

GENERAL SPECIFICATION

ELECTRICAL

GS EP ELE 261

Solar Power System

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1. Scope

This specification covers the minimum requirements for design, manufacture, operation and testing of solar power system in order to supply electrical loads for offshore or onshore unattended/unmanned electrical installations.

2. Reference documents

The reference documents listed below form an integral part of this General Specification.

PV generators, stationary batteries, controllers/battery charging regulators, main junction boxes and distribution panels shall conform in design, material and performance with the appropriate sections of the latest editions (with amendments) of the relevant IEC, CENELEC standards and codes.

The following order of precedence applies specifically to electrical equipment:

- Applicable laws and regulations of the country in which the system will be operated. In cases where no "local" regulations exist, the French laws and regulations shall be used
- Company Particular Specifications and data-sheets (if any)
- Company General Specifications
- Applicable International Electro-technical Commission (IEC) Standards
- Applicable European Standards by CENELEC
- Applicable recognised standards and codes (UTE-NFC, BS, VDE, etc.) when IEC publications have not yet been issued.

External Documents

Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published at the effective date of this document.

Reference	Title
IEC 60068 (All parts)	Environmental testing - All parts
IEC 60079 (All parts)	Explosive atmospheres - All parts
IEC 60146 (All parts)	Semiconductor converters - All parts
IEC 60255 (All parts)	Measuring relays and protection equipment - All parts
IEC 60269-1	Low-voltage fuses - Part 1: General requirements
IEC 60331-21	Tests for electric cables under fire conditions. Circuit integrity - Part 21: Procedures and requirements-Cables of rated voltage up to 0.6/1.0 kV
IEC 60332-3-22	Tests on electric and optical fibre cables under fire conditions - Part 3-22: Tests for vertical flame spread of vertically-mounted bunched wires or cables-Category A

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Reference	Title
IEC 60364-7-712	Electrical installation buildings - Part 7-712: Requirements for special installations or locations - Solar photovoltaic (PV) power supply systems
IEC 60529	Degrees of protection of enclosures
IEC 60896 (Parts 11; 21)	Stationary lead-acid batteries - Parts 11; 21
IEC 60904 (All parts)	Photovoltaic devices - All parts
IEC 61000 (All parts)	Electromagnetic compatibility - All parts
IEC 61204	Low-voltage power supply devices, d.c. output - Performance characteristics
IEC 61215	Cristalline silicon terrestrial photovoltaic (PV) modules - Design qualification and type approval
IEC 61427	Secondary cells and batteries for photovoltaic energy system (PVES) - General requirements and methods of test
IEC 61434	Secondary cells and batteries containing alkaline or other non-acid electrolytes - Guide to designation of current in alkaline secondary cell and battery standards
IEC 62040 (All parts)	Uninterruptible power systems (UPS) - All parts
IEC 62259	Secondary cells and batteries containing alkaline or other non-acid electrolytes - Nickel-Cadmium prismatic secondary single cells with partial gas recombination
IEC 62262	Degrees of protection provided by enclosures for electrical equipment against external mechanical impact (IK code)
IEC 62402	Obsolescence management - Application guide
NASA Data Base	NASA Surface Meteorology and Solar Energy - Available Table (http://eosweb.larc.nasa.gov/sse)

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Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published in the applicable yearly collection.

Reference	Title
GS EP COR 350	External protection of offshore and coastal structures and equipment by painting
GS EP COR 354	External protection of onshore structures and equipment by painting
GS EP ELE 079	Electrical apparatus for potentially explosive gas atmospheres
GS EP ELE 137	Distribution boards
GS EP STR 103	Design and fabrication of skids and equipment supporting structures
GS EP TEC 007	Obsolescence and Lifetime Cycle Management

3. General

3.1 Environmental data

The Solar Power System shall be designed in accordance with the environmental conditions as defined in the Project Particular Specification:

- Hazardous area classification (if any)
- Air temperatures (highest, lowest and average)
- Humidity ratios (highest, lowest and average)
- Altitude
- Maximum wind speeds in function with its dominant direction (1 hour, 1 minute, 3 seconds gust)
- Solar radiation characteristic at site.

In case H₂S might be present, special provisions shall be taken by the Manufacturer to avoid equipment/material corrosion. The Manufacturer shall indicate the proposed protection measures in his bid.

3.2 System reliability and availability

Prototype or unproven equipment not having a well established operating record will not be considered.

The Manufacturer shall state in his bid the availability, reliability and Mean Time Between Failure (MTBF) data for similar units in service.

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3.3 Deviations to specification

The Manufacturer shall advise the Company of any deviations made in respect of this Specification at the time of tendering. Should this Specification conflict with requirements of the listed standards the Manufacturer shall request clarification from the Company.

3.4 Solar power system description

Solar Power system shall be designed in accordance with the Typical Single Line Diagram presented in Appendix 2 or Appendix 3.

Solar power system includes:

- Solar photovoltaic generators
- Controllers/battery charging regulators
- Stationary batteries
- Main junction box (connects controllers/battery charging regulators to stationary battery banks and the main DC distribution panel)
- Distribution panels/boxes.

Distribution shall be designed in accordance with the type of loads (motors, instrument, telecom) to be fed. Particular care shall be taken to avoid disturbances due, for instance, to motor starting (DC/DC or DC/AC converters). The Solar power system shall meet EMC requirements of [IEC 61000](#) (all parts).

3.5 Modes of operation

Solar photovoltaic generators shall simultaneously ensure battery charging and consumers' supply.

Controllers/battery chargers shall maintain output voltage within tolerances as specified in the Project Particular specification.

Stationary batteries shall ensure:

- Continuous power supply without solar photovoltaic generator
- Peak electrical consumptions.

Solar power system arrangement is designed with one or several DC sources and one distribution station.

In accordance with the Typical Single Line Diagram (Appendix 2 or Appendix 3), each DC source comprises:

- One solar photovoltaic generator
- One DC controller /battery charger
- One 2-pole circuit breaker

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- One stationary battery branch
- One battery branch isolator inside the main junction box to connect the DC source to stationary battery branch and the main DC distribution panel.

Battery cells shall be one of the following types:

- Nickel cadmium batteries with partial gas recombination (in accordance with [IEC 62259](#))
- Vented lead acid batteries with tubular positive plates (in accordance with [IEC 60896-11](#))
- Valve regulated gas recombination lead acid cells with recombination ratio $\geq 95\%$ (in accordance with [IEC 60896-21](#)) and tubular positive plates.

High ambient temperatures (above 30°C) severely reduce operating life of lead acid batteries (for every 10°C increase over 30°C, the reduction of operating life will be 50%) and increase the risk of sudden failures. Low ambient temperatures (below 0°C) reduce available capacity of lead acid batteries.

For unattended/unmanned or critical applications (offshore platform for instance) with extreme temperatures (above 30°C or below 0°C), partial gas recombination nickel cadmium battery cells shall be used.

DC sources shall be one of the following types:

3.5.1 Type 1

Solar power system is designed with only one DC source and one distribution station (DC or DC/AC) to supply consumers (see Appendix 2) that do not entail safety of persons or equipment in case of loss of supply (e.g. starting batteries), etc.

3.5.2 Type 2

Solar power system comprises one distribution station fed by two identical DC sources in parallel operation sized to 50% each (see Appendix 3). This arrangement shall supply loads that could entail safety of persons or equipment in case of loss of supply.

4. Design requirements

4.1 Construction requirements

4.1.1 Solar Photovoltaic generator

4.1.1.1 Definition

The abbreviation "PV" is used for "solar photovoltaic".

For better understanding, PV generator arrangement is introduced in Appendix 1; and, the following terminology shall be used, as per [IEC 60364-7-712](#):

- PV cell is the basic PV device which can generate electricity when exposed to light such as solar radiation.
- PV module is the smallest completely environmentally protected assembly of interconnected PV cells.

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- PV array is mechanically and electrically integrated assembly of PV modules, and other necessary components, to form DC power supply unit:
 - PV modules shall be connected in series to achieve the required voltage and built a PV string
 - Several PV strings shall be jointed in parallel and electrically protected by components inside an Array Combiner Box.
- PV generator is an assembly of PV arrays.

4.1.1.2 General

PV arrays and boxes (junction, Array Combiner and PV generator boxes) shall be outdoor, skid mounted, at least IP66-IK08 (IEC 60529 - IEC 62262) and shall be suitable for the site installation conditions (refer to GS EP ELE 079, GS EP COR 350 and GS EP COR 354).

Boxes shall be arranged for front operation and maintenance with a key lockable access door. Warning labels shall be fitted in prominent positions advising care to be taken for access to live equipment.

PV arrays and boxes shall be isolated at 750V DC as minimum.

PV internal wiring shall be as a minimum in accordance with the cubicle internal wiring requirements (see part 4.1.2.6).

Bolts, nuts, washers, clamps... shall be of the same type as than PV array supports. If two types of materials are fitted together, insulating washers shall be required.

Boxes and skids shall be designed to be lifted by use of removable eye bolts.

Two earthing plates or terminals shall be provided at diametrically opposite ends of supports, structures and boxes to allow earthing and bounding external connections to general earthing grid.

Bird spikes shall be provided on the PV arrays in particular to prevent birds from landing, roosting, nesting and/or dropping.

4.1.1.3 PV cells

PV cells shall be high quality and multi crystalline construction.

4.1.1.4 PV modules

PV module shall encapsulate PV cells with tempered glass and anti-reflective coating as cell finish on the front side as minimum.

PV module should be capable to withstand air velocity as specified in the Project Particular specification.

PV cell interconnections shall be redundant, reliable connection, only sealed connection box on cell array structure.

Each PV module shall be provided with by-pass diode inside a junction box.

Each Individual module shall be electrically and mechanically interchangeable.

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High efficiency cell module (W/m²) shall be required to optimise the allocated spaces of PV array arrangement.

4.1.1.5 PV arrays

PV Array shall be:

- A series-parallel combination of PV modules by the Array Combiner Box Components in order to provide the required voltage and current
- Pre-assembled and skid mounted on supports.

4.1.1.5.1 Array Combiner Box

Array Combiner Box shall be designed in order to:

- Combine the grouped PV modules into a common output
- Protect circuit against lightning effects (over-voltage) surges with surge arresters and surge diverters
- Isolate each PV string and prevent with blocking diode inside
- Test array in current and voltage
- Carry a means for connection and disconnection of individual PV array for maintenance, testing, repair and replacement.

4.1.1.5.2 PV array support

PV array support shall be:

- Epoxy painted stainless steel 316L for corrosive atmosphere
- Epoxy painted hot dip galvanized carbon steel for non corrosive atmosphere.

Coating shall comply with Company General Specification [GS EP COR 350](#) or [GS EP COR 354](#) requirements.

4.1.1.6 PV generator

PV generator shall be:

- A series-parallel combination of PV arrays by the PV Generator Box Components to achieve the desired operating voltage and current
- Skid mounted on support structure.

4.1.1.6.1 PV generator box

PV generator box shall be designed in order to:

- Combine the grouped PV arrays into a common output
- Test array in current and voltage.

A complete PV generator drawing set shall be inside.

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4.1.1.6.2 PV generator structures

One structure shall be for one PV array support and shall be adjustable in accordance with its location on the site.

The support structures shall be designed in accordance with Company General Specification **GS EP STR 103**.

The support structure shall allow natural cooling for the modules to increase efficiency.

Basically, PV generator shall be inclined versus horizon plane. This angle shall be determined in accordance with the sun position versus solar panel location (in accordance with longitude and latitude coordinates).

The support structures shall allow adjustment of the PV array tilt angle. Engineer/Contractor shall determine the optimum declination for mounting the arrays. Mounting shall be adjustable about the determined angle ± 10 degrees versus the PV generator angle.

4.1.2 Cubicles

4.1.2.1 Definition

The cubicles shall consist of separate cabinets and independent junction boxes different from Array Combiner boxes and PV generator boxes.

4.1.2.2 Access doors

Cubicles shall be arranged such that internal access can be made. They shall be arranged for front operation and maintenance (except for a battery box which shall be top opening). Warning labels shall be fitted in prominent positions advising care to be taken for access to live equipment.

Access doors shall be lockable with a common key. They shall be fitted with an internal pocket suitable for a complete drawing set. Easy access shall be provided for topping up batteries in position.

4.1.2.3 Outdoor cubicles

Outdoor cubicles shall be suitable for the site installation conditions (refer to **GS EP ELE 079**, **GS EP COR 350** and **GS EP COR 354**).

They shall be skid mounted on supports with the same material as the PV array supports. Their bolts, nuts, washers, clamps... shall be of the same type. However, if two types of materials are fitted together, insulating washers shall be required.

Cubicles and skids shall be designed to be lifted by use of removable eye bolts.

Cubicles shall be at least IP55-IP08 (**IEC 60529** - **IEC 62262**) except for battery boxes which shall be IP23 minimum-IP08. Battery boxes shall be required with rain canopy.

Adequate natural ventilation/convection shall be provided in order to guarantee the proper operation of the equipment at rated conditions, whatever the mode of operation and the autonomy. A calculation note shall be required.

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4.1.2.4 Indoor cubicles

Indoor cabinets and boxes shall be at least IP21-IP08 (IEC 60529 - IEC 62262).

4.1.2.5 Control and indication

Status/signalling indicators, switches and push buttons shall be installed on each front of cubicles and shall use the following colour code:

- Status
 - On/Closed/Running RED
 - Off/Open/Stopped GREEN
 - Fault/Trip YELLOW
 - Voltage presence WHITE
- Switches & push buttons
 - On/Closing/Starting GREEN
 - Off/Opening/Stopping RED

4.1.2.6 Cubicle internal wiring

Internal wiring shall be PVC insulated 750 V grade, flame retardant (IEC 60332-3), stranded copper conductors, except for connection on printed circuits:

- 2.5 sq. min for current circuits
- 1 sq. min for voltage circuits
- 0.75 sq. min for auxiliary circuits.

Cabling between components shall be continuous; joining of cables is not permitted.

Internal wiring within the board shall be securely held in position (either loomed or run in trunking).

Wiring identification shall be by numbered and/or lettered ferrules, of insulating material and located adjacent to the terminals.

Wiring connections for external connections shall be brought out to individual terminals on a readily accessible terminal block. Wires shall be terminated using compression type lugs or crimp sleeves.

4.1.2.7 Earthing and lightning protection

Two earthing plates or terminals shall be provided at diametrically opposite ends of cubicles to allow earthing and bounding external connections to general earthing grid.

When required, lightning protection by surge arresters shall be installed inside each cubicle.

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4.2 Equipment sizing

4.2.1 Photovoltaic generator

PV generator shall be sized according to the following requirements:

- Minimum Monthly Insolation Incident on a Horizontal Surface (KW/m²/day).
The Minimum Monthly Insolation Incident on a Horizontal Surface shall be determined from the Minimum Monthly Average Insolation Incident on a Horizontal Surface (KW/m²/day) and the Minimum Difference from Monthly Average Insolation (%) as defined by International Available Tables about Surface Meteorology and Solar Energy (as [NASA Data Bases](#)) further to the site location (see example in Appendix 4).
- Battery requested autonomy (see example in Appendix 4).
- Maximum permanent electrical consumption increased by 15% for spare capacity.
- Battery recovery time (after the battery has been totally discharged) simultaneous with power supply to the loads); Battery recovery time shall be defined such that the battery capacity will be ready for the next NO-SUN or BLACK Days (days) in a year as defined by International Available Tables about Surface Meteorology and Solar Energy ([NASA Data Base](#)) further to site location. See example in Appendix 4.
- Design Safety Ratios and de-rating defined as follows (and which shall be submitted to Company):
 - Meteorological uncertainties
 - Ambient temperatures and wind speed (natural cooling)
 - Characteristic dispersion of the modules (mismatch)
 - Losses induced by dust or sand on front face and bird dropping, at least 10% of maximum output applied as de-rating factor for effect of sand
 - Offset from the ideal or optimum directions of true south
 - Ageing, at least 10% to be applied
 - Efficiency of various components of solar system
 - Array solar radiation shading during daylight
 - Solar panel/module efficiency at site, taking into account the [NASA Data Base](#); see Appendix 5 as an example.
- Space allocated for PV generator installation. Back-up power supply shall be considered in the case of the available space for the PV Generators are not sufficient.

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4.2.2 Stationary battery system

Stationary battery system shall be sized in accordance with the following requirements:

- Autonomy in order to cover:

The maximum equivalent number of "NO-SUN" days or BLACK Days (days) within a year seen in the Month period table extracted from the "International Available Tables" about Surface Meteorology and Solar Energy ([NASA Data Bases](#)), see example in Appendix 4.

- Appropriate ageing de-rating factor taken into account for maximum ambient temperatures in order to achieve the design life:
 - For lead-acid cells (see part 3.5):

Max. Ambient T°	20°C	30°C	40°C	50°C
Ageing factor	1.2	1.25	1.88	2.85

Note: Above table valid only for lead acid batteries, to achieve a 5 year design life.

- For Ni-Cd cells (see part 3.5):

Max. Ambient T°	20°C	30°C	40°C	50°C
Ageing factor	1.15	1.15	1.18	1.25

Note: Above table valid only for Ni-Cd batteries, to achieve a 10 year design life.

- Appropriate temperature de-rating factor shall be taken into account in order to achieve the required battery cell performances. Exact temperature de-rating factors shall be given by the battery Manufacturer.
- Power supply of:
 - Maximum continuous electrical consumption increased by 15% for spare capacity
 - All peak electrical consumptions increased by 15% for spare capacity without decreasing solar power system autonomy.
- End of discharge voltage required in accordance with chosen battery cell type and specified in the chapter 5 of the present document.
- Specified load voltage tolerance on the DC main distribution bus-bar: -15% / +10% without taking into account the voltage drop of the blocking diodes (if any - 0.6V/diode) inside the main junction box, on each DC source.

4.2.3 Protection devices

Design shall take into account the short circuit current calculation and selectivity studies for circuit breaker ratings (and blocking diodes if any).

4.2.4 Controller/Battery charging Regulator

Each DC source shall have an automatic battery-charging regulator/controller. Each charger/regulator shall be housed in a separate enclosure and shall provide accurate control and monitoring.

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Controller/battery charging regulator shall be micro-processor based and shall have the following functions as a minimum:

- Charging control algorithms for maximum battery charging efficiency
- Automatic battery voltage regulation
- Charging voltage compensation with battery enclosure temperature sensor (in particular for lead-acid cells).

5. Battery

The batteries shall be designed for photovoltaic applications ([IEC 61427](#)) and shall be of one of the following types in accordance with IEC standards. The final cell type selection shall be indicated in the "Project" particular specification.

5.1 Type A: Partial gas recombination type nickel-cadmium cells

This type of cell shall have a gas recombination rate in floating mode as defined in the [IEC 62259](#) standard. In this application, end of discharge voltage shall be between 1.00 V and 1.18 V per cell at 20°C. Life duration under the project conditions shall be at least 10 years.

5.2 Type B: Vented lead-acid cells

This type of cell shall fully comply with the [IEC 60896-11](#) standard. These cells shall be specified with tubular plates. System using lead acid batteries shall be equipped with a deep discharge protection device. In this application, end of discharge voltage shall not be lower than 1.85 V per cell at 20°C. Life duration under the project conditions shall be at least 5 years.

5.3 Type C: Sealed gas recombination type lead-acid cells

This type of cell shall fully comply with the [IEC 60896-21](#) standard. These valve regulated gas recombination lead acid cells shall be specified with tubular plates. They shall have a gas recombination rate equal to or greater than 95% in any charge mode. System using lead acid batteries shall be equipped with a deep discharge protection device. In this application, end of discharge voltage shall not be lower than 1.85 V per cell at 20°C. Life duration under the project conditions shall be at least 5 years.

Selection between A, B and C type shall be indicated in the Project Particular Specification taking into account the requirements listed in the part 3.5 of the present document.

5.4 Battery construction

Battery cells shall be assembled in flame retardant heat resistant, shock-absorbing plastic containers with covers attached to form a permanent leak-proof seal.

For all batteries type, covers shall be sealed against leakage of electrolyte and shall be fitted with spray-proof flame arresting vent plugs.

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5.5 Battery installation

5.5.1 Outdoor Installation in hazardous area

Batteries shall be installed in suitable certified battery boxes and adapted to the battery type in accordance with **GS EP ELE 079**.

5.5.2 Battery stands

The stands shall be supplied by the battery manufacturer and made of electrolyte resistant steel or suitably treated wood. The battery stands are prohibited for outdoor installations.

5.5.3 Battery cabinet (indoor)

Battery cabinet shall be fitted with cell racks mounted on electrolyte resistant sliding frames complete with stoppers. Mechanical interlock shall be provided to prohibit withdrawal of more than one cell rack at a time.

Each sliding rack shall be carefully connected to the main earth bus-bar by means of flexible copper connections.

5.6 Battery terminals

All cell terminals shall have adequate current carrying capacity. Cell terminal posts shall be equipped with connector bolts. Cell terminal posts, bolts, interconnecting links and associated hardware shall be of electrolyte-resisting material and protected by insulating screens to prevent risk of contact with live parts.

5.7 Battery capacity

Engineer/Contractor shall provide a calculation note justifying the type and reference of the battery selected and the number of elements.

6. Controller/battery chargers and main junction box

6.1 Electrical service conditions

PV generators shall allow battery charging and load supply with the controllers/battery charging regulators via main junction box.

All equipment shall meet the requirements of the IEC and CENELEC standards regarding Electro-Magnetic Compatibility (EMC).

6.2 Battery charging regulator operations and main junction box

- a) Charger/regulator units shall have two automatic modes of operation: "boost" and "float". (The boost charge at the beginning of a cycle allows the electrolyte of the lead acid battery to be mixed to avoid stratification).

When required in the project, an automatic "battery test" function shall be provided.

Automatic pre-set parameters shall be easily adjustable. Nevertheless, access to such parameters shall be limited to authorised operators via key and/or password.

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Facilities shall also be provided to manually initiate all modes of operation but the return to safe operation for the battery shall always be automatic.

The controller shall protect from over temperature the battery cells by thermal switches; they shall de-energise the regulators and initiate an alarm (in particular for the lead-acid cells).

The regulator shall be capable of limiting the output current at its rated value and of limiting the battery charging current to the safe value corresponding to the mode of operation and battery manufacturer's requirements.

A voltage free contact for remote indication of charge mode status shall be provided.

Only for lead acid battery, float voltage shall be adjusted automatically depending on the battery temperature monitored by a probe. Battery temperature shall be displayed.

However, in cold area applications (below 0°C), float voltage (for Ni-Cd cells and lead acid cells) shall be adjusted automatically depending on the battery temperature monitored by a probe. Battery temperature shall be displayed.

- b) In case of type 2 DC source arrangement (see the part 3.5.2), charger/regulator units associated with their stationary battery branches will be able to operate in parallel via DC 2-pole circuit breakers and blocking diodes (if any) inside the main junction box.
- c) Battery cubicle isolation switches shall be 2-pole circuit breakers with a trip coil and required as one per battery bank. Circuit breakers with over-current protection only and an under-voltage tripping coil shall be provided for ESD purpose. "Reset" of this circuit breaker shall be possible by an "externally accessible" operating handle and including provisions for inhibition of tripping order.

6.3 Battery charging regulator characteristics

The regulator rating shall be adequate for the normal operating duty in conjunction with the calculated PV generators, battery banks and electrical load of the system.

The maximum allowable voltage fluctuations required on the DC main distribution bus-bar shall apply during charging of the battery and during discharge. If the charger and the battery is not able to provide such a voltage regulation a DC/DC converter or dropping diodes would have to be provided in series with each charger. If the use of dropping diodes is acceptable for this purpose, it shall be specified in the project requirements. A by-pass contactor shall be provided to by-pass the converter or the dropping diodes in case of failure and use the autonomy of the related battery when both PV generators are lost.

Ripple in the battery charger output voltage shall not exceed 1% of rated rms voltage for all values of load within the regulator rating with the battery not connected.

6.4 Minimum features to be provided

Each regulator and main junction box shall be equipped with:

1. Protection

- Miniature Circuit Breakers for auxiliary circuits

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- Output voltage monitoring relay providing:
 - High DC voltage shall disconnect PV generator(s); a time delay shall be required to re-connect automatically PV generator(s)
 - Low DC voltage alarm shall trip several (or all - if required) outgoing circuit breakers of the main DC distribution panel
 - Imminent battery shutdown shall initiate a remote alarm
 - End of discharge shall trip battery circuit breaker
 - Earth fault monitoring shall be provided
 - Deep discharge protection shall disconnect the battery bank for lead-acid type battery.

2. Control and monitoring

Control and monitoring shall be provided by a microprocessor based controller.

Local control and monitoring shall be given on the front of equipment and shall include as minimum:

- One alpha-numeric display with pushbuttons for operator interface
- Two LED's normal and fault
- On/off Controller/regulator switch
- A buzzer providing audible alarm (for manned installations only).

The display shall provide the following indications as a minimum:

- Measurements:
 - DC supply voltage (from PV generator)
 - DC supply current (from PV generator)
 - DC output voltage (of each DC source - see the part 3.5 of the present document)
 - DC output current (of each DC source - see the part 3.5 of the present document)
 - Battery current (+ or -).
- Status of operating modes
- Alarms and faults for each component (in particular failure and ON/OFF status).

Remote alarms and faults (the same as in local) shall be provided through a serial link with a protocol which shall be defined in the Project Particular specification. Contractor and Supplier shall ensure the serial link compatibility with the ECS or ICSS of the plant and, if required, provide the necessary interfaces without any time and cost implication to the Company.

3. A mimic (graphic display) shall be provided on the front of the main junction box.
 4. Permanent nameplates shall be provided identifying each component. Labels shall also be provided for each individual cell to facilitate test, operation and maintenance.
- Nameplates shall be laminated engraved plastic with black letters on a white background.

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Rating plates shall be provided as per [IEC 62040](#) and riveted on the front panel.

7. Main DC Distribution panel

Each solar power system shall be provided with a main DC distribution panel.

DC distribution panel shall include two incoming circuit breakers:

- One from the main junction box
- One from outdoor DC emergency socket.

A mechanical interlock shall prohibit that these 2 incomers shall be in switch on in same time.

Distribution shall be carried out with only one bus.

Bus suitable for "clip-on" CB mounting shall be used up to 32A.

Bus bar shall be copper insulated with heat shrinkable sleeves and insulating screens shall be installed between horizontal and vertical bus-bars. Protection shall be provided to prevent contacts with live parts.

Each outgoing circuit shall be protected by a two pole DC circuit breaker with over-current protection plus a tripping fault contact and a tripping coil to facilitate isolation (see part 1 of the paragraph 6.4 of the present document). The circuit breaker shall be sized for the specific circuit requirements and shall be fully selective with other devices in the circuit.

All circuit breaker tripping fault contacts shall be gathered on a signalling loop and brought to control terminals for remote indication.

A minimum of 10% equipped spare outgoing CBs shall be fitted.

DC distribution shall be unearthed except where specified otherwise. A ground fault detector relay to provide local and remote alarm shall be installed.

This protection shall be based on the detection of a low frequency AC current circulating between DC network and earth.

This shall allow trouble shooting of the system with all circuits in operation by tracing the faulty circuit with a portable tong tester. A front panel mounted indicator shall permanently indicate the value of the network insulation impedance.

Internal wiring shall be 750 V insulated, at least flame retardant and fitted at both ends with lugs and ferrules. All external cables shall be connected on terminal blocks for connection at bottom.

8. AC or DC secondary distribution system

The AC or DC distribution system behind the main DC distribution panel may be required if motors and/or luminaries are found in the project consumer list.

Also, AC or DC distribution panel shall be fed by the main DC distribution panel via (1x100% or 2x50%) DC/AC or DC/DC Converters.

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8.1 Converters

8.1.1 Converters characteristics

Converter(s) shall be microprocessor based.

Converter(s) shall be capable of operating within the specified output limits as specified in the part 4.2.

The DC/AC converter output shall be 230 V and DC/DC converter output shall be as per load requirements. The output voltage shall be adjustable by $\pm 5\%$ to allow for voltage drop across the distribution system. For AC system, Total harmonic content shall not exceed 5% in all operating duties.

Under steady state load conditions the converter output voltage measured at AC or DC distribution bus-bar shall be maintained at $\pm 5\%$ of nominal voltage (with a maximum frequency tolerance of $\pm 1\%$ for AC distribution). The maximum allowable transient voltage variation except where otherwise specified, shall not exceed $\pm 10\%$ under the following conditions:

- Disconnecting PV generator with Controller/regulator from main DC distribution panel bus-bar
- Return of full load to converter
- Load change
- Peak consumption from load starting (starting current shall be supplied by stationary battery branches through converter(s)).

Voltage recovery to 95% nominal following any of the above disturbances shall be within 50 ms.

Converter(s) shall be capable of starting up and supplying the load without reference to an external source.

The current rating of the converter semi-conductor components shall not be less than 120% of the maximum current flowing through the elements at full load. The maximum allowable operating temperature of the inverter semi-conductors shall be limited to 80% of their maximum permissible value.

The inverter rated output shall, where necessary, take into account the non-sinusoidal nature of the connected load.

8.1.2 Converter operations

Converters shall be protected by 2-pole circuit breakers in incoming and outgoing. Therefore, in the (2x50%) arrangement, inverters shall work synchronised.

8.1.3 Minimum features to be provided on converter(s)

Local control and monitoring of converter(s) shall be given on the front of equipment and shall include as a minimum:

- One alpha-numeric display with pushbuttons for operator interface
- Two LED's normal and fault indications
- auxiliary contacts for converter failures

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- Converter circuit breaker status (upstream & downstream)
- Out of synchronisation for DC/AC converters (inverters)
- On/off switch
- A buzzer providing audible alarm (for manned installations only).

The display shall provide for each converter, the following indications as a minimum:

- Measurements:
 - DC supply voltage (from the main DC distribution panel)
 - DC supply current (from the main DC distribution panel)
 - Converter output current
 - Converter output voltage
 - Inverter output frequency (for AC system)
- Alarms and faults.

Remote alarms and faults (the same as in local) shall be provided through a serial link with a protocol that shall be defined in the Project specification.

The Supplier shall ensure the serial link compatibility with the ECS or ICSS of the plant and, if required, provide the necessary interfaces without any time and cost implication to the Company.

A mimic (graphic display) showing the complete AC system shall be provided on the front of the cubicle.

Rating plates shall be provided as per [IEC 62040](#) and riveted on the front panel. Components nameplates shall be laminated engraved plastic with black letters on a white background.

8.2 AC or DC distribution panel

In case of 2x50% converter arrangement, AC or DC distribution panel shall include two incoming switches.

The distribution shall be split into only one bus bar. This would allow replacement or installation of additional outgoing CB without complete AC or DC distribution shutdown.

Bus suitable for “clip-on” CB mounting shall be used. Bus bar shall be cooper insulated with heat shrinkable sleeves and some insulating screens shall be installed between horizontal and vertical bus-bars. Protection shall be provided to prevent contacts with live parts.

The neutral phase shall be always either grounded or connected to high earthing impedance further to Project requirements. Therefore, outgoers shall have earth leakage relay for consumers certified in hazardous areas.

If an earth fault detector relay is required (high earthing impedance), it shall be based on the detection of a low frequency AC current circulating between AC network and earth.

Each outgoing circuit shall be protected by a two pole circuit breaker with over-current protection fitted with a tripping fault contact.

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All circuit breaker tripping fault contacts shall be gathered on a signalling loop and brought to control terminals for remote indication.

A minimum of 10% equipped spare outgoing CBs shall be fitted.

9. Accessories

A complete set of tools required for maintaining the equipment shall be provided.

A tin of finish paint shall be provided to permit final "touch up" following installation.

10. Inspection and testing

The Manufacturer shall carry out tests upon completion of construction to demonstrate to Company, or his representative, that the requirements of this Specification and any subsequent amendments have been fulfilled in accordance with the applicable standards and regulations.

Test requirements are defined in the [IEC 60146](#), [IEC 60068](#), [IEC 61427](#), [IEC 62040-3](#) standards:

- Physical check of general appearance, finish, undamaged condition and general completeness
- Check of compliance with applicable standards and specifications listed in the chapter 2
- Dimensional check
- Space available for cable termination, terminals (size and number) and cable supporting devices
- Type test certificates in accordance with the [IEC 60068](#) standard:
 - Cold test
 - Rapid change temperature test
 - Dry heat test
 - Salt mist test
 - Composite temperature / Humidity test.
- Earthing continuity test
- Rated current test
- Power losses determination
- Checking and testing of auxiliary devices
- Measurement of output voltage (DC)
- Checking of control equipment
- Checking of the protective devices
- Checking of supervision and remote signalling circuits
- Checking of measuring devices

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- Measurement of ripple voltage and current
- Battery test autonomy
- Light load and functional test
- Insulation/Earth test fault
- Functional tests of power requirement with solar array in accordance with the site conditions - 1/4, 1/2, 3/4, 4/4 load and functional test
- Synchronisation test (for the 2x50% inverter arrangement)
- Frequency variation test (AC)
- Mechanical interlocking.

For the battery cells, the Manufacturer shall deliver to Company the type test certificates in accordance with:

- [IEC 62259](#) standard, for gas recombination nickel cadmium batteries
- [IEC 60896-11](#), for vented lead acid batteries
- [IEC 60896-21](#), for valve regulated gas recombination lead acid batteries.

The type certificates shall be provided with the Manufacturer bid.

10.1 Factory Acceptance Tests (FAT)

The Manufacturer shall carry out tests upon completion of construction to demonstrate that full specification requirements have been fulfilled. Factory acceptance tests shall be as defined in the Project Particular Specification.

10.2 Site tests

Site tests shall be carried out as defined in the Project Particular Specification based on the above test list updated in accordance with Company requirements.

10.3 Test reports

A pro-forma of test procedures and reports shall be presented to Company for approval before placing the order.

The test reports shall detail as a minimum:

- The expected theoretical values
- The tolerances
- The results of the measurements, including if applicable, any intermediate values which have caused a temporary rejection.

The test reports shall be included in the contractual technical documents, and shall be considered as an integral part of them.

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11. Design Life & Obsolescence

Equipment and component obsolescence management shall be as per **GS EP TEC 007**.

Facilities are typically designed with an expected design life in the order of 25 years.

The solar power system design shall therefore take into account the requirement that the equipment will most probably require to be upgraded during the design life of the facilities in particular for all the electronic based components. These requirements shall be incorporated from Basic Engineering stage.

The design will include provisions to allow an upgrade of the solar power system to be performed with minimal disturbance to the power generation and distribution systems, fixed cabling infrastructure and infrastructure.

All hardware and software that may be developed by the Supplier further to the solar power system delivery shall ensure full ascending compatibility to allow for easy replacement of equipment that became obsolete with limited reconfiguration.

At the Bid stage, the solar power system Supplier shall detail his lifecycle management strategy focusing on product obsolescence, support options and further migration alternatives. The lifecycle/obsolescence management plan and associated cost shall be part of the Bid process evaluation.

The solar power system Supplier shall complete an inventory of all provided equipment (hardware and software) matching to different lifecycles phases, including all Sub-Vendors equipment (e.g. servers, operator stations, switches, routers).

Solar power system **Supplier** shall guarantee that:

- Solar power system components (including software and hardware) shall remain in the "active products" range (i.e. supporting developments and releases) over a period of at least 10 years after the SAT
- An announcement to Customer is provided 5 years prior the end of the commercial phase
- Solar power system components (including software and hardware) shall be fully supported and available over a period of at least 20 years after the SAT
- Maintenance services including availability of engineering services shall be available to support the solar power system during the plant life time.

12. Documentation

As a minimum, the following documents shall be provided for Company review at the tender stage:

- Preliminary overall arrangement drawing
- One line diagram
- DC source calculation notes (PV generator, Battery sizing, Battery charging regulator, circuit breaker ratings)
- Inverter calculation note

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- Type test certificates
- Gas release calculation depending on battery charging mode.

Unless otherwise specified in project particular specification, the Manufacturer shall at least provide the following documents:

- Overall arrangement drawing
- One line diagram
- Solar PV Module data sheet, IV curve, catalogue, and certificates
- Battery Charger/Voltage Regulator data sheet, catalogue
- Battery data sheet, curve, catalogue
- Final source calculation notes (PV generator, Battery sizing, Battery charging regulator, circuit breaker ratings)
- Final Inverter calculation note
- Final gas release calculation depending on battery charging mode
- Troubleshooting drawings
- Schematic diagram
- Civil works drawings
- Wiring diagram
- Maintenance and operation instructions
- Spare part list
- Detailed equipment information (technical documentation)
- Obsolescence management dossier
- FAT reports and Site Acceptance Test report.

13. Transport/packing

The Engineer/Contractor shall specify in the Project Particular Specification the transport/packing conditions. The batteries shall be delivered (charged/discharged) in accordance with the Manufacturer recommendations.

14. Other references

Following documents are applicable:

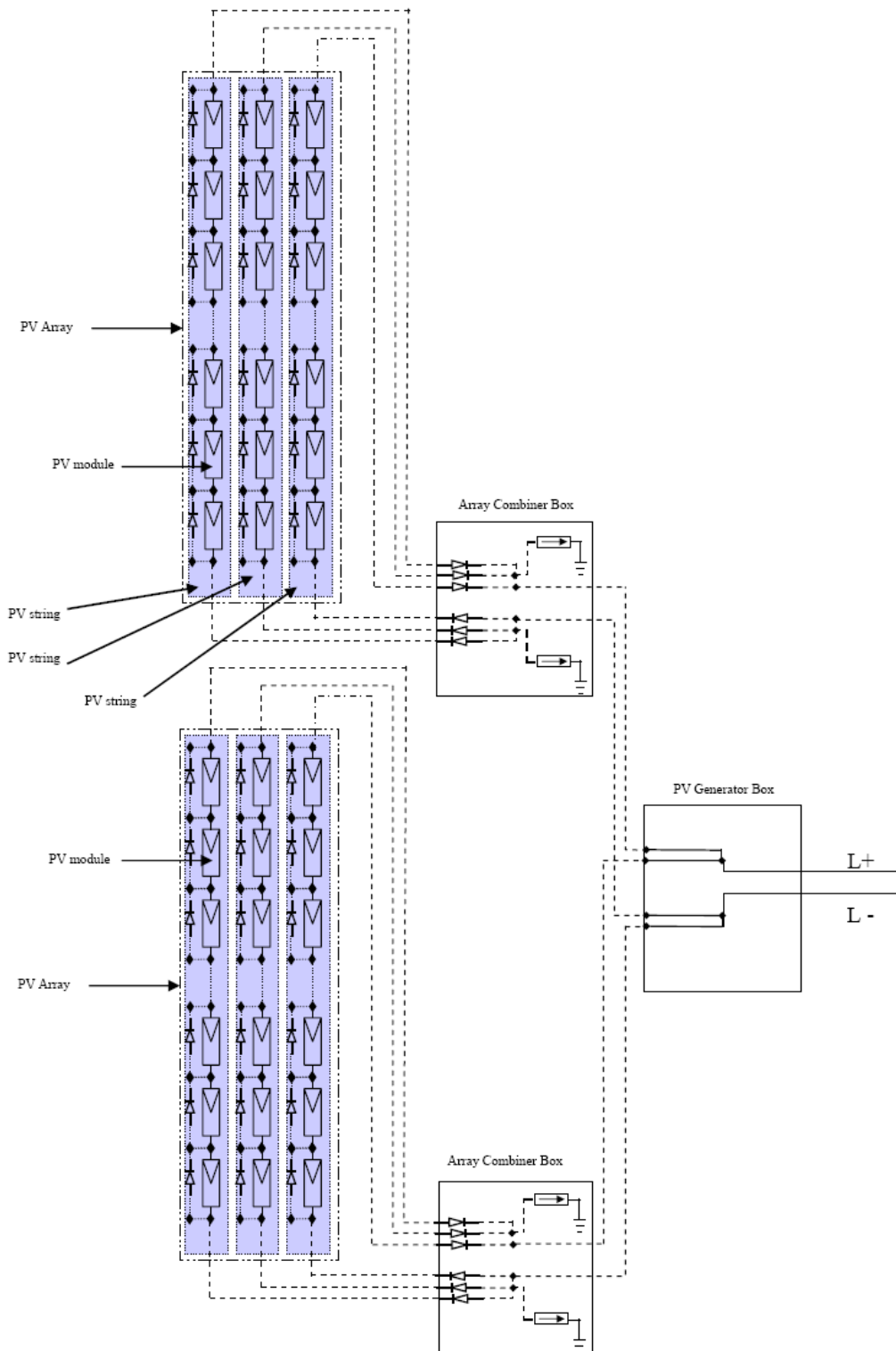
- External documents: [IEC 60079 \(all parts\)](#), [IEC 60255 \(all parts\)](#), [IEC 60269-1](#), [IEC 60331-21](#), [IEC 60904](#), [IEC 61204](#), [IEC 61215](#), [IEC 61434](#), [IEC 62402](#)
- Total General Specification: **GS EP ELE 137**.

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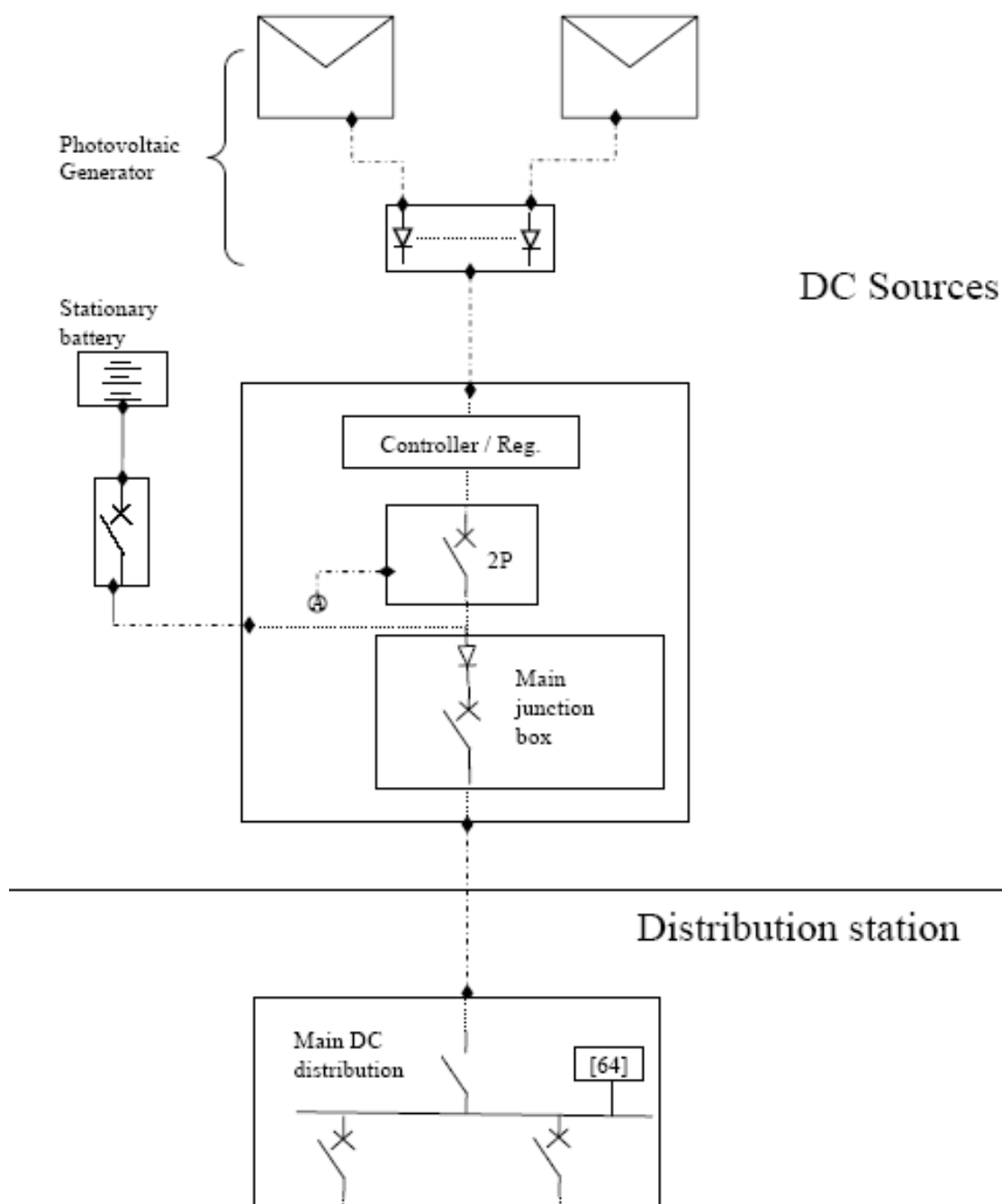
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Appendix 1
Appendix 1 PV Generator arrangement


Appendix 2 Solar Power System Typical Single Line Diagram - type 1



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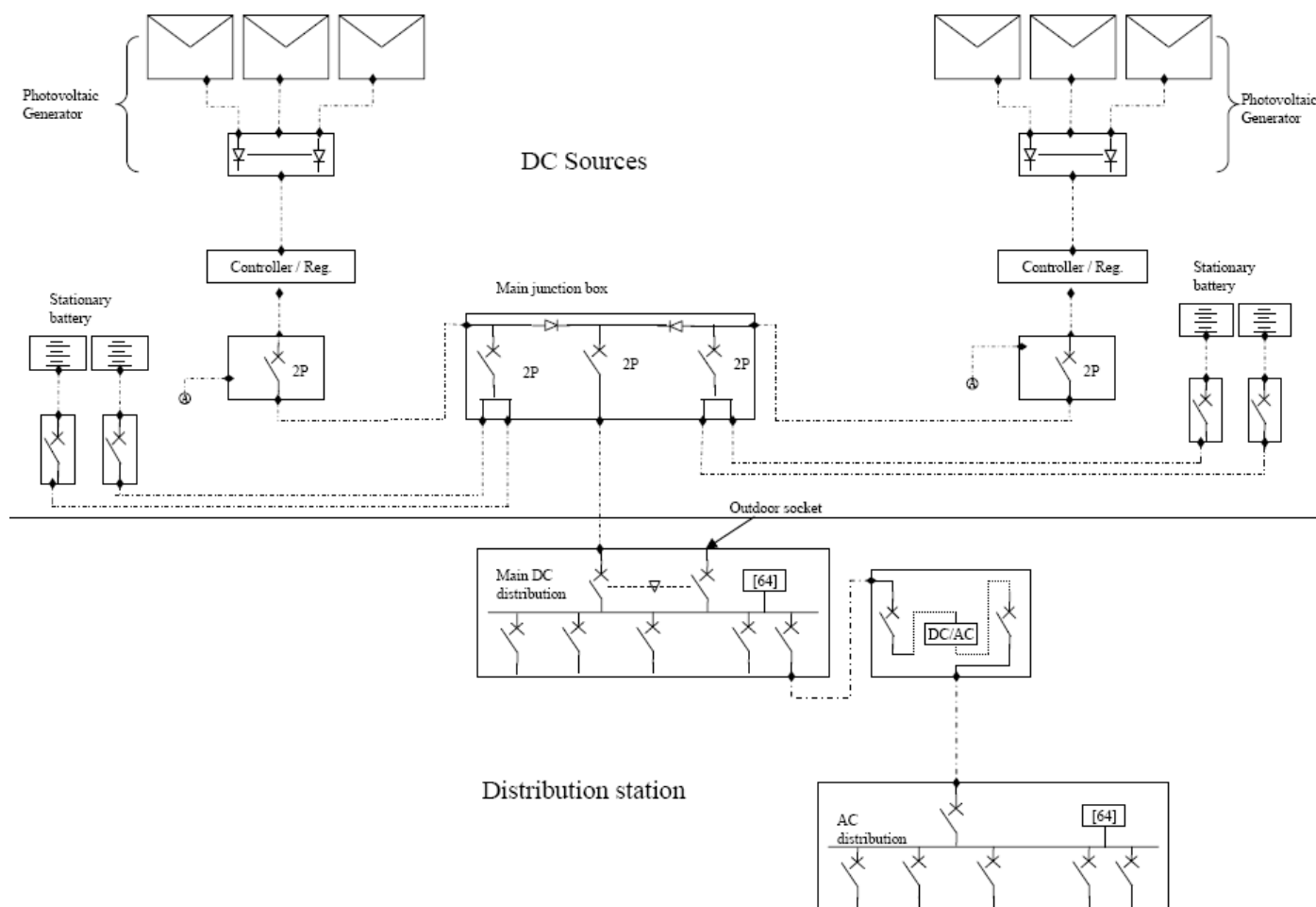
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Appendix 3

Appendix 3 Solar Power System Typical Single Line Diagram - type 2



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Appendix 4

Appendix 4 Determination Of Solar Insolation, Battery Autonomy, And Battery Recovery Time (Example)

1. Determination of the site longitude and latitude coordinate

Example: Latitude -1.00 and longitude 117.00

2. Determination of the Minimum Monthly Insolation Incident on a Horizontal Surface (KWh/m²/day)

- Determination the Minimum Monthly Average Insolation Incident on Horizontal Surface (kWh/m²/day) from the NASA Surface Meteorology and Solar Energy tables:

Monthly Averaged Insolation Incident On A Horizontal Surface (kWh/m²/day)

Lat -1 Lon 117	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
22-year Average	4.61	4.80	4.88	4.69	4.44	4.30	4.29	4.67	4.86	4.72	4.50	4.43	4.59

The Minimum Monthly Average Insolation Incident on Horizontal Surface will be 4.29 kWh/m²/day (on July).

- Determination of the Minimum Difference from Monthly Averaged Insolation (%)

Minimum And Maximum Difference From Monthly Averaged Insolation (%)

Lat -1 Lon 117	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum	-18	-17	-15	-10	-11	-10	-21	-20	-12	-14	-9	-12
Maximum	21	22	19	14	8	11	15	20	13	17	9	13

- The Minimum Difference from Monthly Averaged Insolation on July will be -21% of 4.29 kWh/m²/day

Therefore, the Minimum Monthly Insolation Incident on Horizontal Surface is 3.39 kWh/m²/day.

3. Determination of Battery Autonomy and Battery Recovery Time Requirement

From NASA Surface Meteorology and Solar Energy tables of Parameter for Sizing Battery or other Energy-storage Systems:

Equivalent Number Of NO-SUN Or BLACK Days (days)

Lat -1 Lon 117	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1 day	0.86	0.80	0.96	0.84	0.91	0.89	0.89	0.80	0.89	0.89	0.78	0.91
3 day	1.46	1.57	1.47	1.42	1.74	1.44	1.82	1.51	1.38	1.20	1.26	1.46
7 day	2.28	2.53	2.29	2.13	2.81	2.34	2.64	2.74	2.00	2.21	2.32	1.99
14 day	3.66	3.93	3.40	2.82	3.49	3.29	4.93	4.78	2.94	2.66	3.20	2.93
21 day	3.96	4.81	4.46	3.17	2.83	3.36	5.77	5.66	3.04	3.86	3.61	4.06
Month	5.58	4.84	4.63	2.87	3.42	2.86	6.57	6.30	3.51	4.40	2.80	3.70



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Appendix 4

Definition of equivalent number of NO-SUN days: Hypothetical number of days for which no solar insolation is available.

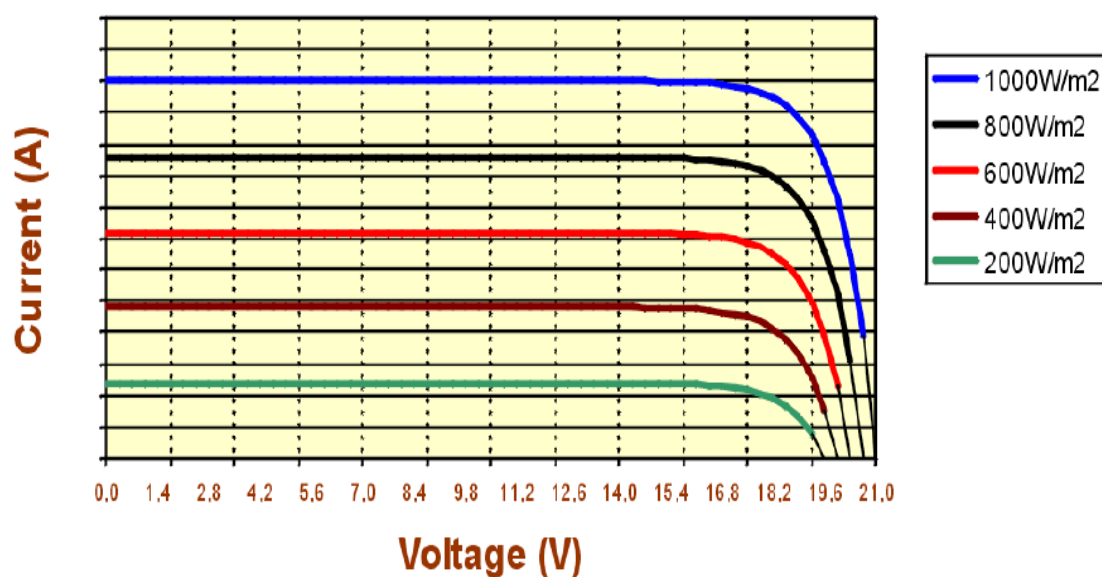
From the above tables to determine the battery autonomy and the battery recovery time (to 100% capacity) that will be required after the battery has been totally discharged (simultaneously with power supply to the loads):

X-consecutive day periods	Battery Autonomy (days)	Battery Recovery Time (days)
30	7	23

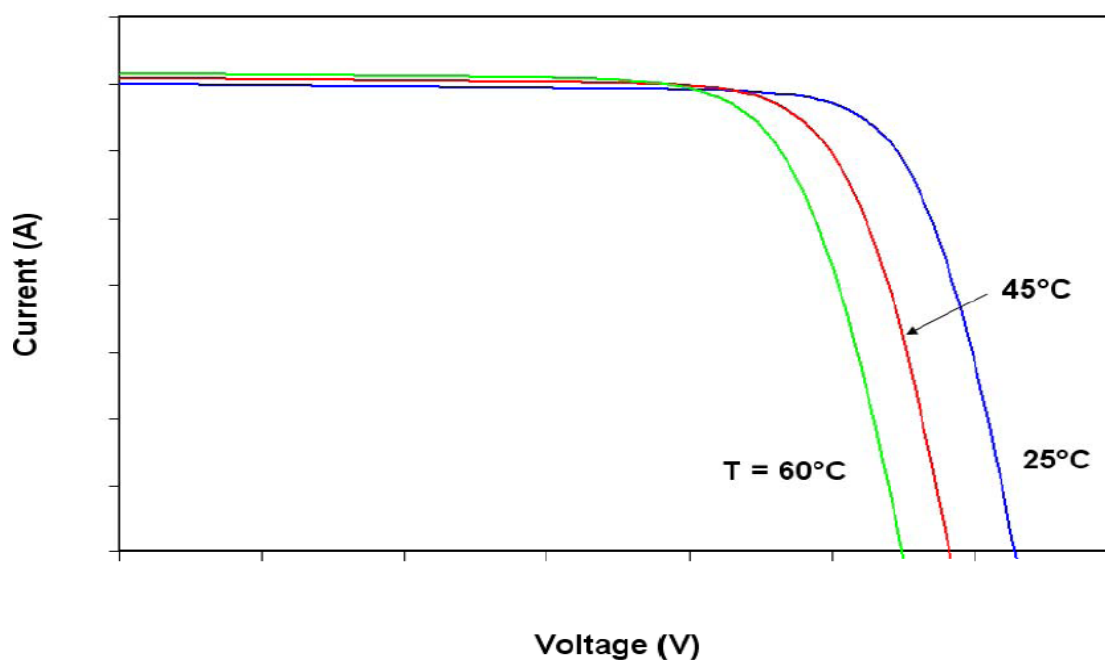
Appendix 5 Solar PV Generator Characteristic To Be Considered For Determination The Solar Module Efficiency (Example)

1. Solar PV Generator Module "IU CURVE" at 25°C

Module I-U characteristics



2. Solar PV Generator Module I-U Curve With Temperature Derating



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Appendix 5
3. Solar PV Generator Module Power Output Efficiency

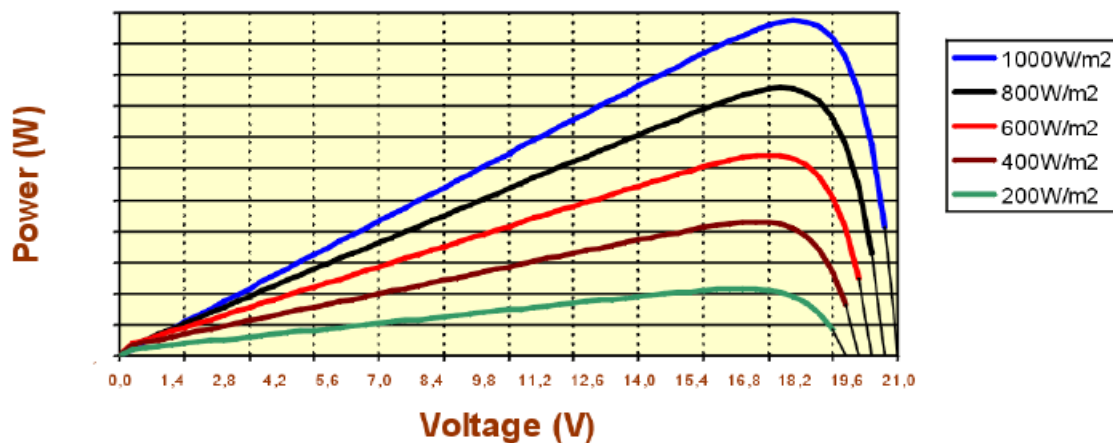
Example of Site location: Latitude -1.00; Longitude 117

[NASA Data Base](#) for Monthly Average Insolation Incident on a Horizontal Surface at Indicated GMT Times (kW/m²)

Monthly Averaged Insolation Incident On A Horizontal Surface At Indicated GMT Times (kW/m²)

Lat -1 Lon 117	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average@00	0.20	0.19	0.21	0.23	0.23	0.21	0.20	0.22	0.26	0.27	0.26	0.22
Average@03	0.56	0.57	0.60	0.57	0.55	0.53	0.52	0.56	0.60	0.60	0.56	0.56
Average@06	0.55	0.56	0.57	0.55	0.50	0.49	0.50	0.55	0.56	0.52	0.50	0.51
Average@09	0.18	0.20	0.19	0.16	0.14	0.15	0.16	0.17	0.15	0.12	0.12	0.14
Average@12	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Average@15	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Average@18	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Average@21	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Output power produce from Solar PV Module:

Module power characteristics


As shown the power output per module will have co-relation between output voltage and solar insolation incident on horizontal surface (kW/m²) within the operational days in situ.

In addition, the Minimum Monthly Insolation Incident on Horizontal Surface value as shown in Appendix 4 shall be taken into consideration for module power output calculation.