PQS Target Product Profile

TITLE: Enhanced solar power system for vaccine refrigerator or combined refrigerator and water-pack freezer.

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1. Need

Recent public sector consultations and reports from the field have identified the need for some amendments and additions to the current PQS specifications for solar power systems for both solar battery and solar direct drive (SDD) equipment. Initial field experiences with first generation SDD products has revealed certain shortcomings in kit completeness and build quality and has also highlighted usability issues relating to installation and maintenance. New refrigeration options may emerge and power system standards are intended to include provision for new options. These matters need to be addressed so that the next generation of solar power systems better meets country needs.

The purpose of this preliminary Target Product Profile is to propose enhancements designed to resolve these issues and initiate a consultation process with industry which will lead to revised PQS performance specifications and verification protocols that result in products with improved overall performance.

2. Normative references

Refer to relevant PQS specifications and verification protocols.

3. Terms and Definitions

Maximum power point tracking 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 so that the solar array output 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 diameters.

Reason for change: Definition required. Maximum power point tracking controls are routinely used to overcome long distance cable lengths and/or to couple higher voltage solar modules to lower voltage batteries.

Proposed timing for PQS inclusion: 2015.

4. Design criteria

4.1 System characteristics

- Additional energy consuming devices (aka load), such as remote temperature monitoring, may be approved for connection to the solar power system.
- A system that is able to provide spare power for other approved facility electrical loads (e.g. rechargeable cold chain support devices such as temperature monitoring devices, mobile phone charging, computing, lighting) is acceptable provided the vaccine refrigerator is always prioritized ahead of other power uses.

Reason for change: There is increasing demand for solar power for other uses in health facilities. Next generation SDD power supply specifications need to acknowledge this requirement whilst assuring the priority need to keep vaccine within the acceptable temperature range.

Timing for PQS Inclusion: 2017, subject to change upon further discussions.

4.2 Photovoltaic array and array output cable

- Solar modules must comply with IEC 61215 (crystalline solar modules) or IEC 61646 (thin film solar modules). Solar module voltage up to 45 volts open circuit (Voc) is acceptable provided all electrically powered system components are integrated in such a way that performance and component life is not reduced by voltage input from the solar array.
- The power warranty is to be a minimum of 25 years to 80% of the initial power rating.
- The minimum solar array capacity is to be no smaller than an array capable of sustaining the maximum load, including all power system losses and power output degradation x 1.25.
- All cable and cable connectors not in conduit must display a rating confirming its suitability for exterior use in direct sunlight. Exterior rated conduit with weatherproofing or equal protection must be provided at the point where cable enters the building.
- Cable for optional pole mounts to be suitable for direct burial with either conduit or armoured cable.
- A minimum cable length of 20 meters is to be supplied utilizing factory installed connectors to prevent reverse polarity and simplify installation.
- Manufacturers are to provide instruction for estimating cable diameter and for ordering non-standard lengths of cable.

Reasons for change:

- Solar array cable requirements were not adequately specified in previous PQS.
- Use of solar modules of up to 45 Voc is acceptable when matched to power system components and refrigerator electrical input requirements with consideration for site temperatures.
- The majority of solar modules provide a 25 year power.
- "Plug and play" connectors are widely used and can reduce installation time, installation error and maintenance.

Proposed timing for PQS inclusion: 2015.

- Solar module, solar array and refrigerator connectors to be MC4 equivalent or compatible.

Reasons for change:

- Solar array and cabling may outlast the refrigerator and be useful in powering replacement refrigerators and/or future power consuming devices. Standardized cable connectors will support reuse of solar arrays while minimize training and tool requirements.
- MC4 connectors are widely used and MC4 compatible connectors are available from a selection of manufuacturers.

Proposed timing for PQS inclusion: 2017, subject to change upon further discussion.

4.3 Array support structure

- Generalized roof/ground mounts with adjustable tilt angles and optional pole mounts are to be offered by all manufacturers.
- The combined array structure and photovoltaic panel assembly must be designed to withstand wind loads of 200 kg per square metre and supplied with supporting wind load calculations.

- The array structure package is to be supplied with a complete set of theft deterrent fasteners including any special tool or bit required. 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. All fasteners that are accessible to unauthorized persons must be theft deterrent. Theft deterrent fasteners include tamper resistant bolts requiring a special tool or bit for fixation/removal. Special tools and/or bits must be either unique or not commonplace in the country of installation and must be supplied with each system. In cases where multiple systems are supplied the quantity of special theft deterrent tools and/or bits must be adequate for the quantity of systems supplied and agreed upon in advance of order placement.
- 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 array and the structure for lightning protection purposes in accordance with the solar module manufacturer's instructions, and drilling tools and fasteners to effect proper connection.
- Generalized roof/ground mounts with adjustable tilt angles are to be supplied with all theft deterrent fasteners needed to attach to a pitched roof with wood structure and flat concrete on either an existing roof or ground foundation cast at time of installation.
- Generalized roof/ground mounts with adjustable tilt angles require tilt adjustment 0 to 40 degrees from horizontal. For optional pole mounts the manufacturer or qualified supplier must include solar array maintenance tools and materials. Pole and concrete requirements are not required to be supplied however these materials and typical tool requirements are to be clearly identified in advance of sale to prospective buyers.

Reasons for change:

- Power systems have been found to be incomplete causing the recipient to obtain components in country or to install without complete components. Examples include kits supplied with no fasteners for fixing structure to building or foundation, no grounding, insufficient theft deterrent fasteners, no cable protection for entry points into the building, no disconnect switch, and battery enclosures with no ventilation or lock.
- Pole mounts are a commonly applied mounting solution when required to avoid shading and/or deter theft.
- Solar array wind loading calculations provide documentation that the structure can meet the prescribed wind load requirement.
- Solar array structure theft deterrent fasteners kits have been found to be incomplete in both necessary fasteners and special tools or bits required**.**
- Solar arrays may need to be adjusted, relocated or temporarily removed in association with building maintenance work and breakaway fasteners are not compatible with this requirement.
- Adjustable tilt mounts have been found to have limited adjustability.

Proposed timing for PQS inclusion: 2015.

4.4 Battery set sizing

- 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/72 hours at 25°C for a 3-day autonomy period to a final voltage that ensures the minimum required battery set life of 1800 cycles to 50% 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 50% discharge.

Reason for change: Reduced depth of discharge to increase battery life.

Proposed timing for PQS inclusion: 2015.

4.5 Battery type

- Both sealed and flooded lead acid batteries are acceptable for Type 1 systems, although sealed batteries are preferred for installations in remote areas where maintenance will be difficult. Lithium batteries and other battery alternatives are not permitted.
- Only sealed lead acid batteries are acceptable for Type 2 ancillary batteries to minimize maintenance and corrosion in the refrigerator compartment. Lithium batteries and other battery alternatives are not permitted.

Reason for change: Lithium batteries and other battery alternatives to lead acid batteries will not be permitted until a preponderance of evidence is made available confirming safe operation and control in solar electric operations.

Proposed timing for PQS inclusion: 2015.

4.6 Battery charge regulator

Note: Applies to **Type 1** system only.

- Battery charge regulator control strategy may be either pulse width modulation, series switching, shunt or maximum power point tracking. All battery charge regulators must minimize wiring complexity and limit field connection points to no more than six conductor connections (e.g. solar array + and -, battery + and – , and load + and –). Battery temparature sensor connections are also acceptable.
- Maximum power point tracking controls are to be sized to the actual installed solar array voltage, current, and the battery voltage and may not add additional wiring complexity compared to other control strategies that use solar array, battery and battery temperature sense wiring.

Reason for change: Maximum power point tracking controls are routinely used to overcome long distance cable lengths and/or to couple higher voltage solar modules to lower voltage batteries.

MPPT controls with more than six connections add complexity to field installations.

Proposed timing for PQS inclusion: 2015.

4.7 Power switch

- At least one method to disconnect the refrigerator from the solar power system must be supplied. This isolator (aka disconnect) can be a switch built into the refrigerator or a separate wall mounted switch. Disconnecting energized cables is not an acceptable means of disconnect, although this method can be used in case of emergency.

Reason for change: Clarification was required to permit a means of safe disconnect at the appliance and to alert manufacturers to instruct users to not use quick disconnect connectors to routinely disconnect power. Arcing will eventually damage connectors disconnected under load.

Proposed timing for PQS inclusion: 2015.

4.8 Electrical protection

- For connections to battery systems circuit breakers or fuses must be installed in the positive line, near the battery, and the fuse-holder must be of non-corroding material. If fuses are used there must be a set of 10 spare fuses for each fuse size and type used in a polyethylene bag fixed near to the fuse box.
- For connections to Solar Direct Drive (SDD) installations, the circuit breakers or fuse boxes must be located in an accessible location. The fuse type and rating must be marked close to the fuse holder. Attached within each refrigerator or combined refrigerator water pack freezer there must be a set of 10 spare fuses for each fuse size and type used.

Reason for change: Some SDD refrigerators have been supplied with inadequate spare fuses and spare fuse types not available in country of installation.

Proposed timing for PQS inclusion: 2015.

4.9 User maintenance kit

- All sites are to be supplied with one complete user maintenance kit consisting of all necessary operations and routine maintenance tools and supplies as applies to the installation. The minimum user kit is to include PV array cleaning tools and supplies consisitng of a 5 meter telescoping handle fitted with a glass cleaning scrubber and blade and water bucket dimensioned for scrubber and blade.
- Specialized tools and materials not required for regular operations and routine user maintenance are to be clearly identified to prospective buyers and are to be offered as an option by the manufacturer.

Note: an individual site with multiple solar installations can be supplied with a single maintenance kit suitable for the type of solar power system provided.

Reason: Routine maintenance is typically the responsibility of the user. Specialized tools, accessories and supplies may be required and these must be supplied at each installation site as part of the package.

Power systems have been provided without items required for regular operations and routine user maintenance such as solar module cleaning kits. These tools and materials are not always readily available in the area of installation and additional funds may not be available for user purchases.

To minimize the need to work at height and to enable health workers and other personnel to carry out routine and technical maintenance with minimum risk of injury all sites a standard user maintenance kit is required.

Telescoping poles with squeegee/scrubber attachments will provide a safer alternative for

cleaning some difficult to reach solar arrays (e.g., pole mounts at height and roof mounts in dangerous locations).

Proposed Timing for PQS Inclusion: 2015.

4.10 Specialized installation and technical maintenance tools

- Specialized tools and materials required for installation and technical maintenance are to be clearly identified to prospective buyers and offered as an option by the manufacturer. The type and quantity of special tools must be determined and agreed upon in advance of order placement.
- Solar direct drive installation sites must be sufficiently shade free as determined by a solar site analysis that accounts for the daily average site shading on no less than a monthly basis. Specialized tools for shading analysis must be offered to prospective buyers.

Reason: Power systems have been supplied without a clear indication of specialized tools and/or materials required for installations such as solar shading analysis tools, sealants for building penetrations, tools for theft deterrent fasteners, specific drill bit types and sizes. These items are not always readily available in the area of installation and additional funds may not be available for installer purchases.

Proposed Timing for PQS Inclusion: 2015.

4.11 Ambient temperature range during transport and storage

- -30°C to +70°C when components, sub-components, batteries are in transit. If individual sub-components are not able to withstand this temperature range, special transport arrangements may have to be made.
- Need for special transport arrangements must be notified to the procurement agency/client.

Reason for change: Multiple reports of heat damage occurring during transport and/or storage have led to a requirement to increase the ambient temperature threshold. The ultimate limits will be specified based on the best evidence. Manufacturers are encouraged to share monitored temperatures encountered during storage and/or transport.

Proposed timing for PQS inclusion: 2017, subject to change upon further discussion.

4.12 Warranty

- Any component which fails due to defective design, materials or workmanship must be covered by a replacement warranty. The minimum periods for the warranty must be as follows:
- 25 years for the solar module power output.
- 5 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, in accordance with Figure 1.
- 2 years for all other components.

Reason: Solar modules with 25 year warranties are now widely available. Power system

reuse is possible with adequate assessment of performance, installation quality and remaining useful life of all components.

Proposed timing for PQS inclusion: 2015.

4.13 Essential spare parts

- Supply sufficient spare parts for the first 5 years of operation. Spare parts are to be provided in kit form for storage in appropriate quantities at central or regional level in the purchasing country, as agreed with the purchasing agency. The type and quantity of special tools must be determined and agreed upon in advance of order placement.
- Manufacturers are to publish a list of spare parts recommended for purchases of 10 and 50 power systems. As a minimum supply the following quantities per 10 installations:

  10 spare fuses of all fuse size and type used in the solar power system.

  1 battery charge regulator, if used.

- The type and quantity of spare parts must be determined and agreed upon in advance of order placement.

Reason: Spare parts for purchases of less than 50 systems is not addressed in present PQS specifications. Requirement for spare solar array cables has been discontinued due to few reports of need.

Proposed timing for PQS inclusion: 2015.

4.14 Instructions

- For each installation provide a separate user manual and technician's installation manual in the language most appropriate to the installation site.
- Instructions to include easy to understand visuals whenever possible to avoid reliance on text. The user manual must include the following information:

- The technicians' installation must include the following information:
  - Health and safety guidance.
  - Design rationale.
  - Site-specific drawings (if applicable).
  - Full installation instructions, including array siting recommendations.
  - Wiring diagrams.
  - Full commissioning instructions.
  - User training (a dedicated curriculum designed for the installer to use in training the user in operations and maintenance of the solar fridge and solar power system).
  - Periodic preventative maintenance checks.
  - Diagnostic and repair procedures.
  - Itemized list of spare and repair parts including part numbers.
  - Resource recovery and recycling procedures.
- For Verification review purposes instructions are to be provided in the English language

Reason for change: In recognition of the importance of local language materials to support proper installation, use, maintenance and repair the traditional requirement for manuals in 5

languages has been removed and replaced with a requirement for local language materials and a review copy in English.

User training has not been systematically addressed. Installers are guaranteed to be on site and must be prepared to provide user training.

Proposed timing for PQS inclusion: 2015.

4.15 Training support

- Specific user training instructions must be provided by the Manufaturer to enable an instructor (e.g. health worker supervisor or installer) to provide product specific training for the responsible, on-site refrigerator user.
- Optional training courses may be offered by the qualified supplier or a designated representative.

Reason for change: User training has not been systematically addressed. Product specific lessons will assist third party instructors to convey operations and maintenance information deemed essential by the Manufacturer.

Proposed timing for PQS inclusion: 2015.

4.16 Verification

- In accordance with PQS Verification Protocols **E003/PV01-VP1.2** and **E003/PV01-VP2.2,** Legal Manufacturers will be required to present evidence of conformity at time of solar refrigerator lab testing including a completed Type Examination and English language version of all manuals.

Reason for change: In the past there has been no formal PQS review of solar power system**.** Various interpretations and omission of some requirements has led to this requirement to provide a type examination with evidence of compliance to be included in E003/PV01-VP1.2 Test 1: Type Examination. For example, evidence can include: schematic drawings (e.g., electrical wiring diagrams), calculations (e.g., wind load calculations for mounting structure), a complete bill of materials (e.g., sufficiently detailed to indicate the quantity, type and location of theft deterrent fasteners), photos of components (e.g., options for cable entry through building structure or through roof), equipment manuals (e.g., detailing user training to be carried out by the installer), component specifications (e.g., third party component OEM specifications and instructions) and all component warranties.

Proposed timing for PQS inclusion: 2015.

4.17 Packaging

- Materials used for packaging components are to be free of ozone-depleting compounds as defined in the Montreal Protocol.
- The packing must be of a sturdy export quality, and of a commercial standard that will provide adequate protection of the goods for carriage by air, sea and/or road to final destinations worldwide, including remote locations under adverse climatic and storage conditions and high humidity (i.e. not less than 17kN edge crush resistance with minimum

60% remaining with 90% humidity at a temperature of 70 degrees Celsius in tropical conditions).

- The general specification of shipping containers will be subject to agreement with the individual procurement agencies.

Reason: Receiving countries are known to experience difficulties with the disposal of waste packaging materials, particularly if they are not biodegradable. UNICEF Supply Division and manufacturers are requested to propose specifications for recyclable/biodegradable packaging.

Proposed timing for PQS inclusion: 2019, subject to change upon further discussion.

Revision history

Date	Change summary	Reason for change	Approved