements

8.2.1 Users of Solar PV systems should ensure that upon completion of the design, installation and commissioning of the system that adequate and proper documentation and handover is provided by the Solar PV System Integrator. Refer to Annex F for the Solar PV System Document check list.

8.3 Routine inspection

8.3.1 The purpose of routine inspection is to ensure that the integrity of the installed Solar PV System remains intact throughout the intended life of the system.

8.3.2 Solar PV Systems typically requires little maintenance, and the majority of maintenance issues can be discovered by doing a proper visual inspection and understating the information provided by the remote monitoring and data logging systems provided by the majority of Inverter manufactures.

8.3.3 It is recommended that Solar PV Systems be inspected and maintained on regular basis, typically once a year. Refer to Annex C for recommended routine maintenance and remedial actions.
Annex A- SELF-REGULATING GENERATION (SOLAR PV) LICENCE Process Flow Chart

This process will continue to be applicable until the proposed exemption scheme is developed by the Bureau.
Contractors applying for a licence specific to Solar PV System Integrators are required to submit the following information for evaluation of their licence request to the relevant Distribution Company:

1. The Contractor must submit the following documents as part of the Competency Licence Application:
   
   (a) Copy of sponsor’s or national partner’s passport.
   
   (b) Copy of a valid Municipality, Department of Economic Development licence.
   
   (c) Copy of a valid Membership Certificate of Abu Dhabi Chamber of Commerce and Industry.
   
   (d) Copy of a valid lease contract in the name of the Contractor.
   
   (e) Copy of a valid Engineer’s Registration Certificate (Electricity Wiring Regulation Course E1) for the person named as such in the application.
   
   (f) For each technical staff member named in the application:
      
      (i) a copy of passport and a valid Abu Dhabi residence visa page showing sponsorship of the Contractor.
      
      (ii) Experience record or curriculum Vitae along with references
   
   (g) A copy of the notarised Power of Attorney for the Contractor’s authorised signatory.
   
   (h) A copy of the notarised Power of Attorney for the Registered Engineer’s authorised signatory.

2. The Competency Licence Application must be signed and dated by the Contractor’s authorised signatory and sealed by the Contractor.

3. Originals of all documents required to make a new Competency Licence Application must be presented at the Licensing Committee interview.

4. Specific experience in PV Installations (provide brief details on each project):
• List of projects within Abu Dhabi
• List of projects within UAE
• List of projects elsewhere

5. Contractor’s Solar PV related experience

• Total accumulated solar PV capacity installed to date.
• Number of years of active PV installation work and if relevant, any low voltage electrical work including (i.e. design, installation, maintenance and repair etc).

6. HSE Certification and Training

• List of staff with HSEQ certification (e.g. ISO 14001, OHSAS 18001, ISO 9001)
• List of staff with Distribution Company HSE certification (provide copies of the certificates)
• Other HSE and Quality certifications (provide copies of the certificates)
• List of any Solar Integrator training programme by an authorised trainer attended by the company (provide copies of the certificates).
• List of any Personal Protective Equipment (PPE) and training for staff.
• Provide details of any information on the HSE risks associated with PV Installations provided to the Customer (PV owner).

7. Customer Service

• Provide company website to which customers can reach you in case of service requests.
• Provide company contact centre and case tracking system for customer support in Abu Dhabi if available.
• Provide details of the company’s project management system in place.
Annex C- Design and Installation Check List

The following checklist is a brief detail that could be helpful if you have decided to install solar PV system in your premises.

<table>
<thead>
<tr>
<th>No</th>
<th>Design &amp; Installation Check list</th>
<th>Check</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Select a location (e.g. Empty space on roof top)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Check the premises electricity demand and determine the appropriate size of the Solar PV System.</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Assess the installation site for space requirements, and access for maintenance.</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Engage a Solar PV System Integrator</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The appointed Licensed Contractor (i.e. Solar PV System Integrator) will be responsible for the design and implementation of the connection of the Solar PV System to the electrical installation.</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Select PV Module</td>
<td></td>
</tr>
<tr>
<td></td>
<td>a) Number of PV Modules needed.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>b) Type and rating.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>c) Mounting method.</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Select inverter to match PV array:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>a) Number of inverters needed.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>b) Inverter type and rating.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>c) Location of inverters (accessible for inspection and maintenance).</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Select the most appropriate mounting system (mechanical structure) for the Solar PV system. Ensure there are fixing and mounting points available.</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Assess the proposed mounting structure:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>a) Additional load introduced by the Solar PV system on the roof must be checked.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>b) Additional wind load must be checked.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>c) Roof waterproofing must not be compromised during installation.</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>Design &amp; Installation Check list</td>
<td>Check</td>
</tr>
<tr>
<td>----</td>
<td>---------------------------------</td>
<td>-------</td>
</tr>
<tr>
<td>9</td>
<td><strong>Ensure solar system access:</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>a) Ensure location to be mounted will get maximum exposure to sunlight (aim for South);</td>
<td></td>
</tr>
<tr>
<td></td>
<td>b) Ensure location if away from any obstruction and shaded areas.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>c) Ensure adequate space is provided to perform routine module cleaning.</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Ensure all PV modules connected to the same inverter face the same direction or use multiple Maximum power point tracking (mppt) tracking inverters.</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Ensure PV modules are mounted at the optimal tilt angle depending on installation conditions (typically a tilt angle of between 10° to 20° degrees is recommended).</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Ensure sufficient ventilation space is allocated behind the PV array for cooling purposes.</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td><strong>Ensure:</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>a) Cabling used meet sufficient current-carrying capacity and are suitably rated for usage in the environment.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>b) d.c. cables are single-core and double-insulated.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>c) Cable insulation on outdoor cables must withstand high temperature and UV exposure for an estimated period of more than 20 years.</td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>(Note: PVC and XLPE cables are inadequate on the d.c. side and must not be exposed to the weather elements.)</em></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Determine if a Lightning Protection System is needed. Consult a lightning specialist.</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Ensure that the installation is in full compliance with the requirements of the latest edition of the Electricity Wiring Regulations (i.e. General principles, Protection, Isolation and switching, Labelling, inspection and testing).</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>Design &amp; Installation Check list</td>
<td>Check</td>
</tr>
<tr>
<td>----</td>
<td>----------------------------------</td>
<td>-------</td>
</tr>
<tr>
<td>16</td>
<td><strong>During installation:</strong>&lt;br&gt;a) PV system should be installed by qualified/experienced installers&lt;br&gt;b) Safety rules must be observed&lt;br&gt;c) Installer must wear safety protection equipment PPE; and&lt;br&gt;d) Only proper certified safety equipment can be used e.g. scaffolding, stepladders, etc.</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Cables must be properly connected, secured, and routed.</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Ensure continuity and insulation tests are done.</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Completion of the required documentation, inspection and testing as outlined in Annex F</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Ensure the design meets local utility interconnection and approval requirements.</td>
<td></td>
</tr>
</tbody>
</table>
Annex D-Routine Maintenance

The following table shows some recommendations on the preventive maintenance works on the components and equipment, and the corresponding remedial actions that can be carried out by qualified personnel. Solar PV system inspection report.

<table>
<thead>
<tr>
<th>Solar PV Inspection Report</th>
<th>Routine Inspection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installation address</td>
<td>Reference:</td>
</tr>
<tr>
<td></td>
<td>Date:</td>
</tr>
<tr>
<td>Circuits inspected</td>
<td>Inspector:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Equipment/Circuits Inspected:</th>
<th>Satisfactory</th>
<th>not satisfactory (give details/comments)</th>
<th>not applicable</th>
<th>Urgent work required</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>General</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.c part of the electrical installation is tested in accordance with Regulations 8.1</td>
<td>□ ○</td>
</tr>
<tr>
<td>PV distribution boards room condition</td>
<td>□ ○</td>
</tr>
<tr>
<td>PV distribution boards condition</td>
<td>□ ○</td>
</tr>
<tr>
<td>Proper ventilation behind array</td>
<td>□ ○</td>
</tr>
<tr>
<td>Cable entry weatherproof</td>
<td>□ ○</td>
</tr>
<tr>
<td>Array frame correctly fixed and stable; roof fixings weatherproof</td>
<td>□ ○</td>
</tr>
<tr>
<td>PV Modules</td>
<td></td>
</tr>
<tr>
<td>--------------------------------</td>
<td>-------------------------------------</td>
</tr>
<tr>
<td>Check for dust and dirt build up</td>
<td>It is recommended that modules are cleaned once every 4 weeks.</td>
</tr>
<tr>
<td>Check for damaged modules</td>
<td>Replace damaged modules.</td>
</tr>
<tr>
<td>Check for damaged cables</td>
<td>Replace damaged cables.</td>
</tr>
<tr>
<td>Check for damaged connectors and loose connections</td>
<td>Replace damaged connectors and retighten connections</td>
</tr>
<tr>
<td>Check array mounting frame for any damage or loose fixings</td>
<td>Repair or replace frame as required</td>
</tr>
<tr>
<td>Check for proper ventilation behind PV array</td>
<td>Remove any obstructions that may affect ventilation from behind PV array</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PV Inverter</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Check Inverter mounting frame</td>
<td>Properly secure Inverter</td>
</tr>
<tr>
<td>Check Inverter proper ventilation</td>
<td>Clean any dust build up that may affect ventilation of the inverter.</td>
</tr>
<tr>
<td>Check Inverter cable connections</td>
<td>Tighten connection</td>
</tr>
<tr>
<td>Check Inverter operating temperature</td>
<td>If temperature is abnormally high, replacement of inverter may be required.</td>
</tr>
<tr>
<td>Check Inverter loss of grid functionality</td>
<td>If function does not work as intended, replacement of the inverter is required.</td>
</tr>
<tr>
<td>Check Inverter installation location</td>
<td>Remove any obstructions that prevents access to the inverter</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cabling</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Check cables conditions (Module, String etc.)</td>
<td>Replace if damaged</td>
</tr>
<tr>
<td>Check cables connections for signs of burn or discolouring</td>
<td>Replace if damaged</td>
</tr>
<tr>
<td>Check cables supports and physical protection</td>
<td>Repair or protect cables are needed</td>
</tr>
<tr>
<td>Switching and Isolation</td>
<td></td>
</tr>
<tr>
<td>Check a.c. switch disconnector functionality</td>
<td>Replace if damaged or not working</td>
</tr>
<tr>
<td>Check d.c. switch disconnector functionality</td>
<td>Replace if damaged or not working</td>
</tr>
<tr>
<td><strong>Bonding or exposed conductive parts to lightning protection system</strong></td>
<td></td>
</tr>
<tr>
<td>Check bonding connections</td>
<td>Tighten loose connection</td>
</tr>
<tr>
<td>Check bonding cables conditions</td>
<td>Replace if damaged</td>
</tr>
<tr>
<td>Check bonding cable continuity</td>
<td>Rectify if no continuity is found</td>
</tr>
<tr>
<td><strong>Labelling and identification</strong></td>
<td></td>
</tr>
<tr>
<td>Check all circuits, protective devices, switches and terminals are suitably labelled</td>
<td>Replace damaged labels</td>
</tr>
<tr>
<td>All d.c. junction boxes (PV generator and PV array boxes) carry a warning label indicating that active parts inside the boxes are fed from a PV array and may still be live after isolation from the PV inverter and public supply.</td>
<td>Replace damaged labels</td>
</tr>
<tr>
<td>The main a.c. and d.c. isolating switches are clearly labelled.</td>
<td>Replace damaged labels</td>
</tr>
<tr>
<td>Dual supply warning labels are fitted at point of interconnection.</td>
<td>Replace damaged labels</td>
</tr>
<tr>
<td>A single line wiring diagram is displayed on site.</td>
<td>Replace or provide up to date wiring diagram</td>
</tr>
<tr>
<td>Emergency shutdown procedures are displayed on site.</td>
<td>Provide up to date emergency shutdown procedures</td>
</tr>
<tr>
<td>All signs and labels are suitably affixed and durable.</td>
<td>Replace damaged labels</td>
</tr>
</tbody>
</table>
Annex E- Solar PV System Process

- Select an approved Solar PV System Integrator from the list of Licensed Contractors available with the Distribution Company
  • Responsible: Owner

- Get a Project design proposal for premises roof location
  • Responsible: Owner and Solar PV System Integrator

- Approach RSB to request for a Self-Generating License Note. See details in Chapter 5
  • Responsible: Owner or Solar PV System Integrator on behalf of the Owner

- Apply for building permit with the relevant Municipality for approval of Architectural & Structural design for existing or new building.
  • Responsible: Solar PV System Integrator / Structural Contractor

- Apply for installation/connection of Solar PV System to Grid in ADDC/AADC
  • Responsible: Solar PV System Integrator

- After installation of the system, before connecting the Solar PV System to the Grid: Commissioning test to be conducted by Solar PV System Integrator. Approval & final Inspection required from ADDC/AADC
  • Responsible: Solar PV System Integrator

- Get As-Build Drawings, O&M manuals and relevant training from the System Integrator.
  • Responsible: Owner and Solar PV System Integrator
## Annex F- Solar PV System Documentation

### Solar PV System Document Check List
(based on the requirements of BS EN 62446):

<table>
<thead>
<tr>
<th>No.</th>
<th>Documentations</th>
<th>☑ satisfactory</th>
<th>✘ not satisfactory</th>
<th>☐ not applicable</th>
<th>☒ not provided</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>System data</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Project Reference Number</td>
<td>☒</td>
<td>☒</td>
<td>☐</td>
<td>☒</td>
</tr>
<tr>
<td>2</td>
<td>Rated system power (kW d.c. or KVA a.c.)</td>
<td>☒</td>
<td>☒</td>
<td>☐</td>
<td>☒</td>
</tr>
<tr>
<td>3</td>
<td>PV modules and inverters – manufacture, model and quantity</td>
<td>☒</td>
<td>☒</td>
<td>☐</td>
<td>☒</td>
</tr>
<tr>
<td>4</td>
<td>Installation date</td>
<td>☒</td>
<td>☒</td>
<td>☐</td>
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</tr>
<tr>
<td>5</td>
<td>Commissioning date</td>
<td>☒</td>
<td>☒</td>
<td>☐</td>
<td>☒</td>
</tr>
<tr>
<td>6</td>
<td>Customer name</td>
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<td>☒</td>
<td>☐</td>
<td>☒</td>
</tr>
<tr>
<td>7</td>
<td>Site address</td>
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<td>☒</td>
<td>☐</td>
<td>☒</td>
</tr>
<tr>
<td></td>
<td><strong>System designer information</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Company name</td>
<td>☒</td>
<td>☒</td>
<td>☐</td>
<td>☒</td>
</tr>
<tr>
<td>9</td>
<td>Contact person name</td>
<td>☒</td>
<td>☒</td>
<td>☐</td>
<td>☒</td>
</tr>
<tr>
<td>10</td>
<td>Company address, telephone number, postal address, and e-mail address</td>
<td>☒</td>
<td>☒</td>
<td>☐</td>
<td>☒</td>
</tr>
<tr>
<td></td>
<td><strong>System installer information</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Company name</td>
<td>☒</td>
<td>☒</td>
<td>☐</td>
<td>☒</td>
</tr>
<tr>
<td>12</td>
<td>Contact person name</td>
<td>☒</td>
<td>☒</td>
<td>☐</td>
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</tr>
<tr>
<td>13</td>
<td>Company address, telephone number, postal address, and e-mail address</td>
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<td>☒</td>
<td>☐</td>
<td>☒</td>
</tr>
<tr>
<td></td>
<td><strong>Wiring Diagram</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Module types</td>
<td>☒</td>
<td>☒</td>
<td>☐</td>
<td>☒</td>
</tr>
<tr>
<td>15</td>
<td>Total number of modules</td>
<td>☒</td>
<td>☒</td>
<td>☐</td>
<td>☒</td>
</tr>
<tr>
<td>16</td>
<td>Number of strings</td>
<td>☒</td>
<td>☒</td>
<td>☐</td>
<td>☒</td>
</tr>
<tr>
<td>17</td>
<td>Modules per string</td>
<td>☒</td>
<td>☒</td>
<td>☐</td>
<td>☒</td>
</tr>
<tr>
<td>String cable specifications – size and type</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>String over-current protective device specifications – type and voltage/current ratings</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blocking diode type</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Array main cable specifications – size and type</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Array junction box locations</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d.c. isolator type, location and rating (voltage/current)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Array over-current protective device – type, location and voltage/current ratings</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Details of earthing and bonding conductors – size and connection point, including details of array frame equipotential bonding cable where fitted</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Details of connections to an existing lightning protection system</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Details of any surge protection devices installed (both a.c. and d.c.) including location, type and rating</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a.c. isolator, type and rating</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a.c. overcurrent protective device location, type and rating</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Residual current device locations, type and rating</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 5 Datasheets

- Modules datasheet
- Inverters datasheet

### 6 Mechanical design information

- Mounting system datasheet
<table>
<thead>
<tr>
<th>7</th>
<th><strong>Operation and maintenance information</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Procedures for verifying correct system operation</td>
</tr>
<tr>
<td></td>
<td>A checklist of what to do in case of a system failure</td>
</tr>
<tr>
<td></td>
<td>Emergency shutdown/isolation procedure</td>
</tr>
<tr>
<td></td>
<td>Maintenance and cleaning recommendation</td>
</tr>
<tr>
<td></td>
<td>Considerations for any future building works related to the PV array</td>
</tr>
<tr>
<td></td>
<td>Warranty documentation for PV modules and Inverters, including the starting date of the warranty and period of warranty</td>
</tr>
<tr>
<td></td>
<td>Documentation on any applicable workmanship or weather-tightness warranties</td>
</tr>
<tr>
<td>8</td>
<td><strong>Test results and commissioning date</strong></td>
</tr>
<tr>
<td></td>
<td>Copies of all test and commissioning data</td>
</tr>
</tbody>
</table>