TITLE: Solar direct drive cold and freezer rooms

Product verification protocol:	E001/SDD CR-FR VP.2
Applies to specification ref(s):	E001/SDD CR-FR 0.1
Date of origin:	21 July 2022
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Contents:

1. Scope:

This **WHO/PQS/E001/SDD CR-FR VP.2** quality assurance protocol will be used for the pre-qualification and evaluation of solar direct drive (SDD) vaccine storage cold rooms and/or freezer rooms (CR-FR). Both the initial design proposal phase and the installation and operation phase are included in this protocol. This document is initially used by an employer or their QA assessor to describe the requirements for a specific installation. The document also sets out a required solar power system design methodology, installation, commissioning, inspection and acceptance procedure.

This Quality Assurance Protocol shall be read in conjunction with equipment specification **WHO/PQS/E001/SDD CR-FR** that describes the WHO PQS requirements for an SDD CR-FR and its installation. **WHO/PQS/E001/SDD CR-FR** also specifies the installation and maintenance advisory services that all legal

manufacturers shall offer for supporting a pre-qualified SDD CR-FR. The specification applies to single storey CR-FR rooms with a gross internal cubic capacity of a minimum 5 m^3 and not exceeding 40 m^3. These may be housed within an existing building or as a standalone, free-standing, fully weather-proof CR-FR not requiring additional enclosure, building or structure. Three temperature zone designations are described, and prequalification can be earned for any or all of the temperature zones defined as hot zone, moderate zone and temperate zone.

Verification testing in accordance with **WHO/PQS/E001/SDD CR-FR VP.1** will establish the CR-FR watt-hour per day electricity consumption (aka load) and the minimum solar array capacity and the minimum solar radiation reference period for which the CR-FR will be prequalified for. It will also establish the minimum autonomy that the CR-FR can achieve. In addition, CR-FR are tested to establish a minimum rated ambient temperature designation.

Both the equipment performance specification and this quality assurance protocol should also be read in conjunction with **WHO/PQS/E001/PVAC Solar power system for cold and freezer rooms** (i.e., used for solar arrays when array voltage exceeds 48 Vdc and/or a DC to AC inverter is included) or **WHO/PQS/E003/PV 01 Solar power system for vaccine refrigerator or combined vaccine refrigerator and water-pack freezer** (i.e., used for solar arrays when voltage is 48 Vdc or lower).

Employers should utilize relevant project planning and implementation information from **WHO/PQS/E001/CR-FR VP 2.4 (Cold rooms and Freezer rooms – guidance section)**.

Employers shall be required to provide a completed **WHO/PQS/E001/SDD CR-FR VP 2, Annex 1 - Site requirements schedule** to enable legal manufacturers or their authorized resellers to complete **Annex 2- Solution proposal format** along with the required **Annex 3 - Solar power system sizing worksheet**.

After installation is complete **Annex 4 – Commissioning and inspection record** and **Annex 5 - Temperature mapping procedure** shall be completed by the employer or their QA assessor. Upon acceptable completion of Annexes 4 and 5 then a 30-day period of user operation should be undertaken to verify correct use and acceptable operations followed with completion of **Annex 6 - 30-day user questionnaire**.

WHO/PQS/E001/SDD CR-FR01-VP.1 type examination testing results and a completed **WHO/PQS/E001/SDD CR-FR VP.2**, 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. These documents also form the basis for a separate contractual agreement between the employer and the installer(s). These documents also establish the specifications and procedures used by the employer and their QA assessor to field evaluate the installation and its performance.

2. Normative references

For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 476-10: *Fire tests on building materials and structures. Guide to the principles, selection, role and application of fire testing and their outputs*.
Directive 2002/96/EC of the European Parliament and of the Council: *Waste Electrical and Electronic Equipment Directive.*
Directive 2014/30/EU of the European Parliament and of the Council: *Harmonisation of the laws of the Member States relating to electromagnetic compatibility*.
EMAS: *European Union Eco-Management and Audit Scheme.*
EN 10152: *Electrolytically zinc coated cold rolled steel flat products for cold forming. Technical delivery conditions.*
EN 10169-1: *Continuously organic coated (coil coated) steel flat products – Technical delivery conditions.*
EN 13501-1: *Fire classification of construction products and building elements – Part 1: Classification using data from reaction to fire tests.*
EN 15512: *Steel static storage systems – Adjustable pallet racking systems – Principles for structural design.*
EN 15620: *Steel static storage systems – Adjustable pallet racking – Tolerances, deformations and clearances.*
Generic Guide for the Field Evaluation of New Technologies for WHO PQS Pre-qualification.
IEC 60038: *IEC standard voltages.*
IEC 60335-1: *Safety of household and similar electrical appliances - Part 1: General requirements.*
IEC 60364-1: *Low-voltage electrical installations – Part 1: Fundamental principles, assessment of general characteristics, definitions.*
IEC 60364-4-41: *Electrical installations of buildings – Part 4*: *Protection for safety – Chapter 41: Protection against electric shock.*
IEC 60364-5-54: *Electrical installations of buildings – Part 5*: *Selection and erection of electrical equipment – Chapter 54: Earthing arrangements and protective conductors.*
IEEE 142-2007: *IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems.*
IEEE 1562: *IEEE Guide for Array and Battery Sizing in Stand-Alone Photovoltaic (PV) Systems.*
ISO 9001: *Quality Management Systems – Requirements*.
ISO 14001: *Environmental management systems – Requirements with guidance for use.*
ISO 20282-1: *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/CR-FR VP 2.4: *Cold rooms and freezer rooms.*
WHO/PQS/E001/PVAC01*: Solar power systems for cold and freezer rooms.*

WHO/PQS/E001/SDD CR-FR01: *Solar direct drive cold rooms and freezer rooms – Performance specification*.
WHO/PQS/E001/SDD CR-FR VP.1: *Solar direct drive cold rooms and freezer rooms – Type examination protocol.*
WHO/PQS/E003/PCMC 01: *Phase change material containers.*
WHO/PQS/E003/PCMC VP.1: *Phase change material containers - Type examination protocol.*
WHO/PQS/E003/PV01.4: *Solar power system for vaccine refrigerator or combined vaccine refrigerator and water-pack freezer.*
WHO/PQS/E006/TR03.1: *Programmable electronic temperature and event logger systems with integral alarm and auto-dialler options*.
WHO/PQS/E006/TR03-VP2.1: *Programmable electronic temperature and event logger systems with integral alarm and auto-dialler options-Quality Assurance protocol.*
WHO/PQS/E006/TR05.1: *User-programmable temperature data loggers.*
WHO/PQS/E007/EHC01.1: *Solar direct drive surplus energy harvest control.*
WHO/PQS/E007/EHC01 VP.1: *Solar direct drive surplus energy harvest control – Type examination protocol.*

3. Terms and definitions

Acceptable temperature range (freezer rooms): The acceptable temperature range for all parts of the room designated for vaccine storage must remain between -25°C to -15°C when measured under any loading condition between empty and full and over the full ambient temperature range of the required temperature zone (see clause 4.2.2).
Acceptable temperature range (cold rooms): The acceptable temperature range for all parts of the room designated for vaccine storage must remain between +2°C to +8°C when measured under any loading condition between empty and full and over the full ambient temperature range of the required temperature zone (see clause 4.2.2). Rooms specified to have cold climate freeze prevention must maintain the room temperature between +2°C and +8°C at ambient temperatures down to -10°C.
Annual review: The 12-monthly review which all PQS pre-qualified manufacturers are required to pass in order to remain on the register of pre-qualified companies.
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 specification clause 4.2.4.
Back-up power: A secondary, auxiliary power source (e.g., generator) capable of independently powering 100% of all CR-FR electrical needs.
Cold climate freeze prevention: Any mechanism which prevents the temperature inside a cold room from dropping below +2°C, under low ambient temperature conditions, down to the temperature specified by the employer, at the time of procurement, subject to a minimum ambient of -10°C.
Cool down: The time required to initially cool a walk in cold or freezer room to achieve stable operating conditions within the acceptable temperature range for vaccine storage and achieve its' full autonomy time.
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.

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 the **WHO/PQS/E001/SDD CR-FR** 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.
Energy harvest control (EHC): Accessory control device and/or system to enable the use of surplus solar photovoltaic electricity for powering other electricity consuming devices (loads) in addition to an immunization load. An EHC may harvest surplus electricity when the active cooling system is off and/or when the active cooling system is on and sufficient surplus electricity is available.
Freezing temperature (on walls/lining of vaccine compartment): For sensors placed in direct contact with the walls/lining of the vaccine compartment, freezing temperature is defined as any of the following conditions:
• Excursion between -0.5°C and 0°C for longer than one hour;
• Excursion equal to or below -0.5°C for any amount of time; and/or
• Inability to return to safe operating temperature (i.e., consistently between +2°C and +8°C) within two hours following an excursion equal to or below 0°C.
Hot zone: Hot zone units must operate at a steady +43°C ambient temperature and earn a minimum rated ambient temperature of +10°C or lower.
Installation: The complete cold room or freezer room installation described in **WHO/PQS/E001/SDD CR-FR01-VP.2** and in the companion **WHO/PQS/E001/SDD CR-FR0.1** and normative references (e.g., **WHO/PQS/E003/PV01)** specification documents and any other employer's requirements documentation issued for a specific installation or installations, including a complete solar power system and optional energy harvest and/or back-up power system were 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 CR-FR and/or solar power system.
In writing: Communication by letter, fax or email.
Legal Manufacturer: The natural or legal person with responsibility for the design, manufacture, packaging and labelling of a product or device before it is placed on the market under his own name, regardless of whether these operations are carried out by that person himself or on his behalf by a third party.
Load: Any end-use device in an electrical circuit that can consume power when the electrical circuit is energized. Load energy consumption is expressed as watt hours per day (wh/day).
Maintenance Contractor: A person or organization contracted by the employer to maintain the installation.
Minimum rated ambient temperature: The lowest continuous ambient temperature at which the acceptable temperature range can be maintained. The warmest acceptable minimum rated ambient is +10ºC.
Moderate zone: Moderate zone units must operate at a steady +27°C ambient temperature and earn a minimum rated ambient temperature of +10°C or lower.
Montreal Protocol and Kigali Amendment (2016): Montreal Protocol on Substances that Deplete the Ozone Layer and Kigali Amendment.
QA: Quality Assurance.
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.

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.
Rolling load: The weight applied to a cold room or freezer room floor arising from the routine use of metal wheeled manual pallet trucks and/or powered or manually operated rubber wheeled pallet lifting equipment.
Solar direct drive (SDD): solar photovoltaic power system connected to electrical load(s), without the need for a battery to sustain the acceptable vaccine storage temperature range.
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.
Temperate zone: Temperate zone units must operate at a steady +32°C ambient temperature and earn a minimum rated ambient temperature of +10°C or lower.
User: The person responsible for the day-to-day operation and temperature monitoring of the room.

4. Applicability:

The **Annex 1 - Site requirements schedule** will be completed by the employer. The legal manufacturer or their authorized reseller shall complete **Annex 2 - Solution proposal format**. The **Annex 3 - Solar power system sizing worksheet** will be completed by the legal manufacturer or their designated installer. The **Annex 4 - Commissioning and final inspection report** will be completed by the Quality Assessor with assistance from the installer. The **Annex 5 – Temperature mapping procedure** can be completed by the Quality Assessor or other qualified persons under contract with the employer. The **Annex 6 – 30-day user questionnaire** will be completed by the user after 30 consecutive days of CR-FR operation.

5. Quality assurance checklist:

5.1 Criteria for design acceptance:

Annex 1 - Site requirements schedule lists the required installation requirement(s) and their location(s). Each complete installation (including CR-FR, solar power system, optional back-up power system, optional remote temperature monitoring and optional energy harvest control system) is to be designed and supplied using component elements in accordance with equipment specification **WHO/PQS/E001/SDD CR-FR.**

Annex 2 - Solution proposal format defines the information that legal manufacturers and resellers are required to provide as a proposed solution based on Annex 1 details and in consideration of environmental conditions at the installation site (e.g., in dusty conditions, avoid using components requiring frequent cleaning maintenance or provide equipment for safe and effective cleaning maintenance by on site staff).

Annex 3 - Solar power system sizing worksheet defines the solar array sizing information that legal manufacturers and resellers are required to provide based on

measured climatic, solar radiation and autonomy data conditions at, or as near as possible to, the named site. If measured data is not available then the SDD CR-FR is to be designed on the basis of the best available information for the country, region, province or district specified by the employer.

5.2 Criteria for qualification:

An individual installation will be accepted by the employer when:

- The completed **Annex 4 - Commissioning and final inspection report** shows that all components are correctly installed and are operating satisfactorily.
- A completed **Annex 5 - Temperature mapping procedure** has been received, showing no faults and acceptable temperature range(s) throughout the designated vaccine storage areas of the CR-FR.
- A completed **Annex 6- 30-day user questionnaire** shows the user has received training, can operate and maintain the installation and operation has been correct throughout the first 30 days of operation or has been as correct throughout 30 consecutive days.

6. Quality control checklist:

6.1 Quality control standards:

All installation work must be carried out in accordance with the legal manufacturer's installation instructions. All on-site electrical installation work must comply with applicable national/local codes and the IEC 60364 normative references specified in **WHO/PQS/E001/SDD CR-FR**.

6.2 Manufacturing quality control checklist:

On-site inspection of the production facility may or may not be required at the discretion of the PQS Secretariat.

6.3 Site work quality requirements:

The QA Assessor will carry out an inspection of each completed installation and together with the installer record commissioning details of the installation to complete a copy of the **Annex 4 - Commissioning and final inspection report**. If the installation is satisfactory, **Annex 5 - Temperature mapping procedure** will be conducted and reported. If Annex 4 and 5 are acceptable to the employer, then the SDD CR-FR will be handed over to the user who will complete a copy of the **Annex 6 - 30-day user questionnaire** after 30 days of operation. The employer will only accept the installation when Annexes 4, 5 and 6 are documented and are satisfactory.

6.3.1 Training:

The installer must train the users of the installation using the training materials supplied by the legal manufacturer. Trainees must receive practical hands-on training at the installation site and the course shall include the following topics as minimum:

- Health and safety guidance.
- Description of all system components and their function.
- Correct operations of the installation.
- Basic daily, weekly and monthly maintenance tasks.
- Contact information for service provider(s).

6.4 Handover dossier:

The handover dossier must be issued to the employer after the installation has been completed. The dossier must be presented in a lever arch folder with clearly marked subject dividers and must contain the following:

- Site requirements schedule (Annex 1).
- Completed, signed, Solution proposal (Annex 2) noting comparison to PQS prequalified CR-FR and solar power system. Clearly note any as built modifications or substitutions.
- Completed, signed, Solar power system sizing worksheet (Annex 3) noting comparison to PQS prequalified CR-FR and solar power system. Clearly note any as built modifications or substitutions.
- Completed, signed Commissioning and final inspection report (Annex 4).
- Completed, signed Temperature mapping procedure (Annex 5).
- Completed, signed, 30-day user questionnaire (Annex 6).
- Signed certification that the solar power system complies with normative reference **WHO/PQS/E003/PV01** or **WHO/PQS/E001/PVAC**.
- User manual, installer (technician) manual and installation instructions for the CR-FR, the solar power system and any optional accessories including remote temperature monitoring, backup power system and/or the energy harvest control system containing the materials listed in specification **WHO/PQS/E001/SDD CR-FR**

One copy of the user manual is also to be handed to the responsible person at the installation site. It is recommended that the user manual be kept accessible at the installation site.

7. Customer reference checklist:
Not applicable.

8. Pre-qualification evaluation:
See **WHO/PQS/E001/SDD CR-FR VP.1**.

9. Modified products:
Not applicable.

Annex 1 – Site requirements schedule

The employer is to complete one Site requirements schedule for each site. Technical assistance may be required to estimate accessory electrical load and solar power system requirements.

Cold room/freezer room schedule			**Date:**	
Country:		**City/town:**	**Site name:**	
Procurement agency: Contact name: Address 1: Address 2: Tel: Fax: Email:				
All system components must comply with applicable PQS specifications.				
PART 1: New equipment required: ***Cold room(s) at +2°C to +8°C or Freezer room(s) at -15°C to -25°C:***				
1.1	**Net vaccine volume** *Include all items stored in the cold room. Allow for future needs (e.g., new vaccines and integrated services, plus a minimum 25% safety margin).*	*Net vaccine volume to be stored in cold room:*	*litres*	
		Net vaccine volume to be stored in freezer room:	*litres*	
		Total CR-FR vaccine storage required = net volume x 1.25 =	*litres*	
1.2	**Temperature zone** *Choose the appropriate temperature zone. If winter temperatures are low and site heating is unreliable, specify a freeze prevention circuit.*	*Hot zone (+43°C) when design day ≤ +43°C*	☐	
		Temperate zone (+32°C) when design day ≤ +32°C	☐	
		Moderate zone (+27°C) when design day ≤ +27°C	☐	
		Cold climate freeze prevention circuit: *Yes* ☐ *No* ☐		
		If YES, specify the lowest winter temperature that the cold room will be exposed to:	*°C*	
1.3	**Vaccine storage method** *Choose the required vaccine storage system to be used.*	*Secondary or tertiary cartons on shelves only*	☐	
		Secondary or tertiary cartons on shelves with supplementary vaccines on fixed floor pallet(s)	☐	
		Secondary or tertiary cartons on floor pallets	☐	
		Secondary or tertiary cartons on pallet racking	☐	
		Shipping containers on floor pallets	☐	
		Shipping containers on pallet racking	☐	
1.4	**Mechanical handling equipment** *List type of equipment used in the room, if applicable.*	*Manual pallet truck*	☐	
		Electric pallet truck	☐	
		Manual lift truck: lift height *metres*	☐	
		Electric lift truck: lift height *metres*	☐	
PART 2: Load details				
2.1	**Cold, freezer or combined cold and freezer room**	Manufacturer/model:		
2.2	**Electrical load(s) if known:** *manufacturer, model and electrical data (e.g., voltage, frequency, single or three phase, quantity, watts, energy*	**Load 1** (if known): Wh/day (from Test 1, PQS E001 SDD CR-FR VP.1.		

Cold room/freezer room schedule		Date:	
Country:	**City/town:**	**Site name:**	
	consumption watt hours per average day and watt hours/ design day). *Expand list as necessary with accessory loads not included in the CR-FR as tested. For energy harvesting see note below.*	**Load(s) 2:**	
PART 3: Site specific details			
3.1	**Site location details** *Fields marked * are mandatory. The more precise the other data, the easier it will be to design the solar power system to suit the specific site. If unknown use the "?".*	* Site name:	
		* Latitude: *Longitude:	
		*Elevation:	
		GPS Coordinates:	
		Nearest town/country:	
		Grid or generator electricity is available on site:	Yes No ?
		If YES, note hours/day grid or generator electricity is available, frequency/duration of power outages and quality.	
3.2	**Solar array support details** *If the answer is unknown at by Employer use the "?". The chosen array position must be oriented as close as possible to South (northern hemisphere) or North (southern hemisphere) and must be completely shade free (including overhead cables) from at least 9:00am to 3:00pm throughout the year. Give orientation in Northern hemisphere as: SE, SSE, S, SSW, SW or in Southern hemisphere as: NE, NNE, N, NNW or NW.*	Is array to be attached to CR-FR?	Yes No ?
		Is array unshaded (8 AM to 4 PM)?	Yes No ?
		IF NO, describe the time(s) when the solar array would be shaded and what is causing the shading (e.g., nearby building, tree, etc).	
		Pitched roof mount?	Yes No ?
		If YES give roof pitch in degrees and slope orientation:	
		If YES, state roof structure and finish materials:	
		If YES, height of building to eaves:	m
		Flat roof mount?	Yes No ?
		If YES, height of building to roof:	m
		If YES, state roof finish material:	
		Wall mounting?	Yes No ?
		If YES, give wall orientation:	
		If YES, give mounting height:	m
		Ground mount (detached from CR-FR)?	Yes No ?
		Pole mount (detached from CR-FR)?	Yes No ?
		If YES, give height of pole:	m
		If YES, choose top or side mount:	Top Side
3.3	**SDD array cable length** (if array detached from CR-FR)		m
3.4	**Array cable positioning**	In free air, underground or not known.	
3.5	**Generator or backup system location/notes:**		

Note: Optional energy harvest control system loads will require additional information to be supplied that includes:

1. If a battery is used for non-essential loads then the power system will require an energy harvest control system. For each additional electrical device (load) list load description / quantity / nominal voltage / watts / average on time in hours per day

   Example:
   Non-essential cooling loads can include many and varied loads. This example lists several loads that are not required by the **WHO/PQS/E001/SDD CR-FR** specification followed by the information needed to estimate the additional electrical load. Example devices are:

   a. Perimeter security lights for all night use, every day;
   b. cell phone recharging during hours of a 5-day work week; and
   c. communications radio.

   An energy harvest control (EHC) option will allow these non-essential loads to be powered by a rechargeable battery where the battery charge and discharge is managed by a tested and PQS prequalified energy harvest control system. All of these loads are available in either 120/230 Vac or 12 Vdc. Since 120/230 Vac power requires an inverter system resulting in more electricity consumption the 12 Vdc option will be less expensive with less components.

   The loads estimate requires the following minimum information:

   Lights, quantity = 3, 10 watts/each, each on for a winter maximum of 13 hours every day (voltage =12 Vdc). Load result =

   3 x 10 watt/each x 13 hr/day = 390 wh/maximum day

   Cell phone recharge, quantity = 2, 5 watts/each, connected for 9 hours/day, 5 days per week (voltage =12 Vdc). Load result =

   (2 x 5 W x 9 hr/day x 5 day/week) / 7 days per week = 64 wh/average day

   Communications radio, quantity = 1, 20 watts, (voltage = 12 Vdc) Manufacturer specification sheet states daily energy consumption = 100 wh/average day.

Annex 2 – Solution proposal format

Note: For each site the employer will provide prospective suppliers with as many details as possible with a completed **Annex 1- Site requirements schedule**.
The legal manufacturer or their authorized reseller shall complete Parts A, B and C for their proposed solution. Signature required.

Proposal Details	
Legal manufacturer or authorized reseller company name: Contact person/title: Address: City: Country: Telephone: Mobile phone: Email:	
PART A: Employer and Site requirement summary	
Employer name: Contact person/title: Address: City: Country: Telephone: Mobile phone: Email:	
Site Details	
Site name: GPS Coordinates (or latitude and longitude): Elevation: Address: City: Country:	
Cold Chain Requirements	
Type of room (CR, FR or combined) CR-FR total vaccine volume requirements (litres) Location: Standalone building or sheltered in larger building	
Essential Cooling Power System	
Primary power: Solar direct drive Solar array mounting type: Back-up power: generator or other (specify) Back-up power fuel: (specify)	
Optional Non-Essential Cooling Power Requirements	
(list)	

Proposal Details			
PART B: Legal Manufacturer Proposed Design Solution			
Based on the information provided by the employer the legal manufacturer or their authorized reseller propose the following equipment solution. Note: a completed PQS Solar power system sizing report must be attached (see Annex 3).			
	Test data: *Test data from E001/CR-FR VP.1*	Gross volume of tested CR-FR:	
		Temperature zone(s) for test(s):	
		Simulated SDD array capacity (Wp) used in Test 1:	
		Simulated solar radiation reference period used in Test 1:	
		Cool down time (reported from Test 1):	
		Energy consumption (Wh/day reported from Test 1):	
		System autonomy time (reported from Test 2):	
		Minimum rated ambient temperature (Test 3), for cold rooms only:	
	Site:	Attach design day climate data including dates (e.g., month) for ambient temperatures, solar radiation and autonomy data with clear reference to sources:	
		Design ambient temperature / design month: Source:	
		Solar radiation reference period / design month (lowest average daily solar radiation): Source:	
		Site autonomy requirements: Source:	
	CR-FR: (*Attach PQS data sheet and all specification sheets)*	PQS Catalogue code:	
		Manufacturer: Regional prequalification:	
		Model number:	
		Type of room: CR, FR or combined CR-FR: Compare to tested CR-FR:	
		Gross volume(s): Compare to tested CR-FR:	
		Climate zone: Compare to tested CR-FR:	
		Cooling system type:	
		Cooling system operating voltage:	
		Cooling system peak starting current:	
		Connection for back-up power provided?	
		If back-up power system included attach separate sheet with sizing estimate and all component specifications.	
	Solar array: (*Attach all specification sheets)*	Solar array capacity (maximum power in watts based on solar module standard test conditions):	
		Solar module manufacturer, model number, and proposed quantity: Certifications (e.g., IEC 61215):	
		Solar module electrical characteristics (Voc, Vmp, Isc, Imp, Wp and temperature coefficients):	
		Solar array wiring configurations (number of modules in series and parallel):	

Proposal Details			
		Solar mounting type (attached to room, detached on ground, detached on other building or pole), wind rating, material, coating for corrosion resistance:	
		Theft deterrent manufacturer, model number and quantity supplied:	
		Solar array orientation and azimuth:	
		Estimated cable distance:	
		Cable placement (e.g., in conduit, buried, overhead):	
		Cable size and cable type:	
		Cable protection level:	
		Subarray combiner enclosures:	
		Disconnects and ratings:	
Energy Harvest Control System			
(Optional, required only if accessory loads that are not standard with the CR-FR equipment as tested will be powered by the solar array. Legal manufacturer or reseller to provide load estimation, EHC and battery sizing including all component specifications sheets.			
Electrical Wiring Diagram (Include separate sheet(s) illustrating all integrated components).			
Certification of compliance with all WHO/PQS/E001/SDD CR-FR specifications.			
Authorized person: Printed name, title, signature and date required.		Name _____ Title_____ Signature Date	

C. Proposal Checklist

□ Does the proposer and proposed SDD CR-FR have WHO PQS prequalification for this region, temperature zone and a WHO PQS Catalogue code? ____ PQS code_____
□ Is the gross volume of the CR-FR able to store the total vaccine load x 1.25 ? ____
□ Is the room type as the employer specified (i.e., CR, FR or combination)? ____
□ Is the CR-FR temperature zone prequalification ≥ to design day temperature? ___
□ Is the install site design day solar radiation reference ≥ to 3.5 kWh/m²/day? ___
□ Is the proposed solar array capacity (Wp) ≥ to the capacity of the simulated solar power used for **WHO/PQS/E001/SDD CR-FR VP.1** testing? ___
□ Is the install site unshaded?
If NO, can the solar array be increased to offset all shade losses? ___
□ Is the install site autonomy time ≤ to the autonomy test result per **WHO/PQS/E001/SDD CR-FR VP.1** Test 2? ___
If NO, can the solar array be increased to achieve acceptable autonomy evidenced through the Solar Autonomy Calculation Tool (see Normative References).
□ Are all required support documents, specifications, drawings and Annex 3 attached? ___
□ Proposal certifies that all components comply with WHO PQS specifications? ___

If all checklist questions result in a "YES" answer, then the proposal is to be forwarded to the employer and/or their QA assessor for verification.

Annex 3 -Solar power system sizing requirements

The legal manufacturer or their authorized reseller shall complete a solar power system sizing worksheet and compare the results to the solar array capacity used in the testing (**WHO/PQS/E001/SDD CR-FR VP.1, Test 1**). The larger of the two solar array values (i.e., **Test 1** or **Annex 3 – Solar power system sizing worksheet**) is to be used for the proposed solar power system.

Two worksheet options are acceptable.

Option 1: The solar array can be sized following the instructions in **IEEE 1562: IEEE Guide for Array and Battery Sizing in Stand-Alone Photovoltaic (PV) Systems,** Worksheet 1. The completed Worksheet 1 shall be submitted to the employer or their QA assessor for review.

Option 2: This Annex 3 provides a simplified Solar Array Sizing method that may be used for calculating solar array capacity (Wp).

For either option, the CR-FR load data for the sizing shall be determined by the energy consumption (wh/day) from Test 1 Section 5.5.1 of **WHO/PQS/E001/SDD CR-FR VP.1**. Power system losses must be included and shall not total less than 20% of the solar array capacity. Solar radiation data from a reputable source will be required to verify the site exceeds the minimum solar radiation reference period (i.e., 3.5 kWh/m² day). If at all possible, solar radiation data should be from a nearby reputable weather station. A minimum Array to Load Ratio (ALR) of 1.25 shall be used. The autonomy of the CR-FR for a given temperature zone was established through Test 2 Section 5.5.2 of **WHO/PQS/E001/SDD CR-FR VP.1** and is to be compared to the site autonomy requirements. CR-FR autonomy test result must exceed the site-specific autonomy requirement. Additional information required for the sizing will be: solar module specification sheet, CR-FR temperature zone prequalification, hottest design day temperatures, and operating voltage of the CR-FR.

Solar Array Sizing			**Date:**	
Country:		**City/town:**	**Site name:**	
System Provider: Contact name: Address: Tel: Fax: Email:				
All system components must comply with applicable PQS specifications.				
1	**CR-FR** and **daily load** *As determined from Test 1* ***WHO/PQS/E001/CR-FR VP.1.*** *and Site design temperature and Prequalified temperature zone(s).*	*CR-FR PQS Catalogue code is*_____ *Daily load (kWh/day):*		*kWh/day*
		Design temperature is _____ *PQS zone(s)prequalified:*		
2	**Nominal operating voltage** *Voltage at which the system normally operates.*			*VDC*

Solar Array Sizing				**Date:**	
Country:		**City/town:**		**Site name:**	
3	**System losses** *As calculated from IEEE 1562 Worksheet 1 line 7 or minimum total losses to be 20%.*				*%*
4	**Number of peak sun hours** (kWh/m² /day) *In month with the lowest solar irradiation. (Note: this assumes the site is unshaded. If solar array shaded, a site assessment must determine the losses.)*	*Peak sun hours:*			*hrs*
		Tilt angle:			°
		Orientation:			
		Weather Station: *Source:*			
5	**Array to Load Ratio** *Minimum ALR 1.25.*				*ALR*
6	**Solar module** *Record solar module data.*	*6a. Manufacturer/Model (example):*			
		6b. Peak Power Current (Ipp):			*A*
		6c. Peak Power Voltage (Vpp):			*Vpp*
		6d. Peak Power (Wp):			*Wp*
7	**Parallel calculations** *Number of strings to be wired in parallel.*	*7a. Multiply line 1 by 1000 and divide by line 2:*			*Ah/day*
		7b. Multiply line 7a by line 5:			*Ah/day*
		7c. Divide line 3 by 100 (this converts the percentage to a decimal) and subtract from 1:			
		7d. Multiply line 7c by line 4 and line 6b:			
		7e. Divide line 7b by line 7d:			
		7f. Round line 7e up to the nearest whole number:			
8	**Series calculations** *Number of strings to be wired in parallel.*	*8a. Divide line 2 by line 6c.*			
		8b. Round line 8a up to the nearest whole number:			
9	**Total number of solar modules** *Total number of solar modules required for the system.*	*9a. Multiple line 7f by 8b:*			
		9b. Multiple line 6d by 9a:			*Wp*
10	**Comparison to test results** *Compare the results of the calculations to the tests results the simulated solar power array.*	*Size of Test 1 solar array* ***WHO/PQS/E001/CR-FR VP.1****:*			*Wp*
		How much over (+) or undersized (-) is the calculated solar array verses the Test 1 array?			*%*
		The larger of the two solar arrays should be used. _____ solar array to be used.			*Wp*

Two examples of the Solar Array Sizing option are shown below with input values highlighted in blue:

Example 1: Solar Array Sizing			**Date: 21-July-2022**
	Country: Dem. Rep. of Congo	**City/town: Mouyondzi**	**Site name: Example 1**
1	**CR-FR** and **daily load** *As determined from Test 1* ***WHO/PQS/E001/CR-FR VP.1.*** *and Site design temperature and Prequalified temperature zone(s).*	*CR-FR PQS Catalogue code: E001/xxx* *Daily load (kWh/day):*	*13.5 kWh/day*
		Design temperature=+29°C *PQS zone(s)prequalified:*	*+43, 32, & 27°C*
2	**Nominal operating voltage** *Voltage at which the system normally operates.*		*60 VDC*
3	**System losses** *As calculated from IEEE 1562 Worksheet 1 line 7 or minimum total losses to be 20%.*		*20 %*
4	**Number of peak sun hours** (kWh/m² /day) *In month with the lowest solar irradiation. (Note: this assumes the site is unshaded. If solar array shaded, a site assessment must determine the losses.)*	*Peak sun hours:*	*3.7 hrs*
		Tilt angle:	*15°*
		Orientation:	*N*
		Weather Station: Mouyondzi, Congo *Source: South African Weather Bureau*	
5	**Array to Load Ratio** *Minimum ALR 1.25.*		*1.25 ALR*
6	**Solar module** *Record solar module data.*	*6a. Manufacturer/Model (example):*	*Solar XYZ*
		6b. Peak Power Current (Ipp):	*4.25 A*
		6c. Peak Power Voltage (Vpp):	*37.6 Vpp*
		6d. Peak Power (Wp):	*160 Wp*
7	**Parallel calculations** *Number of strings to be wired in parallel.*	*7a. Multiply line 1 by 1000 and divide by line 2:*	*225 Ah/day*
		7b. Multiply 7a by line 5:	*281.3 Ah/day*
		7c. Divide line 3 by 100 (this converts the percentage to a decimal) and subtract from 1:	*0.8*
		7d. Multiply line 7c by line 4 and line 6b:	*12.58*
		7e. Divide line 7b by line 7d:	*22.4*
		7f. Round line 7e up to the nearest whole number:	*23*
8	**Series calculations** *Number of strings to be wired in parallel.*	*8a. Divide line 2 by line 6c.*	*1.60*
		8b. Round line 8a up to the nearest whole number:	*2*
9	**Total number of solar modules** *Total number of solar modules required for the system.*	*9a. Multiple line 7f by 8b:*	*46*
		9b. Multiple line 6d by 9a:	*7360 Wp*
10	**Comparison to test results** *Compare the results of the calculations to the tests results the simulated solar power array.*	*Size of Test 1 solar array* ***WHO/PQS/E001/CR-FR VP.1****:*	*9800 Wp*
		How much over (+) or undersized (-) is the calculated solar array verses the Test 1 array?	*-25%*
		The larger of the two solar arrays should be used. Tested solar array to be used.	*9800 Wp*

Example 2 Solar Array Sizing			**Date: 21-July-2022**
Country: Ethiopia	**City/town: Addis Ababa**	**Site name: Example 2**	
1	**CR-FR** and **daily load** *As determined from Test 1* ***WHO/PQS/E001/CR-FR VP.1.*** *and Site design temperature and Prequalified temperature zone(s).*	*CR-FR PQS Catalogue code: E001/yyy* *Daily load (kWh/day):*	*6.5 kWh/day*
		Design temperature=+27° *PQS zone(s)prequalified:*	*+27°C*
2	**Nominal operating voltage** *Voltage at which the system normally operates.*		*26 VDC*
3	**System losses** *As calculated from IEEE 1562 Worksheet 1 line 7. Minimum total losses to be 20%.*		*20 %*
4	**Number of peak sun hours** (kWh/m² /day) *In month with the lowest solar irradiation. (Note: this assumes the site is unshaded. If solar array shaded, a site assessment must determine the losses.)*		*3.6 hr*
		Tilt angle:	*15°*
		Orientation:	*N*
		Weather Station: Addis Ababa, Ethiopia *Source: PQS solar autonomy calculation method.*	
5	**Array to Load Ratio** *Minimum ALR 1.25.*		*1.25 ALR*
6	**Solar module** *Record solar module data.*	*6a. Manufacturer/Model (example):*	*Solar XYZ*
		6b. Peak Power Current (Ipp):	*4.25 A*
		6c. Peak Power Voltage (Vpp):	*37.6 Vpp*
		6d. Peak Power (Wp):	*160 Wp*
7	**Parallel calculations** *Number of strings to be wired in parallel.*	*7a. Multiply line 1 by 1000 and divide by line 2:*	*250 Ah/day*
		7b. Multiply line 7a by line 5:	*312.5 Ah/day*
		7c. Divide line 3 by 100 (this converts the percentage to a decimal) and subtract from 1:	*0.8*
		7d. Multiply line 7c by line 4 and line 6b:	*12.24*
		7e. Divide line 7b by line 7d:	*25.5*
		7f. Round line 7e up to the nearest whole number:	*26*
8	**Series calculations** *Number of strings to be wired in parallel.*	*8a. Divide line 2 by line 6c.*	*0.69*
		8b. Round line 8a up to the nearest whole number:	*1*
9	**Total number of solar modules** *Total number of solar modules required for the system.*	*9a. Multiple line 7f by 8b:*	*26*
		9b. Multiple line 6d by 9a:	*4160 Wp*
10	**Compare to test results** *Compare the results of the calculations to the tests results the simulated solar array.*	*Size of Test 1 solar array* ***WHO/PQS/E001/CR-FR VP.1****:*	*3950 Wp*
		How much over (+) or undersized (-) is the calculated solar array verses the Test1 array?	*+5%*
		The larger of the two solar arrays should be used. The calculated solar array is to be used.	*4160 Wp*

Annex 4 – Commissioning and final inspection record

Commissioning and inspection report			**Date:**	
Country:		**City/town:**	**Site name:**	
QA Assessor: Telephone: Mobile phone: Email:				
Name of installation company: Installation supervisor/installer: Telephone: Mobile phone: Email:				
1	**Site conditions**	*Solar conditions (e.g., sunny, partly cloudy, cloudy, etc.):*		
		Ambient temperature:		°C
		Date, time of day:		
		Are the CR-FR and solar array sited to avoid natural disasters (e.g., flooding, landslide)?		
2	**Solar array structure**	*Made of corrosion resistant material?*		
		Corrosion resistant fasteners used?		
		Theft resistant hardware used?		
		Installed at the correct tilt angel? Record the tilt angle.		
		Installed at the correct orientation? Record the orientation.		
		Are all fasteners tight?		
3	**Solar array**	*Is the array protected from unauthorized persons?*		
		Are there unprotected safety hazards?		
		Is all wiring properly secured?		
		Are all cable entries properly sealed?		
		For cables greater than 150 VDC, are the wires installed in metallic conduit?		
		Proper overcurrent protection and safety disconnects?		
		Solar modules properly wired in series and parallel?		
		Are solar array maintenance tools and supplies provided?		
		Is there safe access for users to conduct solar array observation and cleaning?		
		Measure and record the solar array Open Circuit Voltage (Voc).		*VDC*
		Conduct shading analysis and attach the report of shading losses for each month of the year.		
4	**CR-FR**	*Properly secured to the ground/foundation?*		
		Correct thickness of insulation?		
		Record the cool down time of the CR-FR.		
		Record the energy consumption of the CR-FR.		

Commissioning and inspection report			Date:	
Country:		City/town:	Site name:	
		Record the operating voltage (and frequency if appropriate) of the CR-FR.		
		Are all cable entries and penetrations properly sealed?		
		Enclosure made of corrosion resistance material?		
		Backup power system connection found?		
		Is there sufficient lighting?		
5	**Energy harvest system (EHS) (if provided)**	*Confirm proper operation of the Energy Harvest system.*		
		EHS Output voltage.		*VDC*
		EHS Output power or current		
		If applicable, does it recharge the battery?		
6	**Backup power system (if provided)**	*Confirm proper operation of the backup power system.*		
		Generator starts on emergency (e.g., CR/FR is too warm)		
		Backup system is large enough to cool down and maintain temperature.		
		Fuel tank is of sufficient capacity to supply fuel to the generator until the solar system can be repaired or until a fuel truck can refill the tank.		
7	**General**	*Confirm proper operation of the temperature monitoring system.*		
		Warning labels installed for high voltage lines.		
		Is the system properly grounded?		
		Report the impedance measured from solar module frame to ground and ground to earth. Are each 5 Ohms or less?		*Ohms* *Ohms*

Annex 5 – Temperature mapping procedure
Complete per instructions in **WHO/PQS/E001/CR-FR01 VP2.4**, Annex 3.

Annex 6 – 30-day user questionnaire

The user is to complete this checklist for each installation after the first 30 days of operation. If the installation is not acceptable repeat the 30-day user questionnaire after installation corrections/modifications have been made.

Send a copy of the form back to <name of recipient>.

30-day user questionnaire			**Date:**
Site name: Address 1: Address 2: City: Country:			
Contact person/title (Person that completes this questionnaire): Telephone: Mobile phone: Email:			
1.	**Have you received training for:**	*a. Cold room or freezer room?*	
		b. Solar power system?	
		c. Backup power system (if included)?	
		d. Energy harvest control system (if included)?	
		e. Remote temperature monitoring (if included)?	
2.	**Do you have a copy of the *user manuals* for and the cold room or freezer room, the solar power system, temperature / equipment monitoring systems and all optional accessories provided?**		
3.	**Has the cold room or freezer room worked properly throughout the last 30 days?**		
4.	**Does the CR-FR have temperature readout indicator(s) and alarms? If YES, how are temperatures and alarms indicated?**		
5.	**Is the solar power system working correctly?**		
6.	**Is there an optional energy harvest control system with battery included? If YES, what does the battery power? Does the energy harvest control system work correctly?**		

30-day user questionnaire		Date:
7.	**Was a backup power system included (e.g., diesel fuelled generator)? If YES, was the backup power system used? Was the backup power system maintained/tested?**	
8.	**If you have any comments or questions, please write them here:** □	
	User's signature:	Date:

Revision history:			
Date	Change summary	Reason for change	Approved