SINDH SOLAR ENERGY PROJECT: COMPONENT 3

TECHNICAL REQUIREMENTS FOR SHS INSTALLATIONS

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1. INTRODUCTION

1.1 This document forms part of the "Grant Agreement for Supply of Solar Home Systems" signed between Sindh Energy Department ("First Party") and a number of private supply firms (referred to as the "Second Party" in each Agreement) under Component 3 of the Sindh Solar Energy Project (the "Project"). It describes the technical requirements that solar home systems (SHSs) must meet to qualify for grant payments under the Project. These technical requirements include:

- Product eligibility criteria;
- System configuration minimum requirements;
- Minimum performance requirements.

1.2 Quality requirements for SHSs set a baseline level of quality, durability, and truth in advertising to protect consumers. SHSs covered by these quality requirements must meet the eligibility criteria below.

Conformance with these quality requirements is evaluated based on results from laboratory testing according to the Quality Test Method (QTM) in the latest edition of the International Electrotechnical Commission (IEC) Technical Specification 62257-9-5. The tests shall be conducted at a third-party test center that is ISO 17025 accredited to test according to IEC TS 62257-9-5. Laboratory testing shall be done using randomly procured samples, as described in IEC TS 62257-9-5. Test results are valid for a period of two years, after which renewal testing according to IEC TS 62257-9-5 must be conducted for a product to maintain its status as compliant with these quality requirements.

1.3 This document may be revised from periodically, in line with the procedures outlined in the Grant Agreement. The requirements outlined in this document shall apply from the date of issuance for all SHS installations carried out on and after this date and shall supersede all prior versions of this document.

1.4 This document may be revised from time to time, in line with the procedures outlined in the Grant Agreement. The general procedures outlined in this document shall apply from the date of issuance for all SHS installations carried out on or after this date and shall supersede all prior versions of this document.

2. PRODUCT ELIGIBILITY CRITERIA

2.1 All components required to provide basic energy services are installed as a kit:

- PV module(s) (with appropriate panel stand to ensure safety and high efficiency of PV module), charge control unit(s), battery/batteries
- Cables, switches, connectors, and protective devices sufficient to connect the PV module(s), charge control unit(s) and battery/batteries
- Loads (optional): Lighting and requisite cables, load adapter cables (e.g., for mobile phones), and other appliances (dc fan) and their requisite cables

2.2 The PV module's maximum power point voltage and the working voltage of any other components in the kit shall not exceed 35 V DC.

2.3 Only DC systems, outputs, and loads are covered. No inverters, systems with AC outputs/outlets, or AC appliances are eligible.

2.4 The peak power rating of the PV module shall be less than or up to 350 watts.

2.5 No design expertise is required to choose appropriate system components. All electrical connections, except for permanent connections made at the time of installation, can be made without the use of tools. Installation and operation instructions should be presented using language and graphics that can be understood by the typical consumer.

3. MINIMUM REQUIREMENTS: SYSTEM CONFIGURATION & PERFORMANCE

3.1 Qualifying SHSs must provide lighting, ventilation (air circulation) and mobile phone charging, at a minimum. Products that include appliances in addition to the items described in the table below must also meet the minimum system configuration requirements.

3.2 The following table describes the minimum system configuration, specifications and performance for each type of required energy service. Laboratory testing according to IEC TS 62257-9-5:2018 shall be conducted on this minimum system configuration (lighting, ventilation/air circulation and mobile phone charging) to validate that the minimum performance requirements are met by the system after one day of solar charging.

Table 1: Minimum system requirements for each energy service

Category	Minimum Specifications	Minimum Performance	Remarks
Lighting	System includes at least three (3) fixed light points intended for indoor use. Cables connecting light points to other system components must be at least 5 m in length	After one day of solar charging, system capable of providing at least 1680 lumen-hours per solar day of lighting service (when used in combination with DC fan and smartphone charging)	Daily energy services estimated based on daily solar insolation of 5 kWh/m^2, according to test methods specified in IEC TS 62257-9-5.
Ventilation/air circulation	System includes at least one (1) DC fan (table, pedestal or ceiling) that has a metal body and base	After one day of solar charging, system capable of powering included DC fan for at least 8 hours per day Minimum service value for DC fans: - Pedestal: 2.27 m3/min/W +/- 5% - Table: 2.8 m3/min/W +/- 5% - Ceiling: 6.66 m3/min/W +/- 5% (when used in combination with lighting and smartphone charging)	DC pedestal and table fan combination solar run time and air flow measured while in oscillating mode.
Mobile Phone Charging	System capable of charging common models of basic mobile phones and smartphones.	After one day of solar charging, system capable of charging at least one smartphone per day	Smartphone energy demand assumed to be 5.7 Wh.

		(when used in combination with lighting and ventilation/air circulation)	

Table 2: Quality requirements for SHSs

Category *[refer to 6.1 – 6.5]*	**Metric**	**Quality Requirement**	**Remarks**
Truth in Advertising	Manufacturer, Product Name and Model No.	Accurately specified	
	Performance Claims: Light Output, Run Time, Appliance Power Consumption	If reported, accurately specified **[refer to 6.6 – 6.8]**. If there are both pay-as-you-go (PAYG) and non-PAYG versions of a product, each must be truthfully advertised with respect to energy services provided.	
	Lamp Type, PV Power, Battery Capacity, Charger Rating, dc fan power rating, other Aspects	PV power must be accurately reported on the product packaging. All other aspects, if reported, must be accurately specified.	
	Fee-for-service or Pay-as-you-go (PAYG) metering	The PAYG system should be capable of accurately metering service to customers so they reliably get the service that is paid for.	
	Ports	Port voltage and current specifications, if provided, must be accurate. Included appliances must function when connected to SHSs ports. Power	

		output of ports must be sufficient to power appliances that are advertised but not included. Specific guidelines for USB and 12 V and 5 V ports are below **[refer to 6.10 – 6.20]**. Ports of included appliances are not required to meet this standard.	
	Functionality **[refer to 6.9]**	All advertised features must be functional. Any description of the product that appears on the packaging, inside the package and in any other medium (internet, etc.) should be truthful and accurate. No statements should mislead buyers or end users about the features or utility of the product. Any user interfaces (charge indicators, SOC estimates, etc.) must be accurate.	
Lumen Maintenance	Lumen Maintenance at 2,000 Hours	Average relative light output of 4 tested samples ≥ 90% of initial light output at 2,000 hours with only one sample allowed to fall below 85% OR All samples maintain ≥ 95% of light output at 1,000 hours **[refer to 6.21 – 6.22]**. If an included lighting appliance provides ≥15 lumens, it is subject to the lumen maintenance standard.	
Health and Safety	Circuit and Overload Protection	The system must pass an overcurrent and an overload protection test. Products must include a current limiting mechanism to prevent irreversible damage to the system. The mechanism must be easily resettable or replaceable by the user, or must automatically reset. If replaceable fuses are used for circuit protection, sizes must be labeled on	

		the device and listed in the user manual, and, if fuses are replaceable by the user, at least one spare fuse must be included with the product. Included appliances are not required to meet this standard unless they have ports that are intended to provide power.	
	AC-DC Charger Safety	Any *included* AC-DC charger carries approval from a recognized consumer electronics safety certification organization. (Approved marks: UL, CE, TÜV, CCC, or similar, with accompanying valid documentation of testing by an accredited test laboratory.)	
	Wiring and Connector Safety	Wires, cables and connectors must be appropriately sized for the expected current and voltage[1].	

[1] This includes that all external cords provided with the product must be capable of carrying the electric currents present during normal operation without exceeding 50 °C ± 3 °C (measured at 25 °C ± 3 °C ambient temperature). This quality requirement is primarily assessed using a declaration from the manufacturer.

	DC Fan	Meets IEC 60879:1986 & IEC 60335 standards	
	Hazardous Substances Ban	No battery may contain cadmium or mercury at levels greater than trace amounts (<0.0005% Hg and <0.002% Cd by weight in accordance with the EU Battery Directive)	
Battery	Battery Protection	All 4 tested samples are protected by an appropriate charge controller that prolongs battery life and protects the safety of the user **[refer to 6.23 – 6.25]**. Lithium um batteries must additionally carry UN 38.3 certification and have overcharge protection for individual cells or sets of parallel-connected cells. Batteries of included appliances must also meet this standard. For PAYG systems, appropriate battery protection must remain active regardless of whether the system is in an enabled or disabled state. To avoid damage to a battery during long-term periods of non-payment disabled system status, the solar module must be able to charge the battery even if the product is in a disabled state.	
	Battery Durability	The average capacity loss of 4 tested samples must not exceed 25% and only one sample may have a capacity loss greater than 35% following the	

		battery durability storage test[2]. If an included lighting appliance provides ≥15 lumens, it is subject to the battery durability standard. All other included appliances are not required to meet this standard.	
Quality and Durability ***[refer to 6.26 – 6.27]***	PV Overvoltage Protection	If the battery is disconnected or isolated, the system must not be damaged, and the load terminals will maintain a voltage that is safe for their intended uses.	
	Miswiring Protection	The user interface should be designed to minimize the likelihood of making improper connections. If improper or reversed connections can easily be made, they should cause no damage to the system or harm to the user.	
	Physical Ingress Protection (for components containing electronics or electrical connections)	Fixed Outdoor Components	IP5x
		All PV Modules	IP3x OR IP2x with circuit protection
		All Other Components	IP2x
	Water Protection **[refer to 6.28]**	Fixed Outdoor Components	Permanent outdoor exposure: *IPx5 OR IPx3 with circuit protection*

[2] The battery durability storage test requirement may be waived for flooded lead acid batteries which are shipped dry. In cases where batteries are shipped dry, manufacturers must provide the test labs with an adequate amount of the appropriate electrolyte solution or accurately specify the density and composition of the solution to be used.

	(for components containing electronics or electrical connections)	All PV Modules	Outdoor rooftop installation: *Modified IPx4 OR circuit protection*
		Portable Integrated Components	Frequent rain, which requires meeting one of: *1) IPx3* *2) IPx1 + technical protection* *3) IPx1 + warning label* *4) Technical protection + warning label*
		Portable Separate Components	Occasional rain: *IPx1 OR technical protection OR warning label*
		Fixed Indoor Components	No requirement
	Switch, Gooseneck, Moving Parts, and Connector Durability	Mechanisms expected to be used regularly	All 4 tested samples and any included appliances are functional after 1000 cycles
		Mechanisms expected to be used primarily during installation[i]	All 4 tested samples and any included appliances are functional after 100 cycles
	Stain Relief	All cables on all tested samples and any included appliances must pass a strain relief test.	

	Drop Test	Portable Components	Portable lighting components: all 4 tested samples are functional after drop test (1 m onto concrete on six faces); none result in dangerous failures.[3] Non-lighting portable appliances (such as fans and lights with light output below 15 lumens): 3 out of 4 samples are functional following a modified drop test requiring only 2 drops per sample rather than the standard 6 drops; none result in dangerous failures. The sides on which the product is dropped will be alternated between samples to ensure that all six sides are dropped at least once.
		Fixed Indoor and Outdoor Components	No requirement
	Soldering and Electronics Quality	The system and any included appliances must be rated "Good" or "Fair" for workmanship quality as defined in Annex F of IEC TS 62257-9-5. At most,	

[3] Dangerous failures are defined as those which may expose the user to physical harm, such as harmful chemicals, heat (e.g., from an electrical short or fire), or sharp materials (e.g. broken glass).

		one sample may fail to function when initially evaluated.	
	Cable Specifications	Cables must be at least 3 m long when connecting a "fixed indoor" or "portable separate" component to the PV module or any other fixed outdoor component. Any outdoor cables must be outdoor-rated and UV resistant.	
Consumer Information **[refer to 6.29 – 6.34]**	User Manual	User manual must present instructions for installation, use, and troubleshooting of the system. Installation instructions must include appropriate placement and installation of the PV module. Basic electrical safety and system maintenance must also be covered. Installation and operation instructions should be presented using language and graphics that can be understood by the typical consumer.	
	Component Specifications and Replacement Methods	Consumer information must provide either: specifications for components that may require replacement (fuses, lights, PV, batteries) and instructions for replacement, OR directions as to how the consumer can get components, including the battery, replaced at service centers, both during and post warranty, OR	

		a clear consumer-facing statement that the batteries and other components are not replaceable. Detailed instructions or descriptions regarding replacing components may be included in the user manual, but a clear statement regarding the battery replacement must be included on the consumer-facing packaging. Accepted phrases are: Battery is field replaceable Battery may be serviced by manufacturer Battery is not replaceable	
	Minimum Warranty Terms	Accurately specified and consumer-facing; minimum coverage of at least two years for the system and one year for most included appliances. Details are noted below.	

4. WARRANTY REQUIREMENTS

4.1 The minimum warranty period from the time of purchase by the end-user is at least:

- 2 years for the main system, including the PV module, control box, cables and lights and the system battery. (Note that batteries included within appliances are only required to meet the 1-year warranty). The battery warranty is assumed to include a capacity retention figure of at least 80% at two years, benchmarked to the advertised battery capacity and/or the battery capacity presented in the test report, whichever is higher.
- 2 years for all lighting appliances that include their own batteries (including pico-power lights), all non-lighting appliances such as DC fans, USB charging adaptors and similar accessories.

- The warranty must cover, at a minimum, manufacturing defects that impede operation under normal use and protection from early component failure.
- The consumer-facing warranty must explain how the consumer can access the warranty (return to point of purchase/distributor/service centre, call or SMS a number, etc.), how the warranty will be executed (repair, replacement, etc.), and should advise the customer to inquire about the warranty terms prior to purchase.
- The consumer-facing warranty must be available to the consumer in writing in a way that enables the end user to verify and understand the terms of the warranty prior to purchase. The written information should be in a regionally appropriate language. Consumer-facing warranties could be included on the product box, or on a user agreement or warranty card that is easily accessed prior to purchase.

4.2 Note that this is a *minimum* requirement and it is up to the discretion of manufacturers and distribution partners to exceed the basic protection offered in these terms to differentiate their products in the market.

5. ELECTRICAL CONNECTION REQUIREMENTS

5.1 All electrical connections, other than permanently installed connections made at the time of installation, must be made using plug-and-socket connectors without the use of tools.

5.2 Permanently installed connections that are made at the time of installation may be made with screw terminals, spring or lever-actuated terminals, quick disconnect (blade) terminals, or similar methods, provided that the following requirements are met:

- The connection is straightforward to make, provides a good quality electrical connection, and does not require technical expertise to make, such as wrapping wire in a specific direction, soldering, or crimping in the field. For example, the following connections are not eligible (note, this is not a comprehensive list):
  - Alligator (crocodile) clips
  - Connections made in the field that require soldering or crimping

- Screw terminals or binding posts in which the wire is wrapped around the screw and held in place with the screw head or nut, rather than being clamped between two plates or washers. For instance, some binding posts have a hole to insert the wire; in others the wire needs to be wrapped around the post. The latter type requires slightly more care to make a good connection; those that require wrapping the wire are not permitted due to the increased likelihood of the connection being improperly made.
- Twist-on wire connectors (wire nuts) or wires twisted together

- Adequate instructions are provided for making each type of connection, including:
  - A list of all required tools.
  - Sufficient instructions, including illustrations, to make each type of connection so that it will be safe and reliable.
- After installation, all terminals, other than connections on the charge controller, must be insulated so that no live electrical parts can be contacted or must be enclosed in a way that the component would meet IP2x (i.e., a 12.5 mm probe cannot enter the enclosure where the terminals are located). In the case of battery terminals, only one terminal must be insulated.

5.3 Connectors on charge controllers need not be enclosed or insulated but shall be designed in a way to minimize the potential for short-circuiting, such as with plastic dividers.

5.4 Additionally, the leads from the battery to the charge controller and PV module to the charge controller must have short circuit protection which will be assessed by inspection. This protection should be located as close to the battery or PV module as practical.

5.5 Overcurrent protection for the PV module or array shall meet the requirements of IEC 60364-7-712:712.43 unless all of the following criteria are met:

- The potential maximum current from all sources (the entire array) does not exceed the ampacity of the conductors.
- The inverter or battery is incapable of back-feeding power to the array.
- The array has no more than two identical modules (or series-connected strings of identical modules) wired in parallel.

5.6 All terminals for loads are considered ports and are subject to the ports and protection tests, which include the overcurrent protection and PV overvoltage. The entire product is subject to the miss wiring test.

- Adequate strain relief shall be provided for all screw terminal connections. The method for providing strain relief shall be clearly described in the installation instructions and, if any equipment or devices are required, these shall be included with the kit. Easily disconnected terminals, like blade terminals, are only permissible if enclosed in a way that the consumer cannot easily access the terminals.
- A means is provided and described in the instructions to identify wires or cables in order to avoid incorrect connections (e.g., colour coding or labelling of wires).

- Any required tools other than commonly available tools (e.g. flat or Phillips screwdrivers, pliers, wire cutters, manual wire strippers) shall be included with the kit. Alternatively, for SHSs that are exclusively installed by the company's trained and authorized technicians, tools need not be included in the kit, but documentation shall be submitted confirming that the necessary tools are supplied to the installing technicians.
- All required materials (e.g. wire and terminals) are provided with the kit, supplied to the installing technician, or adequately specified to allow the installer to select the correct materials to make the connection. Note, for most kits, the required wire shall be included with the kit. For systems that are exclusively installed by the company's trained and authorized technicians, wire need not be included and sold with each kit. If wire is not included with the kit, the company shall provide a sufficient sample of the wire they provide to their installers for testing; the length of the sample may be specified by the test lab and must be of sufficient length to perform all of the required tests. The wire shall be accompanied by a declaration stating that the sample is representative of the wire used in the field and that the wire is appropriately sized for the system. The declaration and user or installation manual shall also specify the wire type and maximum distance for all wires in the system. The testing laboratory shall test the product using the minimum distance of wire for the lumen maintenance test and the maximum distance of wire for all other tests in IEC/TS 62257-9-5.
- All connectors or terminals shall be appropriate for the wire type and size, number of wires, current, voltage, and installation location. If terminals are for indoor use only, this limitation shall be clearly indicated in the installation instructions. Connectors shall be used within their design limits. The company is required to provide specifications for connectors from the connector manufacturer upon request.[ii]

5.7 NOTE: In most cases, these connections are not considered to be "sensitive electronics," and therefore the physical and water ingress protection requirements according to IEC/TS 62257-9-5 are as follows:

- For connectors in junction boxes on the back of PV modules: IP3x, or IP2x with technical protection
- For connectors permanently installed outdoors: IP55
- For connectors used indoors: no protection necessary (IP00)

6. FURTHER NOTES

6.1 If a sample fails on any aspect at any point during testing, even if not during the specific test used to evaluate that aspect, the sample will still fail on the basis of that aspect. For example, if a switch stops functioning on a sample while its luminous flux is being measured, the product would fail for functionality.

6.2 Numeric aspects, such as light output and run time, must deviate no more than 15% from advertised ratings (though it is always acceptable if actual performance is better than advertised). If a range is provided, the best rating must be within the 15% tolerance. If a run time is advertised, it is assumed

to be for solar run time and for the highest setting, e.g., brightest, unless otherwise stated. All advertised features shall be functional. Any description of the product that appears on the packaging, inside the package, and in any other medium (internet, etc.) should be truthful and accurate. No statements should mislead buyers or end users about the features or utility of the product.

6.3 Light distribution must only be measured for two samples to determine the full-width-half-max (FWHM) angle.

6.4 Included appliances are subject to truth-in-advertising requirements for performance claims. Relevant tests include: light output, battery capacity, power consumption, and the full-battery and solar run time. Existing performance test results for non-lighting appliances (such as TV power consumption from Global LEAP testing) may be referenced in place of additional testing. Only lights brighter than 15 lumens are required to be assessed for light output and light distribution.

6.5 Advertising regarding physical and water ingress protection shall be evaluated in relation to equivalent ingress protection (IP) ratings. If a product advertises an IP rating of IP54 or higher, the manufacturer must provide documentation of meeting that IP rating based on test results from an accredited laboratory. The following common advertising terms are expected to meet the following IP levels:

- IPX7: Waterproof, or similar
- IPX4: Splash proof, or similar
- IPX3: Rainproof, protected from heavy rain, or similar
- IPX1: Water resistant, splash resistant, rated for outdoor use, or similar
- IP5X: Dustproof, protected from dust, or similar
- Note, advertisements cannot supersede the basic IP requirements by component form factor described in these quality requirements.

TRUTH-IN-ADVERTISING REQUIREMENTS FOR PORTS

6.6 Advertised port voltage ranges are subject to truth-in-advertising requirements.

6.7 The measured values shall not fall more than 0.1 V outside of the advertised range for a 12 V port or more than 0.05 V outside of the advertised range for a 5 V port, except that the voltage may fall below the lower limit at th e low-battery voltage.

6.8 Any port power and current specifications, if provided, shall be accurate. If a current or power range is advertised in association with a port, the port shall be able to provide within 5% of the advertised rating at the typical battery discharge voltage. The current and power ratings are evaluated using the average measured value across all samples. Power output of ports shall be sufficient to power appliances that are advertised but not included.

FUNCTIONALITY REQUIREMENTS

6.9 Included appliances shall function when connected to ports and shall not be damaged or present a safety hazard over the entire voltage range of the port as assessed in the appliance operating voltage range test or the assessment of DC ports of IEC/TS 62257-9-5. The appliance need not function when the product's battery is at the low-battery voltage if the feature or behavior is

described in the user manual and the description is written in a way that is meaningful to a typical user; for example: "some appliances may not work when the battery is low."

NON-STANDARD CONNECTORS

6.10 Ports with a connector type that is not commonly used for 12 V or 5 V ports need not meet the functionality requirements below, provided that the consumer-facing advertising or documentation states that generic user-supplied or off-the-shelf appliances cannot be used and no adapter that converts the port to a commonly used connector type is included or described. The following receptacle types are not eligible for this exception unless modified so that standard or conventional plugs cannot be inserted:

- Any receptacle type defined by any version of the USB standard;
- A barrel jack of any dimensions;
- A cigarette lighter receptacle.
- 12 V ports
- All ports advertised or reasonably expected to provide 12 V shall maintain a voltage of at least 10.5 V over the advertised current range, or, if no current range is advertised, over the entire tested range of currents. However, port voltages may fall below 10.5 V when the product's battery is at the low-battery voltage if the feature or behaviour is described in the user manual and the description is written in a way that is meaningful to a typical user; for example: "some appliances may not work when the battery is low." At no time shall the port voltage exceed 15 V.

12V PORTS

6.11 Separate current ratings may be specified for functionality and for overcurrent protection. The current rating for functionality shall not be less than the current required to use the advertised appliances and to allow the operation of user-supplied appliances in a manner consistent with the consumer-facing advertising and documentation. For example, consider a 12 V-rated port that can reliably provide 12 V at 3 A and has overcurrent protection that activates at 6 A. In this example, the port cannot sustain 12 V at currents above 3 A, and a typical 12 V, 6 A appliance may not work properly at a reduced voltage. A current rating for this situation could state: "the port can supply 6 A, but some appliances might not function properly if the load exceeds 3 A."

6.12 Ports that would be reasonably expected to provide 12 V, but meet all of the following criteria, need not comply with the lower voltage limit of 10.5 V:

- The port is not a cigarette lighter receptacle.
- One of the following is true:
  - The consumer-facing documentation and advertising materials, including but not limited to the packaging, user manual, and manufacturer's website, do not state that the product can be used with any appliances other than the included lighting appliances or depict such use, or
  - There is a prominent consumer-facing statement on the product box or user agreement clearly stating that the product can be used only with manufacturer-supplied appliances,

whether included or sold separately. No other consumer-facing information may contradict this statement.

6.13 Ports that meet the requirements above need not comply with the upper voltage limit if there is a consumer-facing warning on the packaging or user manual that clearly states that user-supplied appliances can be damaged if connected to the port.

5 V PORTS

6.14 All ports with a USB form factor and all 5 V ports advertised or reasonably expected to be used for mobile phone charging (including barrel plugs) must meet the requirements below. These requirements are based on the USB Battery Charging Specification Revision 1.2 (USB Implementers Forum, 2012), with some modifications to address common charging requirements in the SHSs market. Ports must comply with these default limits unless an acceptable reason and clear justification is presented for the port managing current and voltage in a different manner.

6.15 USB ports shall be able to provide at least 0.5 A at all simulated battery voltages when tested according to IEC/TS 62257-9-5.

6.16 Voltage requirements when the port is operating at a current less than or equal to 0.5 A or the advertised maximum current, whichever is greater:

- Minimum steady-state voltage: 4.5 V at all simulated battery voltages except the low-battery voltage; 4.25 V at the low-battery voltage.
- Maximum steady-state voltage: 5.5 V

6.17 Voltage requirements when the port is operating at a current greater than 0.5 A or the advertised maximum current, whichever is greater:

- No minimum steady-state voltage requirement
- Maximum steady-state voltage: 5.5 V

6.18 Separate current ratings may be specified for functionality and for overcurrent protection. The upper limit above refers to the advertised maximum current for functionality.

6.19 In the special case that a product has at least two USB ports and at least one of these ports meets the voltage requirements for 5 V ports listed above, the other port may be designed to provide a voltage that exceeds 5.5 V. The maximum steady-state voltage of this port must not exceed 6.0 V under any test conditions and must comply with all other 5 V port requirements list above. The user manual must include a description of the difference between the two ports, indicate which port is higher voltage, provide a way to identify each port, and state that not all devices will be compatible with the higher voltage port.

6.20 There are no requirements for dynamic port performance and the dynamic portion of the ports assessment need not be conducted.

LUMEN MAINTENANCE

6.21 The lumen maintenance requirement can be assessed using a 2000-hour test or an expedited method that requires LM80 data for the LEDs. Each of these procedures areas outlined in Annex J of IEC TS 62257-9-5. If the 2000-hour test is used, and the pass/fail determination is made at 1000

hours, the test will continue to complete the 2000 hours with no further verdict. The expedited method includes a 500-hour lumen maintenance test and single point temperature measurements of the LED array. The temperature measurements are compared to IESNA LM80-08 data from the LED manufacturer to determine the lumen maintenance at 2000 hours. For the LM80 method, the average lumen maintenance at 500 hours and the average estimated lumen maintenance at 2000 hours must be ≥ 90% of initial light output, with no more than one sample below 85%.

6.22 For products that undergo 500-hour tests with a sample size of two (n=2) to meet these quality requirements or to renew compliance with these quality requirements, both samples must maintain ≥ 95% of initial light output at 500 hours. If a product fails the 500-hour test, re-testing with 6 samples for the full 2000 hours will be required.

BATTERY PROTECTION

6.23 Table 2 contains default battery deep discharge protection voltages during testing and Table 3 contains default battery overcharge protection voltages and maximum cell temperatures specific to the five common types (i.e., chemistries) of batteries. These default values are used when determining appropriate charge controller behavior, unless alternate appropriate design values are provided by the battery manufacturer for the deep discharge protection voltage cutoff, overcharge protection voltage cutoff or maximum cell temperature. Note that the minimum voltage specification for nickel-based batteries only applies in cases where more than one cell is wired in series.

Table 2. Default battery deep discharge protection voltage specifications

Battery type	**Deep discharge protection voltage (V/cell)**		
	Recommended	Minimum	Maximum
Flooded lead-acid	≥ 1.87	1.82	---
Valve-regulated / Sealed lead-acid	≥ 1.87	1.82	---
Lithium-ion	≥ 3.00	2.95	---
Lithium iron phosphate	≥ 2.50	2.45	---
Nickel-metal hydride	= 1.00	.95	1.10

6.24 The requirement for PAYG products to be able to charge the battery in a disabled state may be waived for products using lithium-based batteries in cases where the product is designed to protect the battery from damage when not charged for extended durations (e.g. up to one year). The design shall also ensure the product can still charge once payment is made and the charging system is re-connected. The preventive measures shall address both the discharge during use and self-discharge of the battery. Allowable exceptions will be determined by Lighting Global based on evidence provided by the product designers.

Table 3. Default battery overcharge protection voltage and temperature specifications

Battery type	Overcharge protection voltage (V/cell)			Maximum charging temperature (°C)
	Recommended	Minimum	Maximum	
Flooded lead-acid	= 2.40	2.35	2.50	45
Valve-regulated / Sealed lead-acid	= 2.40	2.35	2.45	45
Lithium-ion	≤ 4.20	---	4.25	45
Lithium iron phosphate	≤ 3.65	---	3.70	45
Nickel-metal hydride	≤ 1.45	---	1.50	60

6.25 If the product has output ports, the product shall have sufficient protection from PV overvoltage as determined by the PV overvoltage protection test of IEC/TS 62257-9-5. This test is used to verify that if the battery is disconnected or isolated, the system will not be damaged, the PV open-circuit voltage will not be present on load terminals and the load terminals will maintain a voltage that is safe for their intended uses. For ports with a nominal port voltage of 5 V, the allowable port voltage limit shall be 6.0 V, which deviates from the limit listed in IEC/TS 62257-9-5. All other allowable port voltage limits are as listed in IEC/TS 62257-9-5.

QUALITY AND DURABILITY

6.26 All applicable quality and durability standards are extended to PAYG components, such as remote-entry keypads, integrated circuits, and any other hardware systems that are included with the product.

6.27 Some quality and durability requirements may be waived for non-lighting appliances that can be proven to meet other relevant standards. For instance, the following tests may be waived if the manufacturer provides evidence (test report, certification and/or other relevant documentation) showing that the appliance meets an internationally recognized standard for appliance safety, such as IEC 60065 (for TVs and radios) and IEC 60335 (for fans).

- Physical ingress protection,
- Strain relief,
- Switch, gooseneck, moving part, and connector durability,
- Drop test,
- Battery protection (charge controller)

WATER PROTECTION

6.28 There are two alternative water protection compliance pathways allowed (i.e., these are alternatives to meeting the IP class requirements). In one alternative ("technical equivalent"), the whole system of protection (ingress protection + electronic circuit protection + manufacturing QC) is evaluated to determine if the protection level is equivalent to that of a product with the required level of ingress protection. In another alternative ("warning label") there are clear messages to the consumer about the degree of protection from water.

CONSUMER INFORMATION

6.29 Most switches and connectors are considered to be intended for regular use. Mechanisms expected to be used primarily during installation are limited to only a few cases, such as:

- A safety-disconnect switch or circuit breaker that is turned on after installation and only turned off for maintenance.
- Connectors dedicated to light points that are specifically designed and explicitly stated to be for permanent installation and are not intended to be relocated after installation
- Connections between a light point and an extension cable.

6.30 At a minimum, the operation manual must contain graphical and/or written guidance on the following:

- How to connect the PV module to the unit for charging.
- Instructing the user not to shade the PV module.
- Facing the PV module surface toward sun.
- How to make all required permanent connections.
- How to connect all advertised appliances.
- How to interpret the battery state-of-charge indicator or other instructions related to determining and understanding the battery state-of-charge.
- If any required pre-use steps are necessary for the product to properly function (e.g. fully charge battery before initial use, insert supplied fuse, how to operate the PAYG system), these shall be clearly described.

6.31 If the business model of a company is to exclusively install products using trained and authorized technicians, then the product need not have consumer-facing installation instructions. In this case, the manufacturer shall provide the training manual or instructions given to the technicians, which shall contain the elements listed above. The product shall still include a user manual covering basic operation instructions for the consumer.

6.32 If the consumer information requirement is met by providing Option 1: "specifications for components that may require replacement (fuses, lights, PV, batteries) and instructions for replacement," relevant specifications include the following:

- PV module(s): power, voltage (nominal, open-circuit and maximum power point), current (short circuit and maximum power point). All ratings should specify the conditions of the measurement (e.g., STC or NOCT) and should be included in a user manual or packaging.

Ratings may be included on the module, but they must also be included in the user manual or packaging.

- Battery/batteries: battery chemistry, nominal voltage, and capacity. Specifications must be provided for the main product battery or batteries; specifications for appliance batteries are not required but recommended.
- Main lights: drive voltage, power, and luminous flux (in lumens)
- Fuses: as noted in the "Circuit and Overload Protection" standard, if replaceable fuses are used for circuit protection, sizes must be labeled on the device and listed in the user manual, and, if fuses are replaceable by the user, at least one spare fuse must be included with the product. Included appliances are not required to meet this standard.
- Other appliances: specifications are not required but are recommended.

6.33 Any other specifications necessary for a PV module, battery, light, or fuse to function with the system shall be included in the user manual. The purpose of this option is to enable a user or technician to be able to reasonably find a replacement if a key component of the system fails.

6.34 If the consumer information requirement is met by providing Option 2: "directions as to how the consumer can get components, including the battery, replaced at service centers, both during and post warranty," the information must clearly state that the consumer can still have access to parts, repairs and replacements after the warranty period (these may be made available at a cost).

DC FAN

6.35 DC fans shall have been passed through the following test procedures for the evaluation of product performance:

- A procedure for measuring air delivery, power input, and energy efficiency value adapted from IEC 60879:1986: Performance and Construction of Electric Circulating Fans and Regulators;
- A procedure for inspecting fan blades and guards adapted from IEC 60335-2-80: Household and similar electrical appliances for safety. Particular requirements for fans.

6.36 Test reports along with product brochure for the DC fans shall be provided with the application for product evaluation.

6.37 Additional tests for DC Fan to address off-grid performance/requirements:

- Quality and workmanship inspections
- Voltage fluctuation conditions (±15% of rated voltage)
- Harsh environment exposure conditions (40C ±2°C temperature and 93% ±3% relative humidity)
- Drop test (IEC TS 62257-9-5:2018)
- Visually inspect the product for protection against ingress of solid foreign objects to determine whether the product meets IP20, IP30, and IP40 requirements, in accordance with Clause 13 (Tests for protection against solid foreign objects indicated by the first characteristic numeral) of IEC 60529:1989+AMD1:1999+AMD2:2013 CSV.

7. DECOMMISSIONING AND RECYCLING

7.1 Provide a solar panel mounting frame with all SHS so that the solar panel orientation is not a problem. Battery buy-back or disposal of batteries after end-of-life will be the responsibility of the Second Party.

7.2 Second Party will make necessary efforts to implement an electronic waste (e-waste) management procedure, in particular a strategy for used battery disposal. As a minimum the e-waste management procedure, Second Party will ensure safe collection and safe disposal or recycling of the provided system components once they are no longer in use. In this context safe means that there are no detrimental effects to human beings or to the environment during the stated procedures.

7.3 Qualified SHSs Suppliers will not be allowed to replace old batteries with new ones without collecting the former. A buy-back option can be given to the customer limited to lead acid batteries, which will be collected and transported to designated formal and safe recycling units (e.g. in Karachi and Lahore).

There are two alternative water protection compliance pathways allowed (i.e., these are alternatives to meeting the IP class requirements). In one alternative ("technical equivalent"), the whole system of protection (ingress protection + electronic circuit protection + manufacturing QC) is evaluated to determine if the protection level is equivalent to that of a product with the required level of ingress protection. In another alternative ("warning label") there are clear messages to the consumer about the degree of protection from water