Global LEAP Off-Grid Refrigerator Test Method

Version 2

April 28, 2019

The test method is developed by CLASP in collaboration with the Efficiency for Access Coalition's Refrigeration Technical Working Group. The refrigeration technical working group was convened in late 2016 to further develop this first test method for off-grid and weak-grid appropriate refrigerators. The authors express their gratitude to the many experts from around the world who contributed their time and expertise to this document.

Contents

1 Scope

This document defines methods to evaluate the quality, energy consumption and performance of refrigerators and refrigerator-freezers intended to be used with a PV module, a solar home system, or with the mains power in the weak grid context.

The test method consists of the following major components:

- Overall **product quality** inspection and evaluation
- Evaluation of **energy performance**
- Evaluation of **refrigerating/freezing performance**

The following international refrigerator test procedures have been referenced in the preparation of this document:

- IEC 62552-1,-2,-3: 2015: Household refrigerating appliances – Characteristics and test methods
- WHO/PQS/E003/RF05-VP.4: Refrigerator or combined refrigerator and water-pack freezer: Solar direct drive without battery storage
- IEC 62124: 2004: Photovoltaic (PV) stand alone systems – Design verification
- IEC 60335-2-24: 2017: Household and similar electrical appliances - Safety - Part 2-24: Particular requirements for refrigerating appliances, ice-cream appliances and ice makers

2 Product Definitions

2.1 Refrigerating appliance

Insulated cabinet with one or more compartments that are controlled at specific temperatures and are of suitable size and equipped for household or small commercial use, cooled by a natural convection or forced convection air flow.

2.2 Fresh food compartment

Compartment for the storage and preservation of unfrozen food and beverages, where the average storage reference temperature is 4.0°C (41°F).

2.3 8°C compartment

Compartment for the storage and preservation of unfrozen food and beverages, where the average storage reference temperature is 8.0°C (46.4°F).

2.4 Unfrozen food compartment

Compartment for the storage and preservation of frozen food where the storage temperature is a fresh food compartment or an 8°C compartment.

2.5 Frozen food compartment

Compartment for the storage and preservation of frozen food where the storage reference temperature is –6°C (21.2°F) or colder.

2.6 Refrigerator

Refrigerating appliance having at least one fresh food or 8°C compartment.

2.7 Refrigerator-freezer

Refrigerating appliance having at least one fresh food or 8°C compartment and at least one frozen food compartment.

2.8 Multi-Temperature Refrigerator

Refrigerator that has one or more compartments with a multi temperature compartment that can be operated either as a frozen food compartment or as an unfrozen food compartment. Tests this refrigerator shall be carried out with the multi temperature compartment considered as an unfrozen compartment.

2.9 Thermal battery

Component used for the purpose of storing and releasing thermal cooling energy. Storage of cooling energy is generated when electrical mains supply is present. Release of cooling energy is provided when electrical mains supply is low or not available.

2.10 Electrical battery

Component used for the purpose of storing and releasing electric energy. Storage of electrical energy is generated when electrical mains supply is available. Release of cooling energy is provided when electrical mains supply is low or not available.

2.11 Continuous power supply refrigerator

Refrigerator designed for continuous (24/7) AC or DC power supply, generally without any integrated thermal or electrical battery.

2.12 Solar direct drive refrigerator

DC supply refrigerator designed for direct connection with a photovoltaic solar panel, generally containing an integrated thermal and/or electric battery to allow autonomous operation during the night.

2.13 Weak-grid refrigerator

Refrigerator designed for intermittent AC power supply, generally containing an integrated thermal and/or electrical battery allowing autonomous operation during periods when power supply is lacking.

3 Testing and evaluation definitions

3.1 Quality inspection

Subjective verification of the packaging, product marking, user manual, user safety, cabinet design and durability, serviceability and maintenance and environmental impact considerations.

3.2 Volume

Volume of a specific compartment calculated according to IEC 62552-3: 2015, Annex H.

3.3 Maximum current

The electrical current present when a refrigerator is started at stabilized conditions.

3.4 Pull down time

Cooling time of the unfrozen food compartment to 8°C, after the sample has stabilized to the ambient condition and switched on. The test simulates how quickly an unfrozen food compartment reaches 8°C after installation.

3.5 Energy consumption

Reference energy consumption value at 32°C (89.6°F) ambient, defined at 4.0°C fresh food compartment temperature or at 8.0°C for an 8°C compartment temperature.

3.6 Temperature performance

Compartment temperature performance at 43°C (109.4°F) ambient for a fresh food compartment or 8°C compartment.

3.7 Under voltage

Input voltage operation set at 90% of the rated voltage, or in case an input voltage range is rated then 90% of the lowest value of the rated voltage range.

3.8 Over voltage

Input voltage operation set at 120% of the rated voltage, or in case an input voltage range is rated, then 120% of the highest value of the rated voltage range.

3.9 Voltage protection device

Automatic device switching off the input voltage supply of the refrigerator at high and/or low voltages.

3.10 Water bottle freezing time

The time to freeze a specific number of 500ml water bottles stabilized at the 32°C ambient to -6, -12 or -18°C.

3.11 Load processing energy consumption

The incremental energy consumption required by an unfrozen food compartment due to cooling 500 ml water bottles from 32°C ambient to 4.0°C fresh food compartment temperature or to 8°C for an 8°C compartment temperature.

3.12 Autonomy time

Duration of time of an unfrozen food compartment partly filled with water bottles to rise from 4 to 12°C for a fresh food compartment and from 8 to 16°C for an 8°C temperature compartment after the refrigerator is disconnected from the power supply at 32°C ambient. This test simulates how a refrigerator operates in absence of electrical power input, taking into account a thermal or/or electrical battery if present.

3.13 Ambient temperature

Measured temperature in the air surrounding the refrigerator during the test.

4 Test conditions and measurement uncertainty

4.1 Instruments, accuracy and precision of measurements

For the electrical energy consumption, length, mass, temperature, time, voltage and frequency, reference is made to IEC 62552-1: 2015, Annex A, Chapter A2.

The requirement measurement uncertainty of the inrush current measurement should be better then ± 5%.

4.2 General test conditions

For test conditions related to the ambient temperature, ambient humidity and electricity supply, reference is made to IEC 62552-1: 2015, Annex A, Chapter A3.

4.3 Environmental conditions

Environmental conditions are intended to simulate product operation in typical off-grid operating conditions.

4.4 Test setup

a) Remove any accessories, loose trays, bins or containers that have no dedicated position or essential function during normal use, as specified in the instructions.

b) Remove any thermal storage devices (e.g. ice-bricks or similar) that are removable without the use of a tool, irrespective of any instructions in the product manual.

c) Configure the refrigerator using the power cable included in the product package, as follows:

   i) If a DC cable is provided with the product, use the DC cable and a suitable DC power supply for testing.

   ii) If an AC/DC converter is provided with the product, test without the converter (using a suitable DC supply).

d) The refrigerator shall be placed in the climate room with a rear clearance / distance of 100mm.

e) Record the following data for each test run (as applicable):

   i) number of cooling system duty cycles and a graphical display of on/off cycles .

   ii) the ambient temperature and humidity of the test room.

   iii) the settings of any user-adjustable temperature control devices and any other user-adjustable controls, dampers, etc.

   iv) a diagram showing locations of the temperature sensors in all compartments as applicable.

f) For purposes of this test method, stabilization is determined based on IEC 62552-3:2015.

5 Test procedure

5.1 Quality assessment

1) Take digital photographs of the refrigerator packaging, including all identifying marks.
2) Unpack the refrigerator and install the refrigerator using the manufacturer's installation instructions. Record any problems encountered.
3) Check the refrigerator for defects or damage or any problem which make it difficult or impossible to conduct testing. Record any problems encountered. Record any differences between the refrigerator ordered and the sample received.
4) Review and photograph all supporting documents (e.g. user manual, warranty card, etc.) that are packaged with the product. Fill out the Quality Inspection Checklist according to Annex A of this procedure.
5) Take the following digital photographs of the product:
    i) A three-quarter view photograph of the refrigerator with the door open
    ii) All external surfaces of the refrigerator, the interior layout, and the compressor compartment
    iii) A close-up of the product rating plate, other identifying marks and other indicators including lights, the user controls, and any special features or identified weaknesses of the product.
6) The following aspects are evaluated based on the visual inspection of the product:
    i) General product information
    ii) Quality assessment
        (1) Packaging
        (2) Product marking
        (3) User manual
        (4) User safety
        (5) Design and durability
        (6) Maintenance and reparability
        (7) Environmental impact considerations

5.2 Volume

Determine the volume according to IEC 65552-3: 2015, Annex H for each compartment of the refrigerator.

5.3 Maximum current

a) Ensure that proper measurement equipment (with “inrush current option”) is selected to measure the inrush peak current of the compressor during the start of the test

b) Switch on the refrigerator applying the rated input voltage or the lowest input voltage rated in case an input voltage range is specified.

c) Connect the power supply and inrush current measurement equipment and switch on the appliance.

d) Measure the maximum current and determine whether an inrush current is present and whether the refrigerator is operating in a cycling mode. Repeat this procedure 5 times and determine the maximum and average value of these 5 measurements.

5.4 Pull down test

a) In case the refrigerator contains a thermal and/or electrical battery, ensure that the test is started with an empty battery.

b) Apply the coldest thermostat setting possible.

c) With the test chamber ambient temperature set to 32°C, leave the door/lid open for at least 6 hours.

d) Switch on the refrigerator and apply appropriate input voltage and current type :

i) Use the rated input voltage when a single value is specified (e.g. rated input voltage = 12Vdc)

ii) In case a DC input voltage range is specified: Use a 12Vdc voltage value, in case 12Vdc is within the range. (e.g. if rated input voltage range = 6-24Vdc, then 12Vdc should be applied). In case 12Vdc is not within the range, the minimum voltage should be applied. (e.g. if rated input voltage range = 24-48Vdc, then 24Vdc should be applied).

iii) In case an AC input voltage range is specified: Use a 230V voltage value, in case 230V is within the range. (e.g. if rated input voltage range = 220-240V, then 230V should be applied). In case 230V is not within the range, the minimum voltage should be applied. (e.g. if rated input voltage range = 110-120V, then 110Vshould be applied). Note that the rated frequency should always be applied.

e) Monitor the temperature within the unfrozen food compartment and determine:

i) The cooling time until average compartment temperature reaches +8.0°C.

ii) The time until any thermal battery is fully loaded and until any electrical battery is fully loaded.

5.5 Energy consumption

a) The test determines the temperature performance and reference energy consumption at +4.0°C or +8.0°C compartment temperature at 32°C ambient temperature using interpolation (if required).

b) Set the test chamber ambient temperature to 32°C.

c) Ensure than any internal thermal and/or electrical battery is fully loaded.

d) OPTION 1: For a continuous power supply refrigerator, apply the same input voltage as required for the pull down test.

e) OPTION 2: For a DC solar direct drive refrigerator, apply the following input voltage and input current procedure:

i) Ensure that the input voltage to the refrigerator is limited to the maximum rated voltage, by limiting the output voltage generated by the DC supply.

ii) Determine the maximum input current to the refrigerator, which is the rated current or the maximum input power divided by the minimum rated voltage. It is assumed that this value corresponds with output current of a solar panel, subjective to an irradiation of 1000 W/m^2 (See ANNEX B for background information).

iii) Ensure that the DC supply suitable to generates the following (12 hours) input current signal, corresponding with a 12 hours solar day irradiance pattern of 5000 Wh/m^2 per day (t=time in hours):

$$I_{DC\ Supply} f(t) = \frac{Irradiance\ f(t)}{C_{irradiance\ to\ current}}$$

$$Irradiance\ f(t) = 0.2894t^4 - 6.9456t^3 + 32.65t^2 + 108.292t + 0.06244$$

$$C_{irradiance\ to\ current} = \frac{1000}{I_{max}}$$

iv) Apply the following current signal to the refrigerator

Time [hours]	Input signal	Remark
0 - 12	$I_{DC\ supply}$ *f(t)* in [A]	Stabilization phase
12-24	0	Stabilization phase
24-36	$I_{DC\ supply}$ *f(t)* in [A]	Testing phase
36-48	0	Testing phase

f) OPTION 3: For a weak-grid refrigerator, apply the following input voltage procedure:

i) the rated input voltage level as specified in the pull down test.

ii) Apply the following current signal to the refrigerator, ensuring a daily 10 hours power outage (See Annex C for background information).

Time [hours]	Input signal	Remark
0 - 14	Input voltage [V]	Stabilization phase
14-24	0	Stabilization phase
24-38	Input voltage [V]	Testing phase
38-48	0	Testing phase

g) Follow the energy consumption procedure described in IEC 62552-3:2015 taking into account a target compartment temperature of +4.0°C or +8.0°C. For this test, several tests using different temperature control settings are conducted to obtain values of energy consumption measurement and multiples values for interpolation calculation to estimate the energy consumption for a point where all compartments are at exactly +4°C or +8.0°C. Reference IEC 62552: 2015, part 3, Annex I (Worked examples of energy consumption calculations), section I.3.2.2 (Single compartment example) for detailed calculation methodology.

5.6 Temperature performance

a) The test determines the ability to achieve compartment temperatures between 0.0 and 4.0°C for a fresh food compartment and temperature between 4.0 and 8.0°c for an 8°C compartment.

b) Set the test chamber ambient temperature to 43°C.

c) Ensure than any internal thermal and/or electrical battery is fully loaded.

d) Apply procedure 5.5 d), e) or f), depending on the type of refrigerator.

e) Determine the average compartment temperature over 24 hours and the corresponding daily energy consumption.

5.7 Over-voltage test

a) The test verifies whether the product is able to perform and function normally at high input voltage operation.

b) Check for the presence of a high voltage protection device and record the voltage at which this is designed to be triggered.

c) If the high voltage protection device is present, verify whether this device is functioning.

d) Increase the power supply voltage to 20% higher than the maximum rated voltage[1]. Note that this verification is not required in case the high voltage protection device switches off the refrigerator at a value lower than voltage level required for this test.

e) Check whether the product is in a functional condition at this raised voltage.

5.8 Under-voltage test

a) The test verifies whether the product is able to perform and function normally at low input voltage operation.

b) Check for the presence of a low voltage protection device and record the voltage at which this is designed to be triggered.

c) If the low voltage protection device is present, verify whether this device is functioning

d) Decrease the power supply voltage to 10% lower than the minimum rated voltage[2]. Note that this verification is not required in case the low voltage protection device switches off the refrigerator at a value higher than voltage level required for this test.

e) Check whether the sample is in functional condition at this low voltage.

5.9 Load processing test (not for refrigerators with integrated thermal or electrical battery)

a) Set the test chamber ambient temperature to 32 °C, stabilize the 500ml PET bottles with a water content corresponding with 12 grams water per litre of fresh food volume.

b) Operate the refrigerator applying the input voltage prescribed in the pull down test.

c) Apply the procedure described in IEC 62552-3:2015, Annex G, taking into account a reference compartment temperature before the start of the test of +4.0°C ± 2.0°C for a fresh food compartment or +8.0 ± 2.0°C for an 8°C compartment.

d) Once specified conditions are met, the door of the unfrozen food compartment is opened for a specified time and the water bottles placed in their specified positions. A recommended time for door opening and for door closing is 2,5 s, leaving 55 s to load, as described in IEC 62552-3:2015, Annex G.

[1] Example: In case the input voltage range is 12 – 24V, the over voltage test will be performed at 1.2 x 24V = 28.8V

[2] Example: In case the input voltage range is 12 – 24V, the under voltage test will be performed at 0.9 x 12V = 10.8V

e) Determine the additional energy caused by the loading of the bottles ΔE additional energy in [Wh].

f) Determine the additional energy consumption ΔE in Wh/litres to +4.0 or +8.0°C ($T_{reference}$) with the following formula:

$$\Delta E = \frac{\frac{\Delta E_{additional\ energy}(32 - T_{reference})}{(32 - T_{compartment})}}{M_{total\ water\ bottles}}$$

5.10 Autonomy test

a) Load the appliance as per the load processing test.

b) Set the test chamber ambient temperature to 32°C.

c) For refrigerators that have an integrated thermal and/or electrical battery, make sure the battery is fully loaded and allow the refrigerator to stabilise and then operate normally for 2 hours with an average fresh food temperature of +4.0°C or lower or an 8°C compartment of +8.0°C or lower.

d) Switch off the power supply and record the times

i) From +4.0 to +12.0°C for a fresh food compartment or from +8.0 to +16.0°C for an 8°C compartment.

ii) Until any thermal battery is depleted.

iii) Until any electrical battery is depleted.

5.11 Freezing test (for refrigerator-freezers only)

a) 500 ml test water bottles shall be prepared in accordance with Annex G – IEC 62552 -3- 2015, taking 3.5 litres of water / 100 liters frozen food compartment, with a minimum of 0.5 litres, rounded to 0.5 litres. For each bottle a temperature sensor is placed at the outside surface of the bottle.

b) Set the test chamber ambient temperature to 32 °C and stabilize the water bottles to the temperature.

c) Operate the refrigerator applying the input voltage prescribed in the pull down test.

d) Ensure that any internal battery is fully loaded.

e) Allow the refrigerator to operate normally for 2 hours with an average fresh food temperature of +4.0°C or lower or an 8°C compartment of +8.0°C or lower.

f) Load the water bottles into the freezer compartment and record the elapsed time until average the average bottle temperature becomes -6, -12 and -18°C, if possible.

5.12 Testing overview table

Test / Evaluation	Ambient Temperature	Ambient relative humidity	Target Temperature	Test load
Quality Inspection	N.A.	N.A.	N.A.	N.A.
Volume measurement	N.A.	N.A.	N.A.	N.A.
Maximum current	N.A.	N.A.	N.A.	Empty
Pull down	+32°C	≤75%	8.0°C	Empty
Energy consumption	+32°C	≤75%	4.0°C (*) 8.0°C (**)	Empty
Temperature	+43°C	≤75%	0.0 - 4.0°C (*) 4.0 - 8.0°C (**)	Empty
Under/Over voltage	N.A.	N.A	N.A	Empty
Load processing	+32°C	≤75%	4.0°C ± 2.0 (*) 8.0°C ± 2.0 (**)	500 ml water bottles
Autonomy	+32°C	≤75%	4.0°C ± 2.0 (*) 8.0°C ± 2.0 (**)	500 ml water bottles
Freezing test	+32°C	≤75%	4.0°C ± 2.0 (*) 8.0°C ± 2.0 (**)	500 ml water bottles

(*) Fresh food compartment

(**) 8°C compartment

Annex A: Quality inspection checklist

Use the checklist below to document observations and results of quality inspection.

General Product Information

Sample model	
Legal manufacturer or reseller	
Product Type/Description	
Country of Origin	
Conformity assessment rating	
Serial number	
Height [cm]	
Width [cm]	
Depth [cm]	
Weight [kg]	
Power supply type [AC or DC]	
Rated voltage range [V]	
Rated power range [W]	
Rated current [I]	
Rated frequency (if product is AC)	
Rated volume unfrozen food compartment [litres]	
Rated volume freezer compartment [litres]	
Climate class declared	
Rated temperature range unfrozen food compartment	
Rated temperature range frozen food compartment	

Refrigerant	
Total mass of Refrigerant	
Compressor model	

Product Photographs

Picture of the sample with the door(s) closed	
Picture of the refrigerator with the door(s) open	
Left side picture	
Back side picture	
Right side picture	
Picture of the rating plate	
Picture of controller or control display	
Warmest setting possible fresh food	
Coldest setting possible fresh food	
Picture of compressor compartment	
Picture of condenser	
Picture of sample damage (*if applicable*)	
Transport packaging	

Quality Assessment

In this section, the quality assessment is rated based on poor, fair, and good based on the following criteria.

No.	Aspect	Poor	Fair	Good
1	Quality related evaluation	Substantially worse compared to general products (conventional and off grid) present on the market	Corresponding to general products present on the market	Substantially better compared to general products present on the market
2	Risk of human accidents	High	Low	No risk
3	Risk of appliance damage	High	Low	No risk
4	Risk of decreased appliance lifetime	High	Low	No risk
5	Risk of inferior performance	High	Low	No risk
6	Key information (user manual)	Missing	Limited available	Present

Packaging

Wooden box used	[yes/no]
Carton box used	[yes/no]
Proper protection material used inside carton box (eg. PS)	[yes/no
Plastic foil used around the refrigerator to protect the sample from liquid ingress	[yes/no]
Pallet used	[yes/no]
Refrigerator package mounted fixed on a pallet	[yes/no]
Refrigerator mounted on a pallet avoiding tumbling risk	[yes/no]
Loose components such a shelves and basket protected from movement inside the cooler	[yes/no]
Proper transport signs on shipment package applied	[yes/no]
Remarks	
Relevant aspects defining the score	
Score	**[Poor / Fair / Good]**

Product Marking[3]

Appliance marked with rated voltage of rated voltage range	[yes/no]
Appliance marked with the nature of supply (AC or DC) unless the rated frequency is present	[yes/no]
Appliance marked with rated power in Watts or rated current in Amperes	[yes/no]
Appliance marked with the name, trade mark or identification mark of the manufacturer or responsible vendor	[yes/no]
Appliance marked with the number according to degree of protection against ingress of water, other than IPX0	[yes/no]
Appliances which can be mains and battery operated, marked with the battery voltage	[yes/no]
Appliance marked with caution “RISK OF FIRE” (only applicable for flammable refrigerants and flammable blowing agents)	[yes/no]
Remarks	
Relevant aspects defining the score	
Score	**[Poor / Fair / Good]**

[3] Referencing requirements in IEC 60335-1 and IEC 60335-2-24

Assessment of User Manual

Operation manual included		[yes/no]
Language	Instruction in English	[yes/no]
	Other language(s) used	[list all languages]
Instructions on Installation	Unpacking	[yes/no]
	Door removal, levelling, and alignment	[yes/no]
	Rear condenser vane required between the sample and the back wall described	[yes/no]
	Handle installation and removal	[yes/no]
	Explanation of door lock	[yes/no]
	Location Requirements	[yes/no]
	Electrical Requirements	[yes/no]
	Additional requirements for compression type of refrigerators using flammable refrigerants according IEC 60335-2-24, 7.12	[yes/no]
Instruction on Product Use	Instructions on using the controls	[yes/no]
	Switching on procedure	[yes/no]
	Switching off procedure	[Yes/no]
	Cooling down time	[yes/no]
	Use of temperature controller	[yes/no]
	Indication lights and other displays	[yes/no]
	Connection to power source	[yes/no]
	Compatibility with solar systems	[yes/no]
Maintenance and cleaning	Cleaning the interior	[yes/no]
	Cleaning the condenser	[yes/no]

	Defrosting the evaporator	[yes/no]
	Changing the internal lighting[4]	[yes/no]
	Preventive maintenance checks	[yes/no]
Diagnostic / repair procedures		[yes/no]
Disposal / recovery / recycle procedure		[yes/no]
Remarks		
Relevant aspects defining the score		
Score		**[Poor / Fair / Good]**

[4] Remark IEC 60335-2-24, 7.12

User safety assessment

Internal lighting switches on when the door is open	[yes/no]
Outside finishing sharp edges[5]	[yes/no]
Fan(s) protected with protection grid	[yes/no]
Power switch accessible to the user without tools	[yes/no]
Power switch protected from accidental changes in position	[yes/no]
Grounding present (for AC only)	[yes/no]
Pull relief main supply plug present	[yes/no]
Decent electrical cable finishing	[yes/no]
Electrical scheme present on the cabinet	[yes/no]
Remarks	
Relevant aspects defining the score	
Score	**[Poor / Fair / Good]**

[5] IEC 60335-1, 22.14: Appliances shall have no ragged or sharp edges, other then those necessary for the function of the appliance that could create a hazard for the user in normal use or during user maintenance

Assessment of design and durability

Refrigerator Housing (door excluded)	Robustness of refrigerator housing	
	Robustness of wheels	
	Remarks	
	Relevant aspects defining the score	
Refrigerator housing Score		**[Poor / Fair / Good]**
Cooling System	Refrigerant tubes decently mounted and soldered	
	Compressor suction and discharge tubes mounted flexible to reduce the risk of tube leakages due to compressor vibrations	
	Mounting quality of the compressor	
	Remarks	
	Relevant aspects defining the score	
Cooling System Score		**[Poor / Fair / Good]**
Door	Robustness of door hinge	
	Robustness of door handle	
	Door sealing quality	
	Door opening side adjustable	
	Door mounted flush	
	Remarks	
	Relevant aspects defining the score	
Door Score		**[Poor / Fair / Good]**
General Design and Durability remarks		
General Design and Durability score		[Poor / Fair / Good]

Assessment of Serviceability and Maintenance

Maintenance and cleaning	Cleaning the cabinet	
	Cleaning the condenser	
	Defrosting the evaporator	
	Changing the internal lighting[6]	
	Diagnostic / repair procedures	
	Spare parts list	
	Preventive maintenance checks	
Serviceability evaluation	Replacing the door lock	
	Replacing compressor	
	Replacing the condenser fan	
	Replacing the evaporator fan	
Remarks		
Score		**[Poor / Fair / Good]**

[6] Remark IEC 60335-2-24, 7.12

Environmental impact considerations

Refrigerator designed for safe and easy disassembly and disposal i.e. could a trained professional with limited set of tool disassemble the product?	
Thermal insulation blowing agent complies with Montreal Protocol requirements	
Lead (except in batteries), mercury, cadmium, hexavalent chromium, polybrominated biphenyls (PBB) or polybrominated biphenyl ethers (PBDE) present	
Remarks	
Score	**[Poor / Fair / Good]**

Annex B: Background information related to solar irradiance patterns

The graph presents irradiance patterns used in international standards as well as the assumed LEAP 2019 irradiance curve.

The standards used are:

- IEC 62257-9-5 Integrated systems - Laboratory evaluation of standalone renewable energy products for rural electrification ; being a 7 hours step pattern, with a maximum peak value of 1000 W/m^2 and a daily irradiance of 5000 W/m^2
- WHO/PQS/E003/RF05-VP.4; Refrigerator or combined refrigerator and waterpack referring to IEC 62124 Photovoltaic (PV) stand alone systems - Design verification; being a 12 hours step pattern, with a maximum peak value of 700 W/m^2 and a daily irradiance of 6000 W/m2

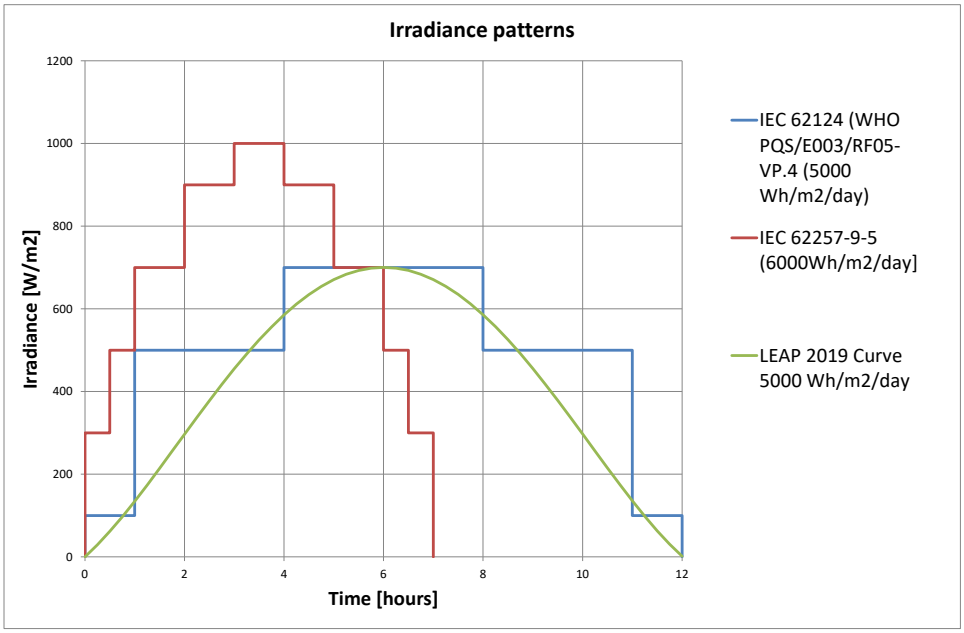

Figure 1; Irradiance curves

The irradiance LEAP 2019 curve is based on the following improvements / assumptions:

- A 12 hours stepless curve is used, which a more representative to real life
- The daily irradiance of 5000 W/m2 is used, see figure 2 the representative regions subjective to this value (= 5.0 kWh/m^2 in Figure 2).
- A maximum peak irradiance value of 700 W/m^2.
- The maximum input current rated on the refrigerator corresponds with a peak irradiance value of 1000 W/m^2

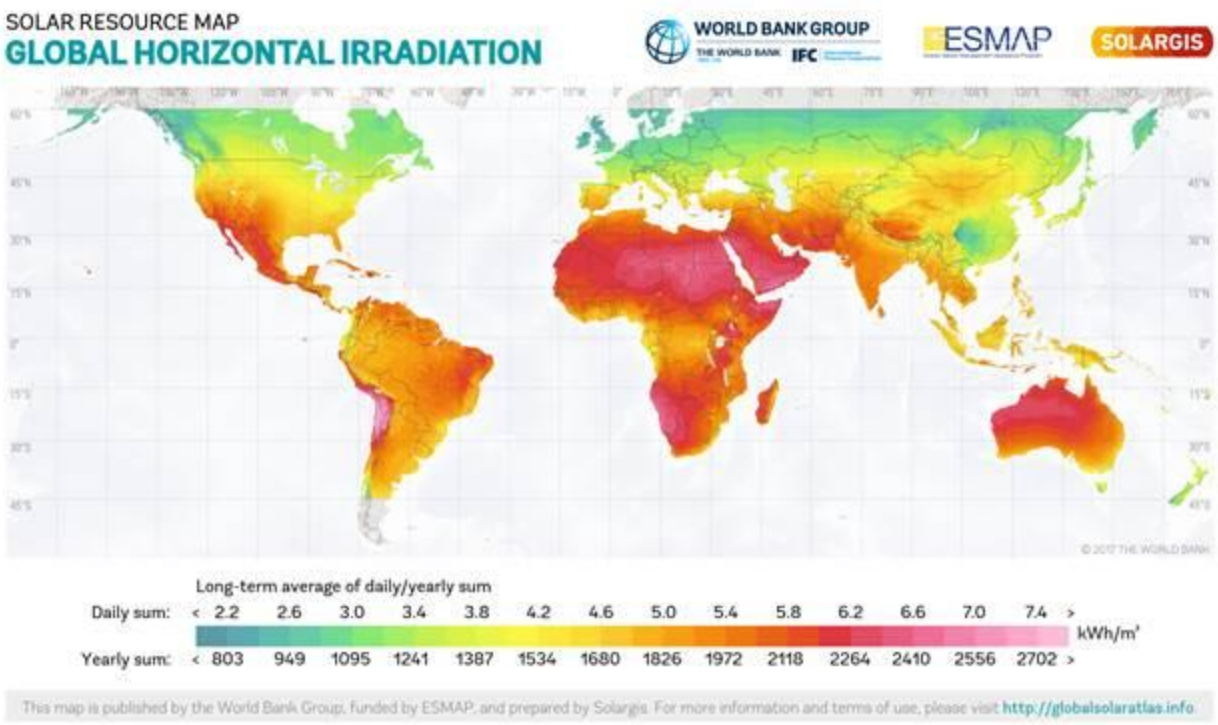

Figure 2; Global irradiance levels

Annex C: Background information related to power outages in sub-Saharan African countries

The graph provides information about the average duration and average number of power outages in Sub-Saharan African countries.

Source: World Bank group, Enterprise surveys:

http://www.enterprisesurveys.org/data/exploretopics/infrastructure#sub-saharan-africa