Solar Home System Kit Quality Standards

Version 2.2 September 2017

Lighting Global has expanded to cover solar home system kits. This document describes the Quality Standards for Solar Home System Kits, which set a baseline level of quality, durability, and truth in advertising to protect consumers. Kits covered by these Standards must be "plug-and-play," and meet the eligibility criteria below. [Note, products smaller than 15 W may be evaluated as pico-products under the Pico-PV Quality Standards.] The Quality Standards are presented on the next pages.

Conformance with the Quality Standards is evaluated based on results from laboratory testing according to the Lighting Global Solar Home System Kit Quality Test Method (QTM). The tests are conducted at a third-party, approved test center using randomly-procured samples. Information contained in Lighting Global Standardized Specification Sheets or Spec Books is acceptable for determining conformity with the Quality Standards. Products that have met the Quality Standards are also issued a Verification Letter and posted on the Lighting Global website: www.lightingglobal.org/products.

On-going qualification is subject to successful market checks according to the Market Check Method (see MCM Policy). Renewal testing, equivalent to a primary market check test, is required after two years (see Associate Renewal Policy).

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PRODUCT ELIGIBILITY CRITERIA

1. **All components required to provide basic energy services are sold/installed as a kit:**
   - PV module(s)
   - 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 (TV, fan, radio, etc.) and their requisite cables

   Note that the kit may consist of interchangeable components from a product family. The product family may be eligible for testing according to the Family of Products Policy. See also the Similar Products, Pay-as-you-go, and Co-branding policies.
2. **The PV module maximum power point voltage and the working voltage of any other components in the kit shall not exceed 35 V DC.** AC inputs may exceed this limit.
3. **Only DC systems, outputs, and loads are covered.** No inverters, systems with AC outputs/outlets, or AC appliances are eligible for support through Lighting Global. AC inputs are permitted if the AC charger meets the AC/DC charger safety standard in Table 1.
4. **The peak power rating of the PV module shall be less than or equal to 350 watts.**
5. **Kits must be plug-and-play.** Plug-and-play implies that no design expertise is required to choose appropriate system components and no technicians or electricians are necessary to safely and successfully install and operate the system. All electrical connections 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.

Table 1. Lighting Global Quality Standards for Solar Home System Kits

Category[a]	Metric	Quality Standard
Truth In Advertising	Manufacturer, Product Name and Model No.	Accurately specified
	Performance Claims: Light Output, Run Time, Appliance Power Consumption	If reported, accurately specified.[b] 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, Other Aspects	PV power must be accurately reported on the product packaging. All other aspects, if reported, must be accurately specified.[b]
	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 SHS ports. Power output of ports must be sufficient to power appliances that are advertised but not included. Specific guidelines for USB and 12 V ports are below.[c] Ports of included appliances are not required to meet this standard.
	Functionality	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 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.[d] 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.
	AC-DC Charger Safety	Any *included* AC-DC charger carries approval from a recognized consumer electronics safety certification organization.[e]
	Wiring and Connector Safety	Wires, cables and connectors must be appropriately sized for the expected current and voltage.[f]
	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)

Category[a]	Metric	Quality Standard	
Battery	Battery Protection	All 4 samples are protected by an appropriate charge controller that prolongs battery life and protects the safety of the user.[g] Lithium 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 samples must not exceed 25% and only one sample may have a capacity loss greater than 35% following the battery durability storage test.[h] 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[i,j]	PV Overvoltage Protection	If the battery is disconnected or isolated, the system must not be damaged and PV open-circuit voltage must not be present on load terminals.	
	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[k] (for components containing electronics or electrical connections)	Fixed Outdoor Components	Permanent outdoor exposure: *IPx5 OR IPx3 with circuit protection*
		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 samples and any included appliances are functional after 1000 cycles
		Mechanisms expected to be used primarily during installation[l]	All 4 samples and any included appliances are functional after 100 cycles

Category[a]	Metric	Quality Standard	
	Strain Relief	All cables on 4 samples and any included appliances must pass a strain relief test.	
Quality and Durability Continued[i,j]	Drop Test	Portable Components	Portable lighting components: all 4 samples are functional after drop test (1 m onto concrete on six faces); none result in dangerous failures.[m] Non-lighting portable appliances (such as battery-powered radios, fans, razors 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.[m] 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 the Lighting Global Solar Home System Kit Quality Assurance Protocols. At most, 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. Otherwise, components will be considered "fixed outdoor" or "portable integrated." Any outdoor cables must be outdoor-rated and UV resistant. [n]	
Consumer Information	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.[o]	
	Component Specifications and Replacement Methods	Consumer information must provide either:[p] 1) specifications for components that may require replacement (fuses, lights, PV, batteries) and instructions for replacement, OR 2) directions as to how the consumer can get components, including the battery, replaced at service centers, both during and post warranty, OR 3) 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: 1. Battery is field replaceable 2. Battery may be serviced by manufacturer 3. Battery is not replaceable Similar phrases may be accepted at the discretion of Lighting Global.	
	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.	

Warranty Requirements Details

To meet the Standard, Lighting Global requires that the following guidelines be followed when presenting and offering a warranty:

- 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 must include a capacity retention figure, benchmarked to the advertised battery capacity and/or the battery capacity presented in the Lighting Global test report. The capacity retention figure must be equivalent to or better than "at least 80% capacity at two years."
  - 1 year for all lighting appliances that include their own batteries (including pico-power lights), all non-lighting appliances, 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 center, 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.

Note that this is a *Minimum* Standard 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.

Other Notes

[a] 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, this failure would be included in the count of failures for the switch test.

In certain cases, where products are designed for special applications (e.g., productive uses), certain requirements may be waived, altered, or strengthened at the discretion of Lighting Global. Any deviations from the requirements listed in this document will be noted on the Standardized Specification Sheet and Verification Letter for the product.

[b] 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.

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

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. At the discretion of Lighting Global, 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.

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Advertising regarding physical and water ingress protection is evaluated at the discretion of Lighting Global. 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: Water proof, 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: Dust proof, protected from dust, or similar

Note, advertisements cannot supersede the basic IP requirements by component form factor described in the Quality Standards.

[c] If a current or power range is advertised in association with a port, the port must be able to provide within 5% of the advertised rating at the typical battery discharge voltage. Advertised voltage ranges are subject to truth-in-advertising requirements. Specific requirements for 12 V and 5 V ports are below.

All ports advertised or reasonably expected to provide 12 V must maintain a voltage between 10.5 – 15 V over the advertised current range, or if no current range is advertised, over the entire tested range of currents, though port voltages may fall below 10.5 V at low battery state-of-charge. If a voltage range is advertised for a 12 V port, the measured values must not fall more than 0.1 V outside of the advertised values, but may fall below the lower limit at low battery state-of-charge. In cases where the measured voltage values fall below 10.5 V or the lower limit of the advertised voltage values during periods of low battery state-of-charge, the port and any advertisements must be marked to indicate that the voltage may drop below these limits at low battery state-of-charge and the feature or behavior must be described in the user manual.

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 standards 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 SHS kit 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. Acceptance of alternate management schemes is at the sole discretion of Lighting Global. If a voltage range is advertised for a 5 V port, the measured values must not fall more than 0.05 V outside of the advertised values and meet the requirements below.

- Voltage requirements for sustained current less than or equal to 0.5 A (or less than or equal to the advertised current if the advertised current is higher than 0.5 A):
    - Minimum steady-state voltage: 4.5 V at all simulated battery voltages except the deep discharge protection voltage; 4.25 V at the deep discharge protection voltage.
    - Maximum steady-state voltage: 5.5 V
- Voltage requirements for sustained current greater than 0.5 A (or greater than the advertised current if the advertised current is higher than 0.5 A):
    - No minimum steady-state voltage requirement
    - Maximum steady-state voltage: 5.5 V
- Overshoot/Undershoot requirements:
    - Minimum undershoot voltage: 4.1 V
    - Maximum overshoot voltage: 6.0 V
    - Maximum undershoot time: 10 ms

[d] The lumen maintenance standard 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 the Lighting Global Solar Home System Kit Quality Assurance Protocols. 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

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sample below 85%. The LM80 test is intended as a way to expedite products entering the market and shall not be used for Associate Renewal or Market Check Method tests.

For products that undergo 500-hour tests with a sample size of two (n=2) to qualify for or maintain program support (Associate Renewal, Market Check Method or Accelerated Verification Method tests), 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.

[e] Approved marks: UL, CE, TÜV, CCC, or similar, with accompanying valid documentation of testing by an accredited test laboratory. Detailed guidelines are described in the AC Charger Safety Approval Policy.

[f] 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 Standard is primarily assessed using a declaration from the manufacturer.

[g] 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	0.95	1.10

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	≤ 3.65	--	3.70	45
Nickel-metal hydride	≤ 1.45	--	1.50	60

[h] 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.

[i] 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.

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[j] At the discretion of Lighting Global, 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)

[k] There are two alternative water protection compliance pathways allowed by Lighting Global (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. The warning level messages must meet Lighting Global program guidelines. The pathways and associated guidelines are described in greater detail in a document titled "Integrated Water Protection Assessment." Additional guidance on testing IP requirements for PV modules is in a document titled "Lighting Global Test Methods for Ingress Protection for PV Modules."

[l] 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.

[m] 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).

[n] Requirements for outdoor cables are detailed in the "Lighting Global Solar Home System Testing Policy for Outdoor-rated Cables." Products must comply with the final policy as of March 2017.

[o] 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.
- Any required pre-use steps necessary for the product (e.g. fully charge battery, insert supplied fuse).
- 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.

[p] 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.

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- **Battery(ies):** battery chemistry, nominal voltage, and capacity. Specifications must be provided for the main product battery(ies); 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.

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.

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).

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