PQS Performance Specification

WHO/PQS/E001/PVAC 01.0
Original: English
Distribution: General

TITLE: Solar power system for cold and freezer rooms

Specification reference:	E001/PVAC 01.0
Product verification protocols:	E001/PVAC -VP.1; E001/PVAC -VP.2
Issue date:	17 February 2020
Date of last revision:	New specification

Contents

1. Scope

Public sector consultations and reports from the field have identified the need for solar power systems for walk-in cold rooms and walk-in freezer rooms.

This specification describes the requirements for a generic hybrid solar power system generating electricity (single or three-phase alternating current (AC) electricity) with a photovoltaic (PV) solar array and additional source of back-up power for cold rooms (CR) or freezer rooms (FR) that comply with **WHO PQS E001/CR-FR01** specifications. It also describes the installation and maintenance advisory services that all legal manufacturers must offer in order to become a prequalified supplier of CR-FR hybrid solar power systems.

Historically, CR and FR operate with electric vapor compression refrigeration which is powered with single or three-phase alternating current (AC) electricity supplied by an electric grid (mains). This power supply is typically backed-up by a fuel-fired generator that is capable of providing 100% of the CR-FR electrical requirements.

The hybrid solar power system must be capable of providing 100% of the site-specific CR-FR electrical requirements, both as a hybrid solar power system with back-up power and as a standalone solar power system operating with no back-up power system. Typically, hybrid

solar power systems will require a solar array, battery, battery charge control, over current protection devices, a DC to AC inverter and a back-up power system capable of also providing 100% of the CR-FR electrical requirements including battery recharging.

If an unreliable electrical grid (mains power with history of frequent and/or prolonged power outages) is available and, if allowed by the local electrical supply authority, a grid-connected solar power system can be used to import power for battery chargers and the CR-FR load. An unreliable grid connection will not, however, be considered a back-up power system. In such cases, the hybrid solar power system would require 100% solar power capability, 100% back-up power capability (e.g. with generators) and have capability to utilize the grid connection.

Grid-tied solar power systems that are synchronized to export power to a reliable grid (mains), direct current (DC) -only solar power systems and solar direct drive CR-FR are not included this specification.

The following documents are associated with this specification:

- **E001/PVAC-VP1** is a type-examination protocol which will be used for prequalification evaluations.
- **E001/PVAC-VP2** is completed by an employer or his QA assessor and sets out the requirements for a specific installation. The document also specifies the installation, commissioning and handover procedure. The completed protocol should be read in conjunction with **E001/PVAC 01**, to which it refers.

E001/PVAC 01 and a completed **E001/PVAC 01-VP2**, together with an employer's other documents, are intended to form the basis for a contractual agreement between the employer and the legal manufacturer or reseller for the supply of the components required for a specific installation. This also forms the basis for a contractual agreement between the employer and the approved installer.

2. Terms and definitions

Alternating current (AC): an electric current that reverses its direction at regularly recurring intervals whose value varies as a sine wave.
Autonomy: time in days that a solar power system can maintain the vaccine load within the acceptable temperature range under low solar radiation conditions (e.g. rain). Autonomy is determined as described in Clause 4.2.3 Battery set sizing.
Back-up power: a secondary, auxiliary power source (e.g. generator) capable of independently powering 100% of all CR-FR electrical needs and battery recharging.
Design day: for purposes of sizing the solar power system, the design day requires the largest of the following three options for sizing the solar array to meet all CR-FR electrical load requirements: 1) based on the lowest monthly solar radiation reference period; 2) based on the highest average daily electrical load requirement for a given month; or 3) both simultaneously.
Direct current (DC): an electric current flowing in one direction.

Employer: the organization that contracts with the legal manufacturer or reseller who will supply the system components and the installation and maintenance advisory services described in this specification. The employer will typically contract with an installer who will install and commission the installation under the supervision of a QA assessor and also with a maintenance contractor who will maintain the installation.
Grid-connected: solar power system that imports electricity from a power grid (mains).
Grid-tied: grid-connected solar power system that also is synchronized to export electricity into a power grid (mains).
Hybrid solar power system: solar power system with one or more auxiliary sources of power (e.g. a diesel or petrol-fueled stand-by generator).
In writing: communication by letter, fax or email.
Installation: the complete hybrid solar power system installation described in this specification and in the companion **E001/PVAC01-VP2** document, together with any other employer's requirements documentation issued for a specific installation or installations including voltage stabilizers and standby generators where these are listed in the employer's requirements.
Installer: a person or organization who has been appointed by the employer to carry out the installation of the system. A qualified installer may be either a legal manufacturer or a reseller or an approved representative and must:

- supply a coherent, correctly sized installation where the settings of all the components have been adjusted for optimum performance at the installation site,
- have installed and supported (e.g. by providing on-going technical assistance, spare parts and system documents) at least five hybrid photovoltaic systems in a developing country or countries for at least two years (detailed references, including donors, locations and contacts, must be provided for independent verification),
- have the capacity and financial resources to provide long-term support to the systems in the country of destination.

Inverter: electronic component to convert DC to AC electricity.
Legal manufacturer: the natural or legal person with responsibility for the design, manufacture or integration of components, packaging and labeling of a product or device before it is placed on the market under their own name, regardless of whether these operations are carried out by that person themselves or on their behalf by a third party.
Maintenance contractor: a person or organization contracted by the employer to maintain the installation.
Maximum power point tracking (MPPT) control: a type of photovoltaic-to-battery charge control that optimizes solar array output by operating as a DC to DC converter. It uses the DC input from the PV array and converts it back to a different DC voltage and current output so that the PV module is correctly matched to the battery. This allows a solar array to be wired at optimal voltage to overcome long cable distances that otherwise would result in excessive voltage drop or unacceptably large cable diameter.
Montreal Protocol: Montreal Protocol on Substances that Deplete the Ozone Layer.
QA assessor: the person or organization appointed by the employer to assess the suitability of candidate installers, to evaluate their proposals and to monitor the assembly and commissioning of the installation on site.
QA: quality assurance.

Region: a contiguous geographical area within which the legal manufacturer or reseller is able to provide the full range of services described in this specification.
Reseller: a commercial entity, licensed to act on behalf of a legal manufacturer, and which carries product liability and warranty responsibilities no less onerous than those carried by the legal manufacturer.
Solar radiation reference period: the minimum average daily solar radiation on the plane of the solar array that is required to properly power the CR-FR, expressed in kWh/m²/day.
Standalone: solar power system capable of independently powering 100% of all CR-FR electrical needs. It is the primary source of power for the CR-FR and can be coupled to a back-up power source (generator) to also operate as a hybrid solar power system.
User: the person responsible for the day to day operation and temperature monitoring of the (CR-FR) room and/or solar power system.

3. Normative references

(Use most current version)

BS EN 60529:1992+A2:2013: Degrees of Protection by Enclosures (IP Code)
EMAS: European Union Eco-Management and Audit Scheme.
IEC 60335-1: 2006 Household and similar electrical appliances - Safety - Part 1: General requirements.
IEC 60364-1: 2005 Low-voltage electrical installations - Part 1: Fundamental principles, assessment of general characteristics, definitions.
IEC 61000-6-1 edition 2.0: 2005 Electromagnetic compatibility (EMC) Generic standards - Immunity for residential, commercial and light-industrial environments.
IEC 61000-6-3 edition 2.1: 2011 Electromagnetic compatibility (EMC) Generic standards - Emission standard for residential, commercial and light-industrial environments.
IEC 61194: 1992 Characteristic parameters of stand-alone photovoltaic (PV) systems.
IEC 61215: 2005 Crystalline silicon terrestrial photovoltaic (PV) modules - Design qualification and type approval.
IEC 61646: 2008 Thin film terrestrial photovoltaic (PV) modules – Design qualification and type approval.
IEC 62109-1 Safety of power converters for use in photovoltaic power systems – Part 1: General requirements.
IEC 62109-2 Safety of power converters for use in photovoltaic power systems – Part 2: Particular requirements for Inverters.
IEC TS 62804-1:2015 Photovoltaic (PV) modules – Test methods for the detection of potential-induced degradation – Part 1: Crystalline silicon.
IEEE 937: Recommended Practice for Installation and Maintenance of Lead-Acid Batteries for Photovoltaic (PV) Systems.
IEEE 1562: 2007 Guide for Array and Battery Sizing in Stand-Alone Photovoltaic (PV) Systems.
ISO 1461: 2009 Hot dip galvanized coatings on iron and steel articles - specifications and test methods.
ISO 9001: Quality Management Systems – Requirements.
ISO 14001: 2004 Environmental management systems - Requirements with guidance for use.

ISO 20282-1: 2006 Ease of operation of everyday products - Part 1: Context of use and user characteristics.
Solar Autonomy Calculation Tool, H.Toma and T. Markvart, University of Southampton, UK 2009.
WHO PQS E001/CR-FR01.4: Cold rooms and freezer rooms
WHO PQS E001/PVAC 01-VP.1: PQS Independent type examination (TBD).
WHO PQS E001/PVAC 01-VP.2: PQS Quality Assurance Protocol (TBD).

4. Design criteria

4.1 General

4.1.1 Initial prequalification

A legal manufacturer or reseller seeking prequalification under the terms of this specification must satisfy WHO that they are able to supply a complete package of components, including an installation and maintenance advisory service to enable a competent installer to assemble and commission the installation and to enable a competent maintenance contractor to maintain the system. Legal manufacturers may offer products suitable for one or more CR-FR, multiple temperature zones and may restrict their offer to one or more named regions.

4.1.2 Extended region prequalification

A prequalified legal manufacturer who wishes to extend the region(s) for which they are already prequalified may do so at the time of the annual review by providing WHO with supplementary evidence in writing that they are able to offer the complete service described in this specification to the additional region(s).

4.1.3 System characteristics

The hybrid solar power system will be connected to CR-FR complying with PQS specifications E001 CR-FR01. Standalone solar power systems with no back-up power are not permitted.

Hybrid solar power systems must be purpose-designed to independently provide 100% of the power consumption and peak electrical demands of all connected CR-FR electrical loads based on the site-specific immunization delivery schedules and climate conditions taking account of ambient temperatures, minimum solar radiation reference period and autonomy requirements.

The required back-up power system also must be capable of independently providing 100% of the power consumption and peak electrical demands of all connected CR-FR electrical loads and battery recharging. Each power system must be complete to allow the entire installation to occur without the need for additional components. The CR-FR is not included in this specification.

Reliability, durability and effective maintenance are essential for a successful installation. Installations are to be designed to achieve a service life of not less than 20 years apart from component replacement, routine cleaning and programmed maintenance.

No additional loads, such as lighting, computing, ventilation or communications are to be connected to a hybrid solar power system except when professionally engineered to provide the capacity necessary for specific additional energy consuming devices or processes while prioritizing the CR-FR cooling needs over all other loads. Because powering additional load(s) requires significant technical experience to design, the design engineer must be capable of accurately assessing additional electrical load requirements and designing a hybrid solar power system that both meets requirements of the added load(s) while prioritizing the CR-FR electrical needs above other load needs.

4.1.4 Design responsibility

The employer will specify the location, site conditions, CR-FR capacity and characteristics of the CR-FR that is to be connected to the solar power system.

The employer must specify location and site conditions including:

- site name and address,
- latitude and longitude,
- elevation,
- monthly ambient temperature range, and
- if available, results of pre-installation site assessment (e.g. solar radiation reference period(s), shading analysis, type of solar array mounting structure, wind load force, location for battery, cable distances, cable placement, etc.).

The employer must specify all connected electrical loads and must define for each load device:

- characteristics - description, quantity,
- electrical - single or three phase, nominal voltage, operating voltage range, running amperes, peak amperes, frequency, and
- time of operation (design day) - device on-time hours (consumption), starting times (peak demand), month or date(s) of design day.

The legal manufacturer must then size the installation to ensure that the specified CR-FR will operate continuously within specified temperature limits, both when back-up power generator or standalone solar power are powering the system and throughout the autonomy period. Equipment monitoring systems must be compatible with the solar power system control equipment and the CR-FR control system.

All hybrid solar power systems must provide a minimum of five days of autonomy unless an alternative autonomy (of greater or lesser days) can be calculated using one of the two methods defined in the normative reference: Toma, H. and Markvart T. *Solar Autonomy Calculation Tool*, University of Southampton, UK, 2009. In no case should the solar power system and battery have an autonomy of less than three days.

The two methods are:

1. selection of autonomy for the specific locations listed in the supporting document to the *Solar Autonomy Calculation Tool*[1] or
2. calculation of autonomy using the formulas and the required long term daily solar radiation data as described in the *Solar Autonomy Calculation Tool*[1]

The installation must then be sized to provide the required autonomy at the specified location.

The solar power system designer must provide the employer with the data used to determine the installation design, including reference periods for temperatures, solar radiation reference period, wind load force, autonomy determination and assumptions made regarding site conditions. The data must include the assumed monthly minimum solar radiation reference period, assumed average minimum and maximum ambient temperatures and the month requiring the most power. Reference period climate conditions are to be in closest accordance with available meteorological data.

4.2 Performance

4.2.1 Solar module, solar array and array output cable

Solar modules must comply with **IEC 61215** and **IEC TS 62804-1:2015** (crystalline solar modules) or **IEC 61646** (thin film solar modules). The power warranty is to be a minimum of 25 years to 80% of the initial power rating. Power tolerance to a minimum of 0 to +5%. The **IEC 61215** minimum mechanical (wind) load is not adequate for locations that experience hurricane or tornado. In areas that are subject to hurricane and/or tornado higher wind ratings must be attained. See Section 4.2.2.

Solar array output voltage must be matched to battery charge control requirements, including MPPT controls that allow higher solar array voltages.

The minimum solar array capacity is to be no smaller than an array capable of sustaining the maximum load (including inverter), plus all power system losses, x 1.25. System losses are typically 10% to 20% (and are to be estimated per **IEEE 1562-2007** Section 9.2 *System Losses Worksheet*[1]).

[1] Instructions for Autonomy Calculation (For Solar Vaccine Refrigeration Systems per the WHO PQS). Table 1 includes a subset of sites for which the data are considered to be sufficiently accurate for solar vaccine refrigerator applications.

Cables must be equipped with strain relief fittings unless otherwise permanently fixed or in conduit. All cables and connectors not in conduit must display a rating confirming their suitability for exterior use in direct sunlight and direct burial if used underground. An exterior-rated conduit with weatherproofing or equal protection must be provided at the point where a cable enters the building. Manufacturers must provide instruction for estimating cable diameter and for ordering non-standard lengths of cable.

4.2.2 Solar array support structure

The photovoltaic array support structure forms part of the installation and typically will match site-specific requirements. All support structures must be constructed of anodized aluminum, stainless steel or steel, hot dip galvanized steel to **ISO 1461** after cutting and drilling.

The combined array structure and solar module assembly must be designed to withstand the full force of the wind (wind load force) expected at the installation site, whether it is fixed to a roof, ground, building or pole structure. This force should be calculated from knowledge of local conditions including wind speed and local features. Particular attention should be given to force caused by wind gusts and possible resonance conditions. Guidance to calculating the wind load force can be found in internationally-accepted building codes.

All solar array structure fasteners must to be theft deterrent, including fasteners required to fix the structure to building, foundation or pole. All solar array structures' packages are to be supplied with a complete set of all unique tools required for fixing the theft deterrent fasteners supplied. It must be possible for an authorized person to adjust or remove the array assembly if required. Breakaway nuts and similar devices are not acceptable.

The support structure is to include all fasteners needed to attach to the site-specific foundation. The array structure package is also to be supplied with sealant for weather-proofing building penetrations and all other necessary subsidiary components, including the components needed to bond the solar array and the structure for lightning protection purposes in accordance with the component and solar module manufacturer's instructions.

Where site-specific works are required to install the support structure, these will be designed by the legal manufacturer and constructed by the installer.

For a roof installation, the roof must be structurally capable of supporting the load of the modules and racking. The modules and racking must be non-combustible. Roof or wall penetrations (such as to attach the racking to the roof) must be flashed and sealed to prevent water, rodents, or insects from entry. Rooftop solar systems must meet the same fire classification as the roof assembly.

4.2.3 Battery set sizing

Batteries must be sized to meet the autonomy period determined as described in Clause 4.1.4, based on the energy required for the CR-FR to which the solar system components are connected. Required battery capacity is estimated over the discharge rate and temperature most closely matching the autonomy period and the temperature at the site (e.g. at C/120 hours at +25°C for a five-day autonomy period to a final voltage that ensures the minimum required battery set life of 1800 cycles to 80% discharge at +20 °C). Battery capacity must be sufficient to ensure that the designed autonomy period is maintained throughout the minimum required battery set life of 1800 cycles to 80% discharge. Minimum battery voltage must be 48 Volts DC (nominal).

4.2.4 Battery type

Both sealed and flooded lead acid batteries are acceptable although sealed batteries are preferred for installations in remote areas where maintenance will be difficult.

The maintenance cycle for flooded batteries must be six months or greater, they must have clear casings to allow the user to inspect electrolyte levels and they must be supplied dry/charged with the electrolyte packed in separate hermetically-sealed containers.

Lithium batteries are not permitted.

4.2.5 Battery set housing

The battery set must be housed within a lockable room or a ventilated cabinet with an IP rating of 11 (interior) or IP33 (exterior) and with a clear viewing window for maintenance inspection by the user. The housing for flooded batteries must include protection against spilled electrolyte. Circuit breakers or fuses must be installed near the battery and the fuse-holder must be of non-corroding material.

4.2.6 Hybrid system battery charge regulator

Type of regulator is not specified and can include series, pulse width modulated and maximum power point controls (MPPT). MPPT controls are acceptable when used to connect a solar array of higher voltage to a battery of lower voltage battery. The battery charge regulator must be sized for a DC current rating of at least 156% of the solar array short circuit rating. All regulators must provide protection from transient electrical events. The regulator must be pre-set to suit the installed battery type. Voltage regulation set points must not be user-adjustable. The set points must be set precisely to meet the charge and temperature requirements of the installed battery set. The hybrid controller should be set such that the generator begins to recharge the battery when the battery state of charge falls to approximately 50% of full capacity in order to provide a minimum of 24 hours of autonomy remaining in the battery, allowing 24 hours to repair a failed generator or provide an alternate power source.

If a load disconnect feature is used it must disconnect the load when the battery has reached a state of charge which can be repeated a minimum of 1800 cycles to 80% depth of discharge. If battery voltage drops below the load disconnect set point, the load must be disconnected and the solar array must remain connected. The load must be automatically reconnected when the system voltage recovers. If used, the load disconnect current rating must be 200% of the maximum load current.

The regulator must automatically compensate for temperature changes. If temperature compensation becomes disabled, the regulator must regulate at voltage regulation set points at +25°C.

At least one method to isolate (disconnect) the battery from the solar power system must be supplied. This switch can be built into the control, inverter or be a separate component.

The regulator unit must have a clearly marked color-coded voltmeter, LED's or other indicators to show:

- array charging (green),
- low battery (orange or yellow),
- load disconnected (red).

An acoustic alarm may be included as a supplementary high/low battery and/or load disconnect warning device.

4.2.7 Battery safety kit

Provide comprehensive safety instructions, hazardous materials data sheets and a lead acid battery safety equipment kit.

The safety equipment for valve regulated lead acid (VRLA, sealed) batteries is to include the following:

- eye, hand and clothing protection,
- sodium bicarbonate for cleaning corrosion.

The safety equipment for flooded lead acid batteries is to include the following:

- temperature compensated hydrometer,
- 1.0-liter plastic decanting jug,
- plastic filling funnel,
- eye, hand and clothing protection,
- sodium bicarbonate for cleaning electrolyte spills,
- a hand pump for electrolyte is to be provided if the electrolyte is supplied in containers of more than five liters.

4.2.8 Inverter

Inverter must comply with **IEC 62109-1** *Safety of power converters for use in photovoltaic power systems – Part 1: General requirements* and **IEC 62109-2** *Safety of power converters for use in photovoltaic power systems – Part 2: Particular requirements for inverters*. Inverter(s) must be pure sine wave quality and match battery voltage, CR-FR voltage, frequency and phase requirements. Inverters may include an internal battery charger that is powered by the back-up power system. Systems with battery chargers must include an automatic or manual transfer switch.

4.2.9 Back-up generator

A back-up power generator in compliance with **E001/CR-FR 01** is required to provide 100% of the CR-FR electrical loads plus full battery charging load in the event the solar power system is unable to meet the CR-FR electrical needs. The generator is to be of continuous operating power type. The generator must be equipped with the electrical control unit with bipolar differential magnetothermic circuit breaker and other protections including over current, single phasing and phase reversal protection and phase unbalance relay (for three-phase only).

Cold rooms and freezer rooms are typically connected to a generator for back-up power. This will either be installed already, or it will be supplied by others. The design of each specific installation must be coordinated with the generator installer. The generator is to match CR-FR voltage, frequency and phase requirements. Fuel capacity should be sufficient for at least 72 hours (three days) continuous running.

4.2.10 Electrical safety rating

The legal manufacturer must certify compliance with **IEC 60335-1** with particular reference to Section 8: *Protection against access to live parts*, and Annex B: *Appliances powered by rechargeable batteri*es. All on-site electrical installation work must comply with **IEC 60364-1**.

4.2.11 Electrical protection

The system design must prevent damage to all components in the event of short circuits, electrical storms and reversed polarity connections. Circuit breakers or fuses must be installed on the DC input to inverter and near the battery and on the AC output of the inverter in series with the CR-FR loads. Battery isolators, DC isolators and AC isolators must be accessible and clearly sign-posted.

A method to disconnect the battery from all voltage sources is required.

Electrical enclosures installed indoors shall have a degree of protection of IP11. Electrical enclosures installed outdoors shall have a degree of protection of IP54. In regions with high corrosion (coastal environments) a degree of protection of IP66 is required.

4.2.12 Lightning surge protection

Lightning surge protection must be provided per component manufacturers requirements. At minimum a complete wire and hardware kit must be supplied to provide an equipment grounding conductor to bond the solar modules and support structure to earth per the solar module manufacturer's requirements. Inverters, electrical controls, electrical distribution systems and any other system component requiring lightning surge protection must also be protected per manufacturer(s) requirements and local and national electrical codes.

4.2.13 User maintenance and installer tool kits

All power systems are to be supplied with one complete user maintenance kit consisting of all necessary operations and maintenance tools as proposed by legal manufacturer. All power systems sites are to be supplied with one complete installer's kit consisting of all unique installations tools as proposed by legal manufacturer.

Note: sites with multiple solar powered CR-FR can be supplied with a single maintenance kit suitable for the type of solar power system provided.

4.2.14 Electromagnetic compatibility

The legal manufacturer must certify compliance with the requirements of the latest edition of **IEC 61000-6-1** and **IEC 61000-6-3**.

4.2.15 Firefighting equipment

A Class C fire extinguisher can be included and is recommended per *IEEE 937 Recommended Practice for Installation and Maintenance of Lead-Acid Batteries for Photovoltaic (PV) Systems*, Section 4.2.

4.3 Environmental requirements

4.3.1 Ambient temperature range during transport and storage

-30°C to +70°C when components are in transit.

4.3.2 Ambient temperature range during use

Photovoltaic modules may be exposed to temperatures from -40°C to +90°C when mounted in their final positions. Battery sets, battery charge regulators and inverters may be exposed to temperatures from -10°C to +43°C after installation and commissioning.

4.3.3 Ambient humidity range during transport and storage

5% to 95%, non-condensing.

4.4 Physical characteristics

4.4.1 Overall dimensions

System components must be able to fit through an 800mm-wide door opening (with the door leaf removed if necessary).

4.4.2 Weight

System components must be capable of being safely moved into their final positions. It is recommended that individual component packages should be designed so that they can be lifted in such a way that no single worker is required to carry more than 25 kg whilst working on their own, or in a group. Mechanical lifting equipment at the installation sites is necessary when component weight exceed practical weight limits of the workforce.

4.5 Interface requirements

4.5.1 Cold rooms and freezer rooms

In order to complete the installation, the legal manufacturer must supply all the hybrid solar power system components needed to connect to the specified CR- FR that comply with PQS specification E001/CR-FR01.

4.6 Human factor

4.6.1 Generally

The solar system components must be easy to assemble and commission, using normally available hand tools, by installers who have received appropriate training. The completed installation must be usable by the widest practicable range of users and health workers, regardless of age, gender, size or minor disability, including color blind users and long-sighted people without glasses, in accordance with the general principles laid out in **ISO 20282-1: 2006**.

4.6.2 Safe access

Photovoltaic arrays must be mounted in positions that allow safe access for installation, maintenance and cleaning, using appropriate fixed access equipment as necessary. Avoid array mounting locations which require access across fragile roof structures and finishes. In locations where safe access is not possible, specialized cleaning tools (e.g. extended handle glass cleaning tools) must be provided to allow cleaning from a safe and secure position.

4.7 Materials

4.7.1 Restricted materials

The product and its constituent components, must not contain lead (except in batteries), mercury, cadmium, hexavalent chromium, polybrominated biphenyls (PBB) or polybrominated biphenyl ethers (PBDE).

4.8 Warranty

Installations are to be covered by a three-year on-site replacement warranty in the event of any component failure arising from defective design, materials or workmanship. All warranty rights begin when they are passed from the approved installer to the employer after the installation has been commissioned and has been formally accepted by the employer. Where the employer is a UN agency, the warranty rights are to pass to the host government.

Any component which fails due to defective design, materials or workmanship must be covered by a replacement warranty. The minimum periods for the component warranty must be as follows:

- 25 years for the solar module power output,
- 10 years for the battery, with a full like-for-like replacement warranty for the first 12 months and pro-rated financial compensation, based on the purchase cost of the battery set, for the remaining period,
- 3 years for all other components.

4.9 Servicing provision

4.9.1 Maintainability

Installations are to be substantially maintenance-free other than solar array cleaning, routine battery servicing (flooded batteries) and periodic battery replacement. Legal manufacturers are to publish and provide a recommended battery replacement plan.

4.9.2 Essential spare parts, consumables and user tools/supplies

Based on product design and requirements the type and quantity of spare parts, basic installation tools/supplies, user and technician maintenance manuals (see Section 4.11 *Instructions*), must be determined and agreed upon in advance of order placement. As a minimum each solar power system to be supplied with 10 spare fuses of all fuse size and types used in the system and two spare circuit breakers of all breaker size and types used in the system. The spares fuses are to be attached within accessible power system enclosures.

Legal manufacturers must publish a list of spare parts recommended for five years of operation. Legal manufacturer must also ensure supply of spare parts for a minimum of five years from the time of cessation of the last production of equipment. Spare parts are to be provided in kit form for storage in appropriate quantities at National or Sub-national level in the purchasing country, as agreed with the employer.

Provide consumables sufficient for two years of normal operation at the specified location(s).

4.10 Disposal and recycling

The legal manufacturer is to provide information to the employer on the toxic and hazardous materials contained within the components and suggestions for resource recovery/recycling and/or environmentally safe disposal. For the European Union, WEEE compliance in accordance with **European Union Directive 2002/96/EC** is mandatory.

4.11 Instructions

Each hybrid solar power system to include a separate user manual and installers manual in Arabic, English, French, Mandarin Chinese, Russian and Spanish. An English version of all instructions and manuals are required to be supplied at time of prequalification. Instructions to include easy to understand visuals whenever possible to avoid reliance on text.

The user manual must include the following information:

- health and safety guidance,
- basic operations description,
- basic troubleshooting, and
- routine maintenance tasks (e.g. daily, weekly and monthly).

The installer manual must include the following information:

- health and safety guidance,
- detailed operations description,
- correct handling to avoid component damage and for the safety of handling persons,
- solar array site shading assessment tools and procedures,
- installation procedures,
- compatible types of back-up power systems,
- technical maintenance tasks (e.g., daily, weekly and monthly),
- periodic preventative maintenance procedures,
- diagnostic and repair procedures,
- itemized list of spare parts including part numbers,
- end-of-life resource recovery and recycling procedures, and
- user training guidance.

Printed user and routine maintenance instructions specifically directed at the CR-FR store staff must be pictorial. All key information must be summarized on a single sheet that can be fixed onto a CR-FR wall cabinet at time of installation; the sheet should be sufficiently durable to last the life of the CR-FR and must be in a locally-understood language.

Installation, repair and servicing instructions must be supplied in printed format, and optionally on DVD, USB and/or on-line to instruct the installer in installation standards and practices specific to the CR-FR and its hybrid solar power system. In addition, supporting video material supplied on DVD, USB and/or on-line can be provided to assist the instructor when delivering on-site user training.

4.12 Training

If specifically required, provide a practical hands-on training course for installers and/or maintenance contractors. The course may be conducted in country or at the legal manufacturer's own workshop.

Specific user training must be provided to the responsible, on-site CR-FR user. User training conducted by legal manufacturer or reseller or installer at time of installation is recommended.

4.13 Verification

In accordance with PQS Verification Protocol **E003/PV01-VP2** legal manufacturers will be required to present evidence of conformity.

5. Packaging

Materials used for packaging components are to be free of ozone-depleting compounds as defined in the Montreal Protocol. The general specification of shipping containers will be subject to agreement with the employer.

6. On-site installation

Unless otherwise requested, installation will be carried out by the employer or by others designated by the employer. The legal manufacturer or reseller is free to offer this service directly, or through a designated representative installer.

7. Product dossier

The legal manufacturer or reseller must provide WHO with a prequalification dossier containing the following:

- dossier examination fee in US dollars,
- general information about the legal manufacturer including name and address,
- general information about the reseller including name and address (where applicable),

- a list of at least five hybrid solar power system installations in one or more less-developed countries completed and supported over a period of at least two years prior to the date of dossier submission. Provide full details of each installation, including details of installed equipment, country and location, employer and named contacts,
- a list of the countries or regions in which the legal manufacturer or reseller is able to offer the optional support services described in Clauses 6 and 8, together with details of these services,
- unique identification reference for the system type,
- full specifications of the components being offered, covering all the requirements set out in this document, including details of product marking and traceability,
- certified photocopies of all type-approvals obtained for the product, including CE marking etc.,
- certified photocopies of the legal manufacturer or reseller's **ISO 9001** quality system certification.
- Where relevant, certified photocopies of the legal manufacturer or reseller's **ISO 14001** certification, EMAS registration or registration with an equivalent environmental audit scheme. Conformity with an environmental audit scheme is not mandatory; however, preference will be given to legal manufacturers who are able to demonstrate compliance with good environmental practice,
- laboratory test report(s) proving conformity with the product specifications, and
- indicative cost of a comparable standalone solar power system including back-up power system for a given CR or FR, EXW (Incoterms 2010).

8. On-site maintenance

Not required, but may be offered.

9. Change notification

The legal manufacturer or reseller must advise WHO in writing of any changes which adversely affect the performance of the product after PQS prequalification has taken place.

10. Defect reporting

The legal manufacturer or reseller's is to advise WHO and the UN purchasing agencies in writing in the event of safety-related product recalls, component defects and other similar events. Report to be issued immediately upon knowledge of such event.

Revision history			
Date	Change summary	Reason for change	Approved