

Procurement Handbook for Off- and Weak-grid Appliances

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1.1. Acknowledgement

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VeraSol is a global quality assurance program that strives to make safe, affordable, and durable products the default option in the off-grid solar market. Grounded in rigorous testing and international best practices, VeraSol sets quality standards, promotes high-performing solar technologies, and supports the adoption of harmonized policies. In doing so, we help improve livelihoods for the most vulnerable people in the least developed countries, reduce greenhouse gas emissions, and increase clean energy access for all.

EforA is a global coalition dedicated to advancing high-efficiency appliances to enhance clean energy access for the world's most impoverished communities. Current EforA Coalition members have programmes and initiatives spanning 62 countries and 34 key technologies. The Coalition is co-chaired by UK aid and the IKEA Foundation and is co-funded by UK aid from the UK government, via the Transforming Energy Access platform, and IKEA Foundation; however, the views expressed do not necessarily reflect the UK government's official policies.

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1.2. Context

In the face of rapid global changes and a growing demand for sustainable energy solutions, the need for reliable access to clean energy has never been more urgent. This is especially true for off-grid communities and humanitarian settings, where energy access can be a critical lifeline. In these contexts, high-quality energy appliances are not just a matter of performance—they are essential for resilience, safety, and long-term impact.

Despite growing interest and investment in off-grid solar solutions, procurement remains a major challenge. Decision-makers are often required to act quickly, yet they lack clear, standardized guidance to make informed choices. This can lead to the selection of products that are poorly suited to local conditions or fail prematurely—undermining consumer's trust and compromising the effectiveness of humanitarian and energy access programs. The absence of harmonized quality benchmarks and performance data further complicates procurement efforts, particularly in humanitarian contexts where stakes are high and time is limited.

This handbook has been developed as a practical guide for establishing procurement guidelines for energy appliances suitable for off- and weak-grid environments. It is intended to support procurement officers and program implementers by providing clear, actionable guidance on setting appropriate quality requirements in the procurement tenders and selecting appliances that are durable, energy-efficient, environmentally sustainable, and economically viable over time.

The technical requirements outlined here draw on industry best practices and global insights to ensure that procured products meet stringent quality benchmarks. For humanitarian settings in particular, where operational challenges and resource constraints are common, high-quality appliances can mean the difference between reliable service and premature failure. By following these guidelines, stakeholders can significantly reduce the influx of sub-standard products, protect vulnerable communities, and contribute to building a more trustworthy and effective off-grid energy ecosystem.

1.3. Scope

The handbook provides procurement guidance on establishing key technical requirements for common productive use of energy appliances that are intended for off- and weak-grid areas. Emphasis has been placed on recommending minimum requirements for quality, safety, and truthful advertising. Additional component and performance requirements are also presented, yet they should only be required if they can be justified by stakeholder consultations and needs assessments.

It is also important to note that, with the exception of solar energy kits, this document does not offer comprehensive guidance on setting technical specifications or requirements for power systems that support or power these appliances. We do emphasize, however, that it is very important to ensure that procured power systems are well designed, comprised of high-quality components, compatible with connected appliances, and correctly installed and maintained.

The appliances covered in this edition include solar energy kits, refrigerators, fans, solar water pumps, and solar streetlights. These products were selected based on their critical role in delivering essential services in off-grid and humanitarian settings—such as lighting, food preservation, water access, and public safety—while supporting broader goals of energy equity and climate resilience. This handbook is intended to be a living document; future editions will expand to include emerging productive use equipment, such as milling machines and electric cooking devices.

In the context of this document, off- and weak-grid appliances are defined as follows:

- **Off-grid appliances** are designed to operate independently of the electricity grid by being powered by solar energy, batteries, or other decentralized energy sources. They are generally highly efficient and primarily used in remote and rural areas where there is no access to the

national grid. They are typically compatible with direct current (DC) systems, such as standalone solar energy kits or mini-grids.

- **Weak-grid appliances** are designed to function reliably in areas where the grid connection exists but is unreliable, experiencing frequent outages, voltage fluctuations, or limited daily supply. They are normally powered by the grid, but may also use backup sources like batteries. These appliances can switch between Alternating Current (AC) and DC power sources.

The handbook also offers recommended requirements for equipment suppliers. In the context of this document, a **supplier** is defined as a company that manufactures or distributes off- and weak-grid appropriate appliances. Suppliers are generally responsible for sourcing, delivering, and sometimes installing large quantities of specified equipment to a buyer, typically under contract terms defined by a bulk procurement process.

1.4. Structure of the Document

The guidance offered in this document is divided into three main parts that provide practical information to help navigate selection, assessment, and procurement of off- and weak-grid appropriate appliances.

Recommended technical requirements for off- and weak-grid appliances (Sections 3 through 7)
These sections provide detailed recommendations for technical requirements for each type of energy appliance listed in the Scope Section, above. The recommendations include minimum quality and safety requirements, as well as additional criteria for organizations to add further performance, component, and system requirements, and a guide to what suppliers need to submit for the assessment of the mentioned requirements.

Product usability, repairability, and end-of-life management (Sections 8 through 10)
These sections address strategies and requirements to ensure that appliances function as expected and meet sustainability requirements that promote positive user experiences and environmental responsibility.

Supplier requirements for off- and weak-grid appliances (Section 11)
Section 11 offers guidance on how programs can design eligibility requirements for suppliers of off- and weak-grid energy appliances. The ideal supplier will not only consistently deliver the right product on time, but will also enhance the system's longevity through quality workmanship, customer support, and warranty service.

1.5. Guidelines on Practical Use of the Document

This document is intended to serve as a practical resource to support procuring and evaluating off- and weak-grid energy appliances, with a focus on ensuring that minimum technical requirements are met. The document is intended to be used as follows:

- **Identify the type of appliance and intended use.** The program or organization procuring the equipment should start by determining which appliances are needed, ideally through stakeholder consultations and needs assessments. The conditions in which the appliances will be operated, characteristics of the power supply**,** and its intended use are all key considerations in this initial step. For best results, we recommend that these activities be led by experienced individuals with the relevant social and technical expertise.
- **Refer to the section on recommended technical requirements for the relevant appliance category.** Sections 3 through 7 present both the minimum advisable and optional requirements for each category of energy appliance. Each section includes a table that presents technical requirements that can be incorporated into tender documents. The tables are organized by first presenting minimum requirements that we believe should be used regardless of the application. This is followed by optional requirements that procuring entities can select according to the particular use cases and objectives. For each requirement listed in the table, we provide key details and insights, as well as specifying which documents should be submitted by bidders as evidence that their products comply.
- **Incorporate requirements into the bidding documents.** The procuring entity's technical staff or hired expert(s) should review the recommended minimum requirements and insert them into the bidding document once/if approved. They should then work through the optional requirements for the product category to propose which ones should be mandatory, in addition to the minimum requirements. Deciding which additional requirements to include in the tender should be based on the consultations and needs assessment described in the first step.
- **Set requirements for product usability, repairability, and end-of-life management.** Complying with technical requirements may not provide sufficient assurance that an appliance will fully meet the needs of the intended users and applications. To establish a comprehensive set of requirements, we

recommend including usability testing combined with requirements for product repair and responsible management of e-waste, which are described in Sections 8 through 10.

- **Set supplier requirements.** In addition to the appliances meeting the technical requirements, the procuring entity should also set requirements for the supplier to ensure they are capable of reliably and sustainability delivering the specified equipment and service. Guidelines for this are provided in Section 11.

2. Recommended Technical Requirements for Off- and Weak-grid Appliances

The following sections provide best-practice guidance for setting technical requirements for off- and weak-grid appliances. Each section focuses on a specific product category, detailing key product information and procurement considerations, including advice for evaluating product conformity.

2.1. General Recommendations for Product Testing and Quality Requirements

Setting requirements for product testing and quality is crucial for ensuring that the products are safe, of acceptable quality, and function as desired. When setting these requirements, reference existing national, regional, or international standards and test methods to ensure credibility and alignment with recognized frameworks. Testing and/or certification of products should be conducted by accredited labs and certification bodies. For more niche or nascent product categories (e.g., solar egg incubators, solar milling machines,, electric cookstoves) that lack established test methods and quality standards, procuring organizations should seek expert guidance to formulate a cohesive set of testing, quality and safety requirements that are based on best practice.

Incorporating environmental and sustainability requirements is also recommended to encourage responsible practices, including the use of recyclable or environmentally friendly materials. Technical requirements for products should be adapted to local contexts and operating conditions like voltage fluctuations and operation in energy constrained settings. Some key guiding principles include:

- **Test methods** – When possible, require that products be tested according to internationally harmonized testing protocol to ensure proper and complete evaluation. By using harmonized test methods, a product can be tested once, and the test report can be accepted across countries, regions, and programs. Test methods published by the International Electrotechnical Commission (IEC) are the go-to when available. When there is no IEC test method for a product category, use best-practice lab test procedures like Global LEAP[1]. When in doubt, consult experts (like VeraSol) for guidance.
- **Test laboratories** – Test products at qualified laboratories. For testing according to internationally harmonized test methods (like those published by the IEC), choose labs that hold ISO 17025

[1] Global LEAP test methods for select solar appliances and productive use equipment are available on the VeraSol website:TVs: https://verasol.org/publications/off-grid-television-test-method
Fans: https://verasol.org/publications/off-grid-fan-test-method
Refrigerators: https://verasol.org/publications/off-grid-refrigerator-test-method
Solar water pumps: https://verasol.org/publications/swp-test-method
Rapid Product Assessment methods are available on the VeraSol website:
Egg incubators: https://verasol.org/publications/rapid-product-assessment-a-new-approach-to-testing-productive-use-appliances
Milling machines: https://verasol.org/publications/rapid-product-assessment-solar-milling-test-method
Agricultural sprayers: https://verasol.org/publications/rapid-product-assessment-agricultural-sprayer-test-method

accreditation for the specific test method. When a product category does not have an IEC test method, require testing by labs that are approved by trusted third parties like VeraSol[2].

- **Quality standards** – If available for a product category, quality standards published by the IEC should be required. In the absence of applicable IEC standards, set quality requirements based on best practice and expert guidance. Be aware that standards intended for on-grid devices (such as refrigerators) may not be fully applicable.
- **Safety standards** – Appliances should also meet internationally harmonized safety standards. In the context of safety requirements, most off- and weak-grid appliances can be considered "household and similar electrical appliances", which are covered by the IEC 60335 series of standards. These documents describe general safety requirements to ensure that appliances are safe for users under normal conditions, fault conditions, and foreseeable misuse. The IEC 60335 series also includes requirements for specific appliance types, such as electric pumps (IEC 60335-2-41).
- **Benchmarking** – For instances where international or nationally recognized quality standards are not yet established for specific appliances, it is advisable to reference quality criteria or performance requirements from similar, well-regarded procurement or incentive programs. The Productive Use Financing Facility (PUFF)[3] employs a comparative method by referencing products that have been recognized through the Global LEAP Awards—an internationally recognized competition that evaluates off-grid appliances based on performance, quality, and energy efficiency. By comparing candidate products to Global LEAP Awards[4] Winners and Finalists, the financing facility ensures that eligible products are on par with those that have been rigorously tested and vetted through an established, independent evaluation process. This practice not only supports informed procurement decisions but also encourages manufacturers to align their products with internationally credible benchmarks.

2.2.Guidance for Setting Additional Technical Requirements

Care must be taken when setting product and supplier requirements that extend beyond quality and safety standards. Unsuitable requirements can have profoundly negative impacts on the intended outcomes of a procurement or incentive program. The following are some key aspects to consider when deciding if additional requirements are appropriate.

- **Understand the users** – First and foremost, set requirements that fulfill the needs and expectations of the users. Take into account where, how, and by whom the product will be used. Specialized applications such as health clinics may demand more stringent requirements. If there is a diversity of expected use cases, it may be advisable to avoid being overly prescriptive, allowing for a broader range of products that can suit various user needs and preferences. Take into consideration other factors such as energy constraints, environmental, social, and economic conditions. Consider conducting a needs assessment before procuring an appliance that matches the specific needs.
- **Set requirements that are easily validated** – To facilitate the bidding and evaluation process, set product requirements that can be confirmed through assessment of commonly available test reports and certificates. Avoid technical requirements that would require suppliers to conduct superfluous or overly-specialized testing, which can be costly and time intensive, ultimately reducing the number of high-quality offerings.
- **Beware of over-specifying** –Setting a large number of performance requirements in addition to minimum quality and safety requirements can drastically reduce the number of products that comply and can greatly increase the costs. To assure a competitive procurement, use the VeraSol Database of

[2] Test laboratories that are approved to conduct tests for VeraSol are available on the VeraSol website: https://verasol.org/test-labs/
[3] Productive Use Financing Facility https://www.clasp.ngo/appliance-financing/
[4] Global LEAP awards https://efficiencyforaccess.org/program/global-leap-awards/

Certified and Tested Products to check if there is a sufficient number of qualifying products that meet the proposed criteria. The VeraSol database contains a wealth of practical information for certified solar energy kits and tested appliances, including refrigerators, fans, electric pressure cookers, solar water pumps, milling machines and walk-in cold rooms.

- **Focus on energy services** – In most cases, avoid setting strict component requirements such as on PV power, battery capacity, and light wattage. Instead, think about what's most important for the user, i.e. the service that the equipment will deliver, and the safety requirements of the components. For example, instead of specifying a 200 W solar water pump system, think about the total volume of water moved (e.g. m^3/day) as the main energy service delivery metric for pumps.
- **Check national regulations and standards** – While many countries with significant markets for energy appliances have adopted the applicable IEC standards, there may be instances where other national standards or regulations may apply. Conduct due diligence to make sure that all product and supplier requirements align with national requirements.

3. Solar Energy Kits (SEKs)

3.1. Product Description

A Solar Energy Kit (SEK) is a pre-configured, standalone, off-grid photovoltaic (PV) system that provides basic electricity access. SEKs meet the following criteria:

- **Pre-assembled system** – Comprised of all components required to provide basic energy services, including PV module, battery, charge controller, cables, switches, and connection ports or integrated optional loads (e.g., lighting, mobile phone charging, TV, radio, fan)
- **Electrical characteristics**
  - PV module peak power is less than or equal to 350 watts
  - System voltage does not exceed 35 volts
  - Direct Current (DC) – No inverter; System outputs and loads are DC only[5]
- **Ease of installation and use** – No technical expertise is required to install and operate the system safely and successfully

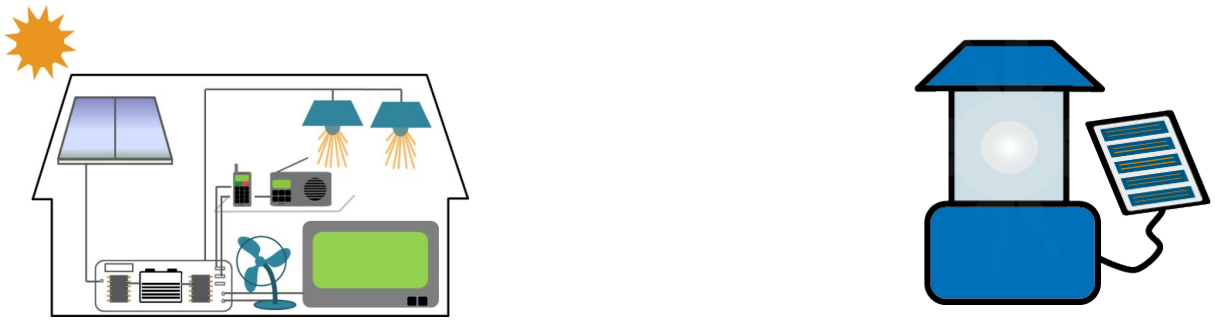

Figure 1: Solar Energy Kit (SEK) illustrations – Solar Home System and Pico-PV product

3.2. Product Testing and Quality Requirements

3.2.1. Test Methods

The International Electrotechnical Commission (IEC) published IEC TS 62257-9-5[6], a comprehensive set of laboratory test methods for SEKs that evaluates product quality, performance, safety, durability and truth-in-advertising. Testing services for SEKs are provided by specialized laboratories that are ISO 17025 accredited to conduct the full suite of tests described in IEC 62257-9-5.

3.2.2. Quality Requirements

The IEC published IEC TS 62257-9-8[7], which sets baseline requirements for SEK quality, durability, safety, and truth-in-advertising[8]. Evaluation of these requirements is based on tests described in IEC TS 62257-9-5.

3.3. Additional Optional Requirements

While compliance with the IEC standard provides confidence that a solar energy kit is high quality, there are situations when procuring organizations and incentive programs may want to set requirements for

[5] AC input to charge the system battery/batteries from AC mains is permitted if the AC charger meets international AC/DC charger safety standards.
[6] IEC TS 62257-9-5 can be purchased from the IEC at https://webstore.iec.ch/en/publication/65559
[7] IEC TS 62257-9-8 can be purchased from the IEC at https://webstore.iec.ch/en/publication/79895
[8] *A summary of the requirements in IEC TS 6257-9-8 is available from the VeraSol website: https://verasol.org/publications/changes-to-test-methods-and-requirements-for-solar-energy-kits-in-iec-ts-62257-9-52024-and-iec-ts-62257-9-82025*

SEKs that go above and beyond the baseline requirements. Additional optional requirements related to product performance and/or component specifications may be desired to account for particular use cases. Avoid setting technical requirements that cannot be confirmed by IEC TS 62257-9-5 test reports or by VeraSol Standardized Specifications Sheets[9].

The guidance issued for SEKs in the following sub-sections helps organizations determine which additional requirements (if any) may be appropriate for the specific circumstances of a bulk procurement or incentive program. Table 1, below, compiles the technical requirements to be considered for SEKs, including practical information for each type of specification, and materials that suppliers should submit as evidence that a product meets each requirement. Common requirements for product suppliers – including product availability, after-sales service, and e-waste management – are addressed for all product categories in Section **Error! Reference source not found.**.

3.3.1. Optional Component Requirements

In some cases, bulk procurements and incentive programs choose to set requirements for key SEK system components to make sure the products are appropriate for the intended beneficiaries. For solar energy kits, avoid setting strict requirements for PV power, battery capacity, and light wattage. Instead, focus on the energy services provided by the system. Table 1, below, presents specifications for lighting, batteries and appliances that should be considered when establishing optional component requirements.

3.3.2. Optional Performance Requirements

The IEC quality standard for SEKs does not include any requirements for product performance (e.g., lighting duration and brightness, appliance run time, and number of mobile phone charges per day). Bulk procurements and energy access programs commonly set additional SEK performance requirements to ensure that products fulfill users' needs and expectations, which are described in the "Performance requirements" section of Table 1.

3.3.3. Optional System Requirements

The market for solar energy kits is characterized by innovation and diversity of product offerings. A wide range of constantly evolving SEKs offers hundreds of choices of product configurations. Optional system-level requirements to be considered – including aspects related to form, function, ease-of-use, and warranty – are detailed in Table 1.

3.4. Summary of Minimum and Optional Requirements for Solar Energy Kits

The following table compiles practical information about the minimum quality requirements and other optional requirements for solar energy kits, which should be considered for any bulk procurement or program that includes SEKs in the product scope.

The "Details" column of the table presents information about each category of requirement/specification that is intended to help decisionmakers determine if it is appropriate for a given application. The "Supplier Submission" column identifies the documentation and other materials that product suppliers should provide as evidence that a SEK meets each requirement/specification[10].

[9] Standardized Specifications Sheets for VeraSol-certified products are available via VeraSol's SEK database: https://data.verasol.org/products/sek?verified=true&sortBy=date-product-listing-was-last-updated-mm-dd-yyyy_desc

[10] For more detailed technical information related to procuring SEKs for humanitarian aid, refer to VeraSol Technical Note 28 "Procurement of Stand-alone Solar Kits for Humanitarian Aid": https://verasol.org/publications/procurement-standalone-solar-kits-humanitarian-aid/

As recommended above in the "Guidance for Setting Additional Technical Requirements", beware of over-specifying. The optional requirements described in the following table should only be considered if there is a strong case based on users' needs or the specific context of the procurement or program.

Table 1: Procurement Specification Options for Solar Energy Kits

Requirement Category	Specification	Details	Supplier Submission
Minimum Quality Requirements			
Complete Solar Energy Kit (SEK)	Meets minimum requirements for safety, durability, and truth-in-advertising	Suppliers must provide valid evidence that the product meets all requirements in the international standard for solar energy kits (IEC TS 62257-9-8) SEKs that meet the quality standard must have been tested using the applicable test methods (IEC TS 62257-9-5) by a laboratory that is ISO 17025 accredited for that method. All VeraSol-certified SEKs have been tested by ISO 17025 accredited labs.	Mandatory: VeraSol certificate Optional: • Test report (IEC TS 62257-9-5) from accredited lab • Proof that the test lab holds a valid ISO 17025 accreditation for IEC TS 62257-9-5 • Picture(s) of product • Digital copy of user manual & any included documentation • Product sample(s)
Optional Component Requirements			
Lighting	Considered a basic function of SEKs, requirements for the types and number of light points are commonly specified by procuring organizations and programs based on surveys of users' needs.		VeraSol Standardized Specification Sheet or Specifications Book*
	Number of light points	Some instances may require a minimum or specific number of light points, particularly for ambient room lighting.	
	Type of light points	Some instances may require a certain type or combination of types of light points, which can generally be categorized as either ambient or task lighting. The specified type(s) of lighting should align with the intended use cases.	
	Number of light output settings	The lights included with solar energy kits commonly have multiple brightness settings (e.g., low, medium, high). The minimum or required number of settings can be specified if deemed important to the intended use cases.	
	Color temperature	The Correlated Color Temperature (CCT) is measured in degrees Kelvin, and describes the color appearance of a light source. "Warm" light (2700-3000 K) has a yellowish appearance, "Cool" light (3000-5000 K) appears bluish, and "Daylight" (>5000 K) is situated in between. Specifying color temperature should typically be avoided unless user surveys indicate a strong preference for or aversion to warm or cool light.	
Battery	SEKs that meet the IEC quality standard (i.e., VeraSol-certified products) have batteries that comply with comprehensive safety and durability requirements. While additional requirements for battery safety and durability are generally not necessary, some organizations and programs do choose to specify the battery chemistry.		
	Battery chemistry	Nearly all VeraSol-certified SEKs use lithium batteries (either lithium iron phosphate [LiFePO4] or lithium-ion [Li-ion]), yet a few products use sealed lead acid (SLA) batteries. Some programs and procuring organizations specify that batteries must be lithium-based to benefit from advantages such as higher energy density, increased life and durability.	
	Battery capacity	Avoid setting a battery capacity (ampere-hours [Ah] or watt-hours [Wh] requirement for SEKs. Opt instead for minimum requirements for the daily energy services that a product can provide, for example daily hours of lighting or appliance operation (refer to “Performance Requirements”, below.	

Included appliances	SEKs often include non-lighting appliances such as fans, radios, and TVs. All appliances included with VeraSol-certified SEKs meet basic quality, safety and compatibility requirements. If a procuring organization requires that one or more appliance must be included with a solar energy kit, make sure that the selected appliances are chosen according to users' needs.		
Optional Performance Requirements			
Lighting	Lighting is considered a basic function of SEKs. Some procuring organizations and energy access programs set additional lighting performance requirements based on surveys of users' needs.		VeraSol Standardized Specification Sheet or Specifications Book*
	Lighting Run Time	Duration of lighting service delivered when all light points are on at the brightest setting; Specified in two ways: 1. **Solar Run Time** - Number of hours of lighting provided after one full day of solar charging; This is the duration of daily lighting that users are likely to have for common use cases. 2. **Full Battery Run Time** - Number of hours of lighting provided when the battery is completely charged; This represents the maximum duration of lighting, which may not correspond with the duration experienced in real-world applications.	
	Brightness	Specified as "Light Output" and measured in units of lumens (lm) on VeraSol Standardized Specification Sheets, the minimum brightness is commonly set for all light points combined. If this optional performance requirement is specified, it should be aligned with users' needs and preferences.	
	Total Lighting Service	Measured in "lumen-hours per solar-day", Total Lighting Service allows for apples-to-apples comparison of products according to both brightness and duration of lighting provided per day of solar charging. Total Lighting Service facilitates quantitative comparison across diverse product configurations, considering both brightness and lighting duration.	
Appliance Run Time	If any included appliances are required, the program or procuring entity may desire to set minimum solar run time requirements. There are two ways to specify an appliance run time requirement: 1. **Solar run time of the appliance when used alone** 2. **Solar run time of the appliance when used in combination** with other available energy services (e.g., lighting, mobile phone charging, other included appliances)		
Mobile Phone Charging	Nearly all VeraSol-certified SEKs include USB output ports that are intended for mobile phone charging. Require mobile phone charging capability if it is deemed important for the intended users.		
	Number of charges	Some situations may need more stringent performance requirements for mobile phone charging. If there is concern that there may be a higher-than-usual energy demand from mobile phone charging, it may be appropriate to set a minimum performance requirement for the number of charges per solar day. The minimum number of mobile phone charges per day can be specified for the case when it is used alone or in combination with all other included lighting and non-lighting appliances.	
Available Daily Electrical Energy	Measured in "watt-hours per solar-day" (Wh/day), Available Daily Electrical Energy allows for apples-to-apples comparison of products according to the total energy services provided per day of solar charging. It sums up all of the energy provided by the SEK, which can be delivered through services such as lighting, mobile phone charging, and powering appliances. This system-level performance metric is most commonly used for Results-Based Financing (RBF) programs that disburse incentives as a function of the energy services provided by a product. It is less frequently used as a minimum requirement for bulk procurement of SEKs.		
Optional System Requirements			

SEK Form Factor	The physical configuration of a solar energy kit is often specified based on the anticipated needs of the users and the context. - **Fixed indoor product** - Typically used for a secure household or for a fixed installation such as a small business, clinic, or community area. Fixed indoor products are often appropriate for instances where there are concerns regarding malicious damage and theft. - **Fixed outdoor product** - Typically used for illuminating an outdoor area, such as for shop fronts or toilets - **Portable product with separate PV module** - Generally appropriate for areas where separate PV modules can be fixed securely but the light must be portable - **Portable product with integrated PV module** - Generally appropriate for settings where a separate PV module cannot be fixed securely		• VeraSol Standardized Specification Sheet or Specifications Book* • Product images • Product sample
Output Ports and Mobile Phone Charging	Most VeraSol-certified SEKs have USB output ports for mobile phone charging or powering other devices. At least one USB output port for mobile phone charging is commonly required by procuring organizations and energy access programs.		VeraSol Standardized Specification Sheet or Specifications Book*
AC Charging	While all VeraSol-certified SEKs can be charged by solar PV modules, a limited number of products are capable of grid charging, i.e., the product's battery can be charged by plugging a charge adapter into an electrical outlet for AC mains. The IEC quality standard requires that AC charging adaptors included with a SEK meet relevant safety requirements such as CE, UL, or similar. AC charging of SEKs is most applicable for urban, peri-urban and weak-grid settings.		
Durability	All VeraSol-certified SEKs must meet robust durability requirements, including durability of moving parts, ability to withstand drops onto hard surfaces (for portable products), protection from ingress of water (for outdoor products), and protection from ingress of physical objects. It is generally advisable not to set any additional durability requirements unless the SEK will be used in extreme environmental conditions. Refer to the summary of IEC TS 62257-9-8 for detailed information about durability requirements for each SEK form factor.		
Product Size and Packaging	Product size and packaging can be important factors for humanitarian applications. Procuring organizations should consider specifying the following physical aspects of SEKs to account for shipping, delivery models, and use cases.		
	Product size and weight	In some instances, it is important to limit the product size and weight. For example, if the SEK is bundled with other goods for disbursement to end users, or if the product will be predominantly used by children, it may be advisable to set maximum allowable dimensions and/or weight.	• Product dimensions & weight: Test report (IEC TS 62257-9-5) • Supplier should provide any missing or relevant specifications as needed
	Package dimensions	Transportation of products to the destination area is a common and important consideration for aid organizations. To comply with logistical constraints (e.g., loading onto pallets or packing for air-dropping), humanitarian organizations may desire to set maximum packaging dimensions, maximum total packaged weight, or minimum number of units per pallet. Agencies may encourage the use of packaging materials that are recyclable biodegradable, and that avoids single use plastics where possible. Agencies may also promote compact packaging to reduce transport volume and environmental impact.	• VeraSol Standardized Specifications Sheet (for most SEKs) • Supplier to provide any additional or relevant specifications as needed (e.g., further description of weights and dimensions, shipping details per pallet or container)
	Custom markings	Aid organizations and programs may require that the supplier afix additional printed content on the product and/or packaging. This may include the logo of the aid organization or program, unique ID numbers, or other custom markings.	Suppliers typically need to provide a written statement that they are capable of meeting any requirements for custom markings. Procuring organizations can request a sample of the product and/or packaging with the requested markings to be used for verification/approval.
Ease of use	The IEC quality standard for SEKs requires that a detailed user manual be provided with the product, which includes instructions for installation, use and troubleshooting of the system. All VeraSol-certified products are accompanied by basic user instructions, but some procuring organizations or program designers may desire to set additional requirements.		

	User Manual	All certified SEKs are required to have a user manual and written content presented in at least one official language of the intended market. Depending on the preferred languages and literacy of the users, one may need to require that printed material be offered in mulitple languages, and that the user manual include illustrations.	For user manual requirements that exceed the IEC standard, the supplier needs to provide a digital sample of any proposed modifications to existing materials.
	Indicators	Many SEKs include small screens or indicator lights that inform users of the system status, e.g., when the product is solar charging, and the battery state of charge. These informative mechanisms are not required by the IEC quality standard, but some procuring organizations may find them important for their intended users.	If status indicators are required, the VeraSol Standardized Specification Sheet describes the "Battery status / other indicator lights". Additional information and photos are included in the test report (IEC TS 62257-9-5).
Extended warranty	As required by the IEC quality standard, all VeraSol-certified SEKs must be covered by a consumer-facing warranty. - **SEKs with PV power rating of 10 W or less**: 1-year warranty (minimum) - **SEK with PV power rating greater than 10 W**: 2-year warranty (minimum) - **All appliances included with SEKs**: 1-year warranty (minimum) Although the quality standard sets robust warranty requirements, some procurements and programs may desire a longer warranty duration. It is not uncommon to see a 3-year minimum warranty requirement.		• VeraSol Certificate is valid evidence that an SEK meets the minimum requirement for consumer-facing warranty, according to the product's PV power rating. • For any warranty requirements above and beyond the quality standard, the following may be requested of the supplier: - Digital copy of the consumer-facing warranty terms that will accompany the SEK - Statement from supplier describing the extended warranty duration (if applicable), and their ability to handle warranty issues in the context of the humanitarian situation, including how users can access warranty and the process they follow
PAYGO / Remote monitoring	Many VeraSol-certified SEKs have integrated pay-as-you-go (PAYGO) technology that allows consumers to make small, periodic payments - typically via mobile money or scratch cards - to either rent or purchase the product instead of paying upfront for the entire system. PAYGO technology can deactivate the SEK, rendering it temporarily non-functional when the consumer has not made a payment. Many PAYGO platforms are also able to log and transmit a breadth of data that are useful for understanding client payment information, system use and performance. While PAYGO is not required by the IEC standard for SEKs, the standard does require that PAYGO-enabled products be capable of accurately metering service to customers so they reliably get the service that is paid for. PAYGO is very commonly required for participation in Results-Based Financing (RBF) programs to facilitate tracking and recordkeeping. Some aid organizations have also required PAYGO functionality for procured SEKs, as it not only helps track system use, but also helps assure that the product is being used by the intended beneficiaries.		• VeraSol Standardized Specification Sheet states if Pay-As-You-Go option is available. • Additional information about the functionality of a product's PAYGO system must be requested directly from the supplier. • It may also be advisable to request a sample of a PAYGO-enabled product for inspection and practical assessment.

** Solar energy kits can be VeraSol certified individually or as part of a "product family", which is a set of interchangeable components sold on a component-level basis or as mix-and-match kits. SEK product families typically include multiple options for batteries, PV modules, as well as lighting and non-lighting appliances that can be configured to form a range of models that meet diverse user needs. Each individually certified SEK has a unique listing in VeraSol's online database of certified SEKs, which includes a VeraSol Certificate and Standardized Specifications Sheet. Each certified SEK product family is also listed in the VeraSol database. Each certified product family has a VeraSol Standardized Specifications Book, which, along with a valid VeraSol Certificate, is used as evidence that the family and the individual models in that family meet the IEC quality standard (IEC TS 62257-9-8). All valid Certificates, Specifications Sheets and Books are publicly available for download and verification in VeraSol's online database of certified SEKs.*

4. Household and Light Commercial Refrigeration

4.1. Product Description

A Refrigerator is an electrical appliance designed to store food and beverages at low temperatures to preserve their freshness and prevent spoilage. It consists of insulated cabinets with one or more compartments that are controlled at frozen or unfrozen temperatures and are of suitable size, equipped for household or commercial use. When used in off-grid or unreliable grid settings, a refrigerator must be designed to maintain proper cooling performance despite fluctuations in power input—whether from changing solar irradiance or unrealiable grid power quality, including voltage spikes and surges.

In the context of this guidance document, a refrigerator meets the following criteria:

- **System Characteristics:** The refrigerator must be intended for or compatible with off-grid energy systems, such as solar energy kits and AC or DC mini-grids, or for unreliable grid operation The scope does not cover vaccine refrigerators and ice pack freezers for medical purposes.
- **Electrical characteristics**
    - Should be designed to properly operate off-grid (standalone) or under unreliable grid (intermittent and/or distorted electrical mains) operating conditions resisting power interruptions and supply variations
    - Power Compatibility: Are capable of operating on either direct current (DC) from solar power systems, alternating current (AC) from mini-grids or national grids, and hybrid systems with battery backup.
- **Ease of installation and use** – Simple to set up and operate with minimal technical expertise.



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FFigure 2: Refrigerating appliance illustrations

4.2. Product Testing and Quality Requirements

4.2.1. Test Methods

VeraSol developed the Global LEAP Off-Grid test method for refrigerators intended to be used in off-grid and unreliable grid conditions. The test evaluates the quality, energy consumption and performance of refrigerating appliances intended to be powered by a PV module, a solar home system, or by AC mains. VeraSol testing services are provided by specialized ISO-accredited test laboratories that conduct the full tests described in the Global LEAP test method.

Currently, VeraSol is working with IEC in developing an international test method for off- and weak-grid refrigerators. The document is expected to be published in early 2026. Once published, the new IEC test method (IEC 63437: "Off-grid and unreliable grid refrigerating appliances for domestic and light commercial use - Characteristics and test methods - Performance requirements and energy consumption") should be used instead of the Global LEAP test method.

4.2.2. Quality Requirements

There are currently no international or national standards specific to off- and weak -grid refrigerators. However, VeraSol has been actively developing quality criteria to support voluntary programs and continues to work on establishing comprehensive quality requirements for these appliances. At present, the recommended quality requirements – including guidelines for performance reporting, performance requirements, safety requirements and consumer information – are outlined in

Table ***2***, alongside the applicable existing IEC safety standards.

4.3. Additional Optional Requirements

In addition to the quality requirements summarized above, there are situations when procuring organizations and incentive programs may want to set requirements for refrigerating appliances that go above and beyond the baseline requirements. The guidance issued for refrigerators in the following sub-sections helps organizations determine which additional requirements (if any) may be appropriate for the specific circumstances of a bulk procurement or incentive program.

Table *2*, below, compiles the technical requirements to be considered, including practical information for each type of specification, and materials that suppliers should submit as evidence for assessing whether the requirement has been met. Common requirements for product suppliers – including product availability, after-sales service, and e-waste management – are addressed for all product categories in Section **Error! Reference source not found.**.

4.3.1. Optional Component Requirements

Some refrigerators are sold and/or used with off-grid photovoltaic (PV) systems. While component-based PV systems are outside the scope of this document, procuring organizations should ensure that the PV system and its components meet all applicable standards and guidelines for design and installation. VeraSol's Quality Assurance Framework for Component-Based Energy Systems[11] is a practical reference for setting these quality requirements. The "Optional Component Requirements" section of Table 2, below, provides basic quality and safety standards for PV module, batteries, solar controllers, and DC-AC inverters.

4.3.2. Optional Performance Requirements

Procuring agencies and programs may choose to set performance requirements to ensure that the refrigerators deliver the desired services under the expected conditions. Three common performance requirements are described in Table 2, below: temperatures for each compartment, temperature retention time, and environmental suitability.

4.3.3. Optional System Requirements

Refrigerators are available in a diverse range of sizes, configurations, and features. Some applications may require specific system characteristics, which should be specified at the time of procurement. Optional system-level requirements to be considered according to the expected use case are detailed below in Table 2.

4.4. Summary of Minimum and Optional Requirements for Refrigerators

The following table compiles practical information about the minimum requirements for quality and safety, as well as other optional requirements for refrigerators, which should be considered for any bulk procurement or program that includes off- or weak-grid refrigerators in the product scope.

The "Details" column of the table presents information about each category of requirement/specification that is intended to help decisionmakers determine if it is appropriate for a given application. The "Supplier Submission" column identifies the documentation and other materials that product suppliers should provide as evidence that a refrigerator meets each requirement/specification.

[11] VeraSol's Quality Assurance Framework for Component-Based Energy Systems, including the framework overview, design guidelines, and installation guidelines, is available for download at: https://verasol.org/publications/quality-assurance-framework-for-component-based-energy-systems/

Table 2: Procurement Specification Options for Weak- and Off-grid Refrigerators

Requirement Category	Specification	Details	Supplier Submission
Minimum Quality and Safety Requirements			
Refrigerator	Performance Reporting Requirements	Sample shall be marked with the following ratings, both on the sample and on the packaging or other consumer-facing material available prior to purchase: • Name or trademark of the manufacturer or responsible vendor • Uniquely identifiable product name or model number • Rated climate class (SN, N, ST, T) and compartment storage temperatures • Volume of each compartment (L) • Daily energy consumption (Wh/day) rated at 32°C ambient temperature • Rated voltage or rated voltage range • Nominal battery voltage if the product is intended to be battery-operated • Nature of power supply (AC or DC) • Rated average power (W) or rated average current (A) reported for each applicable; • Maximum current (A) • Refrigerant type (chemical name, formula, number) • Total mass of refrigerant (g)	Mandatory: Test report(s) • VeraSol test report: Global LEAP off-grid test method for refrigerators, or • Test reports from accredited labs based on the Global LEAP test method Optional: • Photo(s) of product • Digital copy of user manual & any included documentation • Product sample(s)
	Temperature	All refrigerators shall maintain a temperature ≤12°C at an ambient temperature of 43°C All freezers shall maintain a temperature ≤0°C at an ambient temperature of 43°C	• VeraSol test report: Global LEAP off-grid test method for refrigerators, or • Test reports from accredited labs based on the Global LEAP test method
	Safety	Meet the requirements of IEC 60335-1 and one of the following: IEC 60335-2-24, IEC 60335-2-75, or IEC 60335-2-89 These tests also cover key aspects of quality and durability. AC-DC power supplies: Any AC-DC power supply included with a refrigerator should carry a recognized consumer electronics safety certification as specified in IEC TS 62257-9-8.	60335-2-24 test report
	Warranty	• A consumer-facing warranty shall be included with the refrigerator that provides a minimum duration of at least two years on manufacturing defects under normal use. • 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.	Digital copy of consumer-facing warranty terms

	User manual	• A user manual covering installation, use and maintenance shall be provided using language and graphics appropriate for the intended market and typical consumer. • Installation instructions must include appropriate placement and installation of the appliance. • If the refrigerator is included with a solar energy kit, the user manual for the kit or refrigerator must also include instructions on how to connect the refrigerator to the kit.	Digital copy of user manual
Optional Component Requirements			
Power systems	Photovoltaic (PV) modules	Modules must be appropriately rated for powering refrigeration systems and must comply with IEC 61215 and IEC 61730 standards (or equivalent off-grid certification standards). The system should be sized to ensure adequate energy generation to support continuous refrigeration, including during periods of low solar irradiance.	• IEC 61215 certificate / test report • IEC 61730 certificate / test report

	Batteries	If energy storage is included or required to ensure reliable refrigeration (e.g., to maintain cooling overnight or during cloudy conditions), batteries should meet relevant quality and safety standards for cyclic use, such as those outlined in IEC 62257-9-8. Batteries must also provide sufficient capacity and discharge current to maintain compressor operation and startup loads.	• Test reports/certificates for battery:
			  ○ Lithium batteries:
			  ▪ UN 38.3 or IEC 62281 or IEC 62133
			  ▪ IEC 62619 or UL 1973
			  ○ Lead-acid batteries:
			  ▪ IEC 61427 or IEC 60896-11 or 60896-22 (depending on battery type)

	Solar controllers	All controllers must meet off-grid protection and reliability standards (e.g., overvoltage, overload, thermal, and reverse polarity protection).	• Solar controller specification sheet • General safety: IEC 62109-1 test report / certificate
	DC-AC Inverters	For AC-powered refrigerators used in solar systems, inverters must be properly sized to accommodate both the refrigerator's operating power and the peak startup current of the compressor. Inverters should be certified to meet safety and performance standards applicable to off-grid productive use systems.	• Inverter specification sheet • Safety: IEC 62109-1 test report / certificate
Refrigerant	Natural/Climate friendly refrigerants highly recommended, with lower ODP levels. Prioritize GWP≤20 or natural refrigerants, such as isobutane (R600a), R290, or R744 (CO_2). Flammable refrigerants should be marked and include relevant warnings.		Refrigerant specifications sheet
Optional Performance Requirements			
Specific compartment type and corresponding temperature performance	For various compartments-also the internal usable volume of the refrigerator and its cooling & freezing capacity. Additional performance requirement can be added if there is a specific cooling need in the local context. For example, requiring refrigerators to have at least one frozen compartment, with storage temperature not warmer than -6°C (one star compartment), would be appropriate for fishery value chain.		Global LEAP Off-Grid and Weak-Grid Refrigerator Test Method / IEC 63437 test report
Hold over time	In some use cases, it is important for refrigerators to maintain cooling for a specified period during power outages. Procuring organizations may specify a minimum autonomy time for some applications and refrigerator types.		
Durability	To ensure equipment can sustain operation under extreme unreliable power conditions, additional requirements can be included the product to pass under and over-voltage test and voltage withstand test. For under- and over-voltage test, the product should maintain proper performance. For voltage withstand test, the product should not have any performance failure.		
Optional System Requirements			

Internal volume	Some use cases require a minimum, maximum, or range of allowable volume for the refrigerator and/or freezer compartments.		
Power supply	If the type of power input is known, procuring organizations or programs may need to specify whether the refrigerator is capable of accepting AC, DC or AC/DC power.		Product specifications sheet
Size and packaging	Product size and packaging can be important factors for humanitarian applications. Procuring organizations should consider specifying the following physical aspects of refrigerators to account for shipping, delivery models, and use cases.		
	Product size and weight	If needed for logistical purposes, the procuring agency can set the allowable limit of the product size and weight.	Product dimensions & weight: Test report Supplier should provide any missing or relevant specifications as needed
	Packaging	Transportation of products to the destination area is a common and important consideration for organizations. To comply with logistical constraints (e.g., loading onto pallets or packing for air-dropping), humanitarian organizations may desire to set maximum packaging dimensions, maximum total packaged weight, or minimum number of units per pallet. Agencies may encourage the use of packaging materials that are recyclable biodegradable, and that avoid single use plastics where possible. Agencies may also promote compact packaging to reduce transport volume and environmental impact.	Supplier to provide any additional or relevant specifications as needed (e.g., further description of weights and dimensions, shipping details per pallet or container)
	Custom markings	Aid organizations and programs may require that the supplier afix additional printed content on the product and/or packaging. This may include the logo of the aid organization or program, unique ID numbers, or other custom markings.	Suppliers typically need to provide a written statement that they are capable of meeting any requirements for custom markings. Procuring organizations can request a sample of the product and/or packaging with the requested markings to be used for verification/approval.
Ease of use	User manual	As described above in the Minimum Quality Requirements, all products must be accompanied by basic user instructions, but some procuring organizations or program designers may desire to set additional requirements.	Suppliers should provide a digital sample of any proposed modifications to existing materials.
	Indicators	While a graphical user interface is not considered to be a minimum requirement, some procuring organizations or program designers may choose to require functionality such as: • Digital temperature display • Alarms for performance issues or when temperatures exceed an acceptable range • Error codes for troubleshooting • Charging indicator (if applicable)	• Product specifications sheet or VeraSol standardized specifications sheet • Digital copy of user's manual describing user feedback functionality
Extended Warranty	As described above in the Minimum Quality Requirements, all products must be accompanied by a 2-year consumer facing warranty. Some procuring organizations or program designers may choose to require a longer term warranty, and may desire additional requirements.		For any warranty requirements above and beyond the Minimum Requirements, the following may be requested of the supplier: • Digital copy of the modified consumer-facing warranty terms that will accompany the product • Statement from supplier describing the extended warranty duration (if applicable), and their ability to handle warranty issues in the context of the humanitarian situation, including how users can access warranty and the process they follow

PAYGO / Remote monitoring	Some off- and weak-grid refrigerators have integrated pay-as-you-go (PAYGO) technology that allows consumers to make small, periodic payments - typically via mobile money or scratch cards - to either rent or purchase the product instead of paying upfront for the entire system. PAYGO technology can deactivate the product, rendering it temporarily non-functional when the consumer has not made a payment. Many PAYGO platforms are also able to log and transmit a breadth of data that are useful for understanding client payment information, system use and performance. PAYGO and/or remote monitoring functionality is required for participation in some Results-Based Financing (RBF) programs to facilitate tracking and recordkeeping. Some aid organizations have also required PAYGO functionality for procured appliances, as it not only helps track system use, but also helps assure that the product is being used by the intended beneficiaries.	Additional information about the functionality of a product's PAYGO / remote monitoring system must be requested directly from the supplier. It may also be advisable to request a sample of a PAYGO-enabled product for inspection and practical assessment.

5. Fans

5.1. Product Description

A fan is a device used to create airflow, typically to cool or circulate air in a room or space. It consists of blades, a motor, and a housing unit. A fan works by rotating blades to move air, helping to cool down the environment and improve ventilation. Fans come in various types, including:

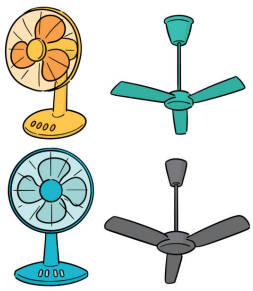
- **Ceiling fan** – A propeller-bladed fan having two or more blades, and provided with a device for suspension from the ceiling of a room so that the blades rotate in a horizontal plane.
- **Table fan** – A propeller-bladed fan having two or more blades, and intended for use with free inlet and outlet of air. It may have a base intended to be placed on a table, or contain brackets for wall, surface, or ceiling mounting
- **Pedestal fan** – A propeller-bladed fan having two or more blades mounted on a pedestal of fixed or variable height and intended for use with free inlet and outlet of air.

System Characteristics: In the context of this document, fans are intended to be used with or compatible with off-grid energy systems, such as solar energy kits and AC or DC mini-grids. The scope does not cover industrial or specialized ventilation fans.

Electrical Characteristics:

- Fans should be designed to operate off-grid (standalone) or under unreliable grid (intermittent and/or distorted electrical mains) operating conditions, resisting power interruptions and supply variations.
- The fans covered are capable of operating on either direct current (DC) from solar power systems, alternating current (AC) from mini-grids or national grids, and hybrid systems.

Ease of Installation and Use: Table and pedestal fans are typically a plug and play appliance. They may require minimal assembly that can be completed with simple household tools, such as screw drivers. Ceiling fans installation is more complex as it'd require securely mounting the fan to a ceiling joist or bracket, which may require drilling, anchoring, and the use of a ladder, as well as electrical wiring. For ceiling fans, it would often requiring the customer/installer to have basic knowledge of electrical connections or the assistance of a qualified electrician.



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JuFigure 3: Illustrations of fan types – table, ceiling, and pedestal

5.2. Product Testing and Quality Requirements

5.2.1. Test Methods

VeraSol published the Global LEAP Off-grid fan test method[12] that measures the performance, quality, and durability of fans intended to be used with off-grid energy systems (e.g. standalone solar home systems, mini-grids). The test references International Electrotechnical Commission (IEC) procedures for evaluating product performance under IEC 60879:2019[13]: IEC TS 62257-9-5:2013[14]: and IEC 60335-2-80[15]. Testing services for this category of fans are provided by specialized ISO-accredited test laboratories that conduct the full tests described in Global LEAP test method.

5.2.2. Quality Requirements

The performance and efficiency requirements of AC fans can be found in national minimum energy performance standards, such as the IS 374:2019 – Ceiling Fans (Indian standard), BDS 1860:2012 Minimum allowable values of energy efficiency and energy efficiency grades for AC electric fan (Bangladeshi standard), or National Energy Efficiency and Conversation Policy in Pakistan. In general, these standards cover power consumption, air delivery, and service delivery value (air delivery/power input, expressed in m^3/min/W).

Fan safety requirements are covered in IEC 60335-2-80 Household and similar electrical appliances. Safety. Particular requirements for fans.

In addition, VeraSol developed quality criteria to support voluntary programs and continues to work on establishing comprehensive quality requirements for these appliances. At present, the recommended quality requirements are outlined in Table 3, alongside the applicable existing IEC safety standards.

5.3. Additional Optional Requirements

The Global LEAP test method assesses the quality and performance of off-grid and weak-grid fans. However, there are situations where procuring organizations and incentive programs may want to set requirements that go above and beyond the baseline standards. This section provides guidance for determining additional requirements, if any, that may be relevant for bulk procurement or incentive programs. It includes key technical requirements and additional optional requirements related to product performance and/or component specifications. The guidance issued for fans in the following sub-sections helps organizations determine which additional requirements (if any) may be appropriate for the specific circumstances of a bulk procurement or incentive program.
Table 3, below, compiles the technical requirements to be considered, including practical information for each type of specification, and materials that suppliers should submit as evidence that a product meets each requirement

[12] The Global LEAP Off-Grid Fan Test Method can be accessed through the VeraSol database at https://verasol.org/publications/off-grid-fan-test-method/

[13] IEC 60879:2019: Performance and Construction of Electric Circulating Fans and Regulators can be purchased from IEC at https://webstore.iec.ch/en/publication/26458

[14] Particularly the drop resistance and physical ingress protection in IEC TS 62257-9-5:2013: Recommendations for small renewable energy and hybrid systems for rural electrification – Part 9-6: Integrated system – Selection of stand-alone lighting kits for rural electrification; can be purchased from IEC at https://webstore.iec.ch/en/publication/59747

[15] IEC 60335-2-80: Household and similar electrical appliances. Safety. Particular requirements for fans. Can be purchased from IEC at https://webstore.iec.ch/en/publication/70375

5.3.1. Optional Component Requirements

Some fans are sold and/or used with off-grid photovoltaic (PV) systems. While component-based PV systems are outside the scope of this document, procuring organizations should ensure that the PV system and its components meet all applicable standards and guidelines for design and installation. VeraSol's Quality Assurance Framework for Component-Based Energy Systems[16] is a practical reference for setting these quality requirements. The "Optional Component Requirements" section of *Table 3*, below, provides basic quality and safety standards for PV modules, batteries, solar controllers, and DC-AC inverters.

5.3.2. Optional Performance Requirements

Certain performance attributes may be necessary or desirable depending on local user needs or environmental conditions. These include:

- Speed and power flexibility – Fans should have multiple speed settings to allow users to trade off airflow and energy consumption depending on availability of power
- The fan shall maintain functional performance at voltages ±15% of the rated input voltage (only tested under Global LEAP test method)

5.3.3. Optional System Requirements

Optional system-level requirements to be considered – including aspects related to product size and packaging, ease-of-use, and warranty – are detailed in Table 3.

5.4. Summary of Minimum and Optional Requirements for Fans

The following table compiles practical information about the minimum technical requirements and other optional requirements for fans, which should be considered for any bulk procurement or program that includes fans in the product scope. The "Details" column of the table presents information about each category of requirement/specification that is intended to help decisionmakers determine if it is appropriate for a given application. The "Supplier Submission" column identifies the documentation and other materials that product suppliers should provide as evidence that a fan meets each requirement/specification.

[16] VeraSol's Quality Assurance Framework for Component-Based Energy Systems, including the framework overview, design guidelines, and installation guidelines, is available for download at: https://verasol.org/publications/quality-assurance-framework-for-component-based-energy-systems/

TABLE 3: Procurement Specification Options for Off- and Weak-grid Fans

Requirement Category	Specification	Details	Supplier Submission
Minimum Quality and Safety Requirements			
Complete Fan	Performance Reporting Requirements	Each fan, along with its packaging or any consumer-facing materials available prior to purchase, shall include the following information: - Manufacturer or vendor name or trademark - Unique product name or model number - Rated voltage or acceptable voltage range - Nature of supply (AC/DC or e.g., direct connection to SHS battery, with/without controller) - Rated input power in watts (W) or rated current in amperes (A) - Air delivery rate (m^3/min) at maximum setting - Fan type (e.g., table, pedestal,ceiling) - Blade diameter or sweep size (mm or inches) - Runtime (in hours) on a fully charged battery at highest and lowest speed settings - Battery compatibility and nominal voltage (if external battery is used)	Mandatory: Test report(s) - VeraSol test report: Global LEAP off-grid test method for fans - Test report based on Global LEAP test method from an accredited lab - VeraSol certificate (if supplied with or intended for use with a solar energy kit) - IEC 60335-1 and IEC 60335-2-80 test reports Optional: • Picture(s) of product • Digital copy of user manual & any included documentation • Product sample(s)
	Safety Requirements	- The fan shall meet the safety requirements of IEC 60335-1 and IEC 60335-2-80 (Particular requirements for fans) - Power supplies, if included, must meet safety standards outlined in IEC TS 62257-9-8 or equivalent recognized standards for off-grid solar components	
	Consumer Information	- Warranty: A minimum of two years warranty shall be provided, covering manufacturing defects under normal use - User Manual: A clear and easy-to-understand user manual shall be included, covering installation, operation, cleaning, and maintenance. Manuals shall use language and graphics appropriate for the intended market - If the fan is supplied with or intended for use with a solar home system (SHS), connection instructions must be included and comply with IEC TS 62257-9-8 when non-standard connectors are used	
Optional Component Requirements			
Power Systems	Photovoltaic (PV) modules	Modules must be appropriately rated for powering the fan and other intended loads. Modules must comply with IEC 61215 and IEC 61730 standards (or equivalent off-grid certification standards).	• IEC 61215 certificate / test report • IEC 61730 certificate / test report
	Batteries	Batteries should meet relevant quality and safety standards for cyclic use, such as those outlined in IEC 62257-9-8. Should be tested and rated for compatibility with fan power draw and runtime expectations	• Test reports/certificates for battery: o Lithium batteries: ▪ UN 38.3 or IEC 62281 or IEC 62133

			▪ IEC 62619 or UL 1973 o Lead-acid batteries: ▪ IEC 61427 or IEC 60896-11 or 60896-22 (depending on battery type)
	Solar controllers	If provided or required, should regulate input and output reliably, with overcharge and low voltage disconnect protections.	• Solar controller specification sheet • General safety: IEC 62109-1 test report / certificate
	DC-AC Inverters	If the fan requires AC power input, any inverter used must be matched to the fan's power needs and comply with relevant safety and efficiency standards.	• Inverter specification sheet • Safety: IEC 62109-1 test report / certificate
Optional Performance Requirements			
Airflow Rate	Fan shall deliver a minimum airflow rate at its maximum setting: 30 m3/min for table and pedestal fans and 200 m3/min for ceiling fans.		Global LEAP/VeraSol Off-Grid Fan Test Report
Run Time	- The fan shall provide continuous airflow for a minimum of 4 hours at highest speed when operated on its designated battery or SHS connection - Where applicable, fans shall be able to run directly from PV modules or a compatible SHS without causing power instability or system faults		
Speed and power flexibility	Fans should have multiple speed settings to allow users to trade off airflow and energy consumption depending on availability of power		
Voltage fluctuations	The fan shall maintain functional performance at voltages ±15% of the rated input voltage (only tested under Global LEAP test method)		
Optional System Requirements			
Quality and Safety	Ingress protection	Meet physical ingress protection level IP2X Pass the Fan Blade Guard Safety Inspection results (not applicable to ceiling fans)	Global LEAP/VeraSol Off-Grid Fan Test Report
	Workmanship Inspection	Product shall be fitted with two or more well-balanced blades made from metal or other suitable material so as to be reasonably free from vibration. Fan bearings should be in good quality and appropriately lubricated for use.	From test report or VeraSol standardized specification sheet Check product images or inspect product samples
Size and packaging	Product size and packaging can be important factors. Procuring organizations should consider specifying the following physical aspects of fans to account for shipping, delivery models, and use cases.		
	Product size and weight	If needed for logistical purposes, the procuring agency can set the allowable limit of the product size and weight.	Product dimensions & weight: Test report Supplier should provide any missing or relevant specifications as needed
	Packaging	Transportation of products to the destination area is a common and important consideration for organizations. To comply with logistical constraints (e.g., loading onto pallets or packing for air-dropping), organizations may desire to set maximum packaging dimensions, maximum total packaged weight, or minimum number of units per pallet. Agencies may encourage the use of packaging materials that are recyclable biodegradable, and that avoids single use plastics where possible. Agencies may also promote compact packaging to reduce transport volume and environmental impact.	Supplier to provide any additional or relevant specifications as needed (e.g., further description of weights and dimensions, shipping details per pallet or container)

	Custom markings	Aid organizations and programs may require that the supplier afix additional printed content on the product and/or packaging. This may include the logo of the aid organization or program, unique ID numbers, or other custom markings.	Suppliers typically need to provide a written statement that they are capable of meeting any requirements for custom markings. Procuring organizations can request a sample of the product and/or packaging with the requested markings to be used for verification/approval.
User Manual Additional Requirements	As described above in the Minimum Quality Requirements, all products must be accompanied by basic user instructions, but some procuring organizations or program designers may desire to set additional requirements.		Suppliers should provide a digital sample of any proposed modifications to existing materials.
Extended Warranty	As described above in the Minimum Quality Requirements, all products must be accompanied by a 2-year consumer facing warranty. Some procuring organizations or program designers may choose to require a longer term warranty, and may desire additional requirements.		For any warranty requirements above and beyond the Minimum Requirements, the following may be requested of the supplier: • Digital copy of the modified consumer-facing warranty terms that will accompany the product • Statement from supplier describing the extended warranty duration (if applicable), and their ability to handle warranty issues in the context of the humanitarian situation, including how users can access warranty and the process they follow

6. Solar Water Pumps

6.1. Product Description

A Solar Water Pump is an electrically powered pumping system designed to extract and distribute water using energy generated by photovoltaic (PV) modules. It consists of a pump, controller, and one or more PV panels. Solar water pumps are commonly used for irrigation and household water supply. The solar water pumps covered meet the following criteria:

- **System Characteristics:** Solar water pumps intended for use in off-grid or weak-grid areas, compatible with standalone solar energy systems, mini-grids, or hybrid energy setups.
- **Electrical Characteristics:**
    - Designed to operate efficiently under off-grid (standalone) conditions or unreliable grid environments, with the ability to withstand power fluctuations and interruptions.
    - Power Compatibility: Capable of running on direct current (DC) from solar PV systems, alternating current (AC) from mini-grids or national grids, or hybrid systems with battery storage for extended operation.
- **Ease of Installation and Use:** Installation of SWP involves advance planning based on the site conditions (e.g. water source, distance of moving water, solar irradiance) and type of crops and their water needs. The pump distributors can help customers select the best combination of pumping solution based on those factors. SWP installation may be done by product distributors or specialized technicians to optimize pump performance.



FIGURE 4: Solar Water Pumping Appliance Illustrations

6.2. Product Testing and Quality Requirements

6.2.1. Test Methods

The International Electrotechnical Commission (IEC) has published IEC 62253, which provides guidelines for the design qualification and performance measurement of photovoltaic (PV) pumping systems. This standard measures performance of pumps including the P-Q (power to flow rate) curve at a constant head and H-Q (head to flow rate) curves at varying power. VeraSol developed a Global LEAP Off-Grid test method[17] for off-grid pumps (stand-alone direct current (DC) and single-phase alternating current which are typically complete products, preconfigured to include all electrical and mechanical components necessary for operation through the PV input interface and do not require expertise for electrical configuration, component compatibility or site design) The systems within the scope of this document are complete products, preconfigured to include all electrical and mechanical components necessary for operation through the PV input interface. The test method includes assessment of pump performance including P-Q and H-Q curves as well as quality, durability and consumer information assessment .

[17] Global LEAP Solar Water Pump Test Method Version 3 can be accessed here https://verasol.org/publications/swp-test-method/#:~:text=The%20test%20method%20consists%20of,durability%20metrics%20(Version%202%20only)

VeraSol test method referenced the following international test procedures in the preparation of the document: IEC 62253: 2011[18], IEC 62257-9-5: 2018[19] and IEC 62257-9-8:2020[20]

6.2.2. Quality and Safety Requirements

Currently, no international standard has been published that sets the minimum quality or performance requirements for solar water pumps. For the purpose of this document, VeraSol developed a preliminary criteria outlined in *Table 4* , alongside the applicable existing IEC safety standards.

6.3. Additional Optional Requirements for Solar Water Pumps

There are situations where procuring organizations and incentive programs require additional specifications beyond the minimum quality requirements. These additional requirements may focus on product performance, component, and system specifications to suit specific use cases. This section provides guidance on determining whether additional requirements for solar water pumps are necessary for a bulk procurement or incentive program. It includes key considerations for setting technical requirements and outlines optional performance and system specifications.

6.3.1. Optional Component Requirements

Solar water pumps are often sold with off-grid photovoltaic (PV) systems. While component-based PV systems are outside the scope of this document, procuring organizations should ensure that the PV system and its components meet all applicable standards and guidelines for design and installation. VeraSol's Quality Assurance Framework for Component-Based Energy Systems[21] is a practical reference for setting these quality requirements. The "Optional Component Requirements" section of Table 4, below, provides basic quality and safety standards for PV module, batteries, solar controllers, and DC-AC inverters, as they relate to solar water pumps.

6.3.2. Optional Performance Requirements

Specific performance features may be required or preferred depending on the local use case, water source, or irrigation system design. These may include:

- Pump type and configuration – Some applications may require submersible pumps with a total dynamic head (TDH) ≥40 meters, while others may prioritize surface pumps for pumping ground water.
- Pump must be capable of delivering a minimum specified daily water volume (e.g., xx liters/day per users needs: Good practice is to conduct a needs assessment under the local solar conditions)

[18] IEC 62253: 2011 Photovoltaic pumping systems – Design qualification and performance measurements can be accessed here https://webstore.iec.ch/en/publication/6636

[19] IEC 62257-9-5: 2018 Integrated systems – Laboratory evaluation of stand-alone renewable energy products for rural electrification can be purchased from IEC at https://webstore.iec.ch/en/publication/59747#:~:text=This%20document%20deals%20essentially%20with,voltages%20and%2For%20power%20ratings.

[20] IEC 62257-9-8:2020 Integrated systems- Requirements for stand-alone renewable energy products with power ratings less than or equal to 350 W can be purchased at IEC at https://webstore.iec.ch/en/publication/62431

[21] VeraSol's Quality Assurance Framework for Component-Based Energy Systems, including the framework overview, design guidelines, and installation guidelines, is available for download at: https://verasol.org/publications/quality-assurance-framework-for-component-based-energy-systems/

6.3.3. Optional System Requirements

Optional system-level requirements to be considered – including aspects related to product size and packaging, ease-of-use, and extended warranty – are detailed in Table 4.

6.4. Summary of Minimum and Optional Requirements for Solar Water Pumps

The following table compiles practical information about the minimum quality requirements and other optional requirements, which should be considered for any bulk procurement or program that includes solar water pumps in the product scope. The "Details" column of the table presents information about each category of requirement/specification that is intended to help decisionmakers determine if it is appropriate for a given application. The "Supplier Submission" column identifies the documentation and other materials that product suppliers should provide as evidence that a fan meets each requirement/specification.

TABLE 4: Procurement specification options for solar water pumps

Requirement Category	Specification	Details	Supplier Submission
Minimum Quality and Safety Requirements			
Solar Water Pump	Performance Reporting Requirements	Each water pump and its associated consumer-facing materials (e.g., packaging, product leaflet, online listing) must clearly display the following information: • Name or trademark of the manufacturer or responsible vendor • Uniquely identifiable product name or model number • Rated voltage or rated voltage range • Nature of power supply (AC or DC) • Rated input power (W) or rated current (A) • Pump type (e.g., submersible, surface) • Head range (m) • Maximum flow rate (liter/min) or total volume of water moved per solar day (m3/day) at specific head size • Recommended PV module power (W), current (I) and voltage (V) for optimal operation • Nominal battery voltage (if battery-operated or compatible)	Mandatory: Test report - Test report based on Global LEAP off-grid test method for solar water pumps, tested by VeraSol Test Lab Network Partner or - IEC 62253 test report from ISO-accredited labs Optional: • Picture(s) of product • Digital copy of user manual, warranty terms, and any other included documentation • Product sample(s)
	Safety Requirements	• Pump and controller system (if included) must comply with IEC 60335-1 and applicable parts of IEC 60335-2-41 (for pumps) • Pump casing must be designed to prevent water ingress. Submersible pumps should have a minimum of IP68 rating and surface pumps should have a minimum of IP54, evaluated per IEC 60529. • Electrical components must be protected against reverse polarity • Have dry-run protection – The pump should be able to detect and stop operation when no water is present (e.g., due to an empty well), protecting the motor from damage • Any included AC-DC or DC-DC power supply or controller must meet safety requirements outlined in IEC TS 62257-9-8, particularly if used in SHS or mini-grid environments • If plug-and-socket connectors are not used, connection interfaces (e.g., screw terminals, crimp lugs) must meet the standards outlined in IEC TS 62257-9-8	- 60335-2-41 test report (for pump safety) or - Test report based on Global LEAP off-grid test method for solar water pumps, tested by VeraSol Test Lab Network Partner (for safety evaluation, reverse polarity, and dry run protection) - IEC 60529 test report (for IP rating) - IEC 62557-9-8 (for AC-DC, DC-DC power supply, controller safety requirements and connectors requirements)
	User Manual	A clear and concise user manual must be provided in the appropriate local language(s), covering: • Installation and maintenance steps	Digital copy of user manual

		• Solar array specifications • Safe operation and daily maintenance • Maximum power input ratings for the pump and controller or inverter • Connection instructions if used with an SHS or mini-grid	
	Warranty	A minimum two-year warranty shall be included, covering manufacturing defects under normal use, including motor, controller, and structural integrity	Digital copy of consumer-facing warranty terms
Optional Component Requirements			
Power System	Photovoltaic (PV) modules	• Must be appropriately rated for solar water pumping applications and meet IEC 61215 and 61730 standards (or equivalent off-grid certification standards). • The PV module voltage and power output must match the operating requirements of the solar water pump.	IEC 61215 certificate / test report or IEC 61730 certificate / test report
	Pump controller	Maximum Power Point Tracking (MPPT) or Pulse Width Modulation (PWM) controllers, if required or included, should meet reliability and protection requirements under off-grid solar standards	• Solar controller specification sheet
	DC-AC inverter	For AC pump systems, any inverter included or required must be appropriately sized and tested to ensure compatibility with the pump's startup surge and operational requirements	• Inverter specification sheet • Safety: IEC 62109-1 test report / certificate
	Batteries	Where battery storage is used (for night or cloudy-day operation), batteries should meet quality and safety requirements relevant to cyclic use, such as those outlined in IEC 62257-9-8	• Test reports/certificates for battery: o Lithium batteries: ▪ UN 38.3 or IEC 62281 or IEC 62133 ▪ IEC 62619 or UL 1973 o Lead-acid batteries: ▪ IEC 61427 or IEC 60896-11 or 60896-22 (depending on battery type)
Physical Durability	To increase the likelihood of long-term functionality of a solar water pump, procuring organizations and projects supporting solar irrigation may desire to set additional durability requirements. The following are commonly used requirements addressing physical durability. - Switches and connectors: No damages or safety hazards and the pump remains functional after 1000 cycles testing. - Cable Strain Relief: No damages or safety hazards and the pump remains functional - Drop test (only for portable surface pumps): No permanent, non-superficial damages or safety hazards caused by the drop test and pump remains functional		Global LEAP test report or Product specifications sheet showing materials used and allowable temperature range.
Optional Performance Requirements			
Pump type and configuration	Some applications may require submersible pumps with a specific head range (e.g. ≥40 meters) if the water source is deep, such as in boreholes or wells, and the pump needs to lift water over a significant vertical distance to the delivery point. To select the proper head range, it is essential to conduct hydrogeological surveys or on-site water level measurement to know the exact water levels of the location.		Review the Product Specifications & test report; should include detailed descriptions of the appliance's parameters, capabilities, performance metrics and/or technical specifications.

Minimum specified daily water volume	Pump must be capable of delivering a minimum specified daily water volume (e.g., xx liters/day per user's needs: Good practice is to conduct a needs assessment under the local solar conditions)		
Optional System Requirements			
Safety	Overload protection & Grounding Should have mechanisms to prevent damage from excessive load & Should have proper grounding to prevent electrical shock hazards		Review test reports and products specifications sheet
Control System	Maximum Power Point Tracking (MPPT)	MPPT Shall have a feature that optimizes the energy extraction from the solar panel, enhancing efficiency.	
	Intelligent Controls	Certain applications may benefit from intelligent features like automatic start/stop based on sunlight availability and water level monitoring	
Size and packaging	Product size and packaging can be important factors, especially for humanitarian applications. Procuring organizations should consider specifying the following physical aspects to account for shipping, delivery models, and use cases.		
	Packaging	Transportation of products to the destination area is a common and important consideration for aid organizations. To comply with logistical constraints (e.g., loading onto pallets or packing for air-dropping), humanitarian organizations may desire to set maximum packaging dimensions, maximum total packaged weight, or minimum number of units per pallet. Agencies may encourage the use of packaging materials that are recyclable biodegradable, and that avoids single use plastics where possible. Agencies may also promote compact packaging to reduce transport volume and environmental impact.	Product dimensions & weight: Supplier to provide any additional or relevant specifications as needed (e.g., further description of weights and dimensions, shipping details per pallet or container)
	Custom markings	Aid organizations and programs may require that the supplier affix additional printed content on the product and/or packaging. This may include the logo of the aid organization or program, unique ID numbers, or other custom markings.	Suppliers typically need to provide a written statement that they are capable of meeting any requirements for custom markings. Procuring organizations can request a sample of the product and/or packaging with the requested markings to be used for verification/approval.
User manual additional requirements	As described above in the Minimum Quality Requirements, all products must be accompanied by a user manual that covers installation, operation and troubleshooting. Some procuring organizations or program designers may desire to set additional requirements appropriate for specific use cases.		Suppliers should provide a digital sample of any proposed modifications to existing materials.
Extended Warranty	As described above in the Minimum Quality Requirements, all solar water pumps should be accompanied by a 2-year consumer facing warranty. Some procuring organizations or program designers may choose to require a longer term warranty and may desire additional requirements such as warranty terms for individual components (e.g., motor, controller), or a 5-year minimum warranty for PV modules.		For any warranty requirements above and beyond the Minimum Requirements, the following may be requested of the supplier: • Digital copy of the modified consumer-facing warranty terms that will accompany the product • Statement from supplier describing the extended warranty duration (if applicable), and their ability to

		handle warranty issues in the context of the humanitarian situation, including how users can access warranty and the process they follow

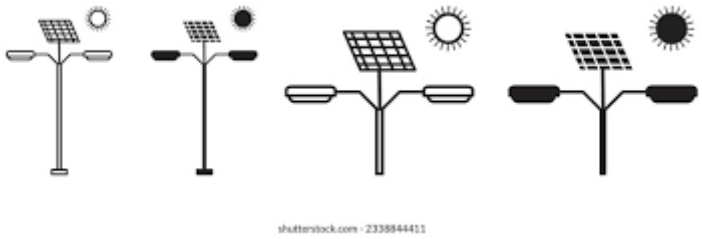
7. Solar LED Streetlights

7.1.Product Description

A solar streetlight is an outdoor lighting system powered by solar energy, consisting of a PV panel, battery, LED light, and a controller. The PV panel and controller charge the battery during the day, then the LED light automatically illuminates streets or pathways at night without relying on the electrical grid. Solar streetlights are widely used in urban and rural areas, highways, public spaces, and community infrastructure projects. They offer a sustainable and cost-effective alternative to conventional street lighting where access to reliable electricity is limited.

The solar streetlights addressed in this document meet the following criteria:

- **Form factor:** A vertically mounted pole supports all major components in a compact design, which includes:
  - PV module located at the top of the pole
  - Flat profile luminaire with an LED array on the underside
  - Battery and controller enclosed in a tamper- and weather-resistant housing; These can be integrated into the luminaire housing (in integrated models) or in a separate compartment on the pole (in split models)
- **Applications:** Designed to operate in off-grid settings to light outdoor public spaces occupied by people at night, including areas such as parking lots, paths and walkways, parks, playgrounds, outdoor markets, and other areas where pedestrians travel or congregate[22]
- **Electrical Characteristics**:
  - Powered by direct current (DC) from solar PV systems
  - Battery capacity sized to support multiple days of autonomy
  - Sensors and control system for automatic nighttime operation and adaptive energy management to optimize energy use and extend battery life



(TO INSERT GOOD GRAPHICS LATER) **FIGURE 5: SOLAR STREET LIGHT ILLUSTRATIONS**

7.2. Product Testing and Quality Requirements

7.2.1. Test Methods

The International Electrotechnical Commission (IEC) and other relevant standardization bodies have established guidelines for the safety, performance, and energy efficiency of electrical appliances, including solar-powered streetlights. Standards such as IEC 60598-2-3 (Luminaires – Particular requirements for road and street lighting) and IEC 62257-9-5 (Recommendations for stand-alone

[22] The recommended technical requirements for solar streetlights in this document do not apply to streets or motorways used primarily by motorized vehicles. These applications require increased attention to safety and visibility factors to mitigate the hazards of pedestrians and vehicles interacting in an outdoor nighttime environment. For these situations, it is vitally important that a lighting design professional be involved in the design and commissioning process, and that national design codes or international lighting standards be incorporated into these lighting projects to ensure public safety.

renewable energy products) provide a framework for assessing the design, efficiency, and operational reliability of solar street lighting systems under various environmental conditions. Key components of solar streetlights (luminaires, PV modules, batteries, charge controllers) should also be tested using IEC and other internationally harmonized test methods.

7.2.2. Quality Requirements

Currently, there is no single quality standard specifically for solar streetlights, but high-quality products should comply with a combination of international standards that cover safety, performance and durability. This guideline recommends a holistic set of component and system requirements that a procuring entity can use to ensure they purchase a safe, durable, and fit-to-purpose solar streetlight.

7.3. Additional Optional Requirements for Solar Streetlights

These guidelines present additional requirements that may be considered for components, the complete streetlight system, and for its performance. Procuring agencies and can select optional requirements in alignment with specific use cases.

7.3.1. Optional Component Requirements

Bulk procurements and incentive programs may prefer to set prescriptive requirements for the batteries and charge controllers included in solar streetlights. Lithium batteries are being more frequently specified due to multiple benefits over lead-acid batteries and increasingly competitive pricing. Battery charge controllers that use Maximum Power Point Tracking are also commonly specified, as they are readily available, affordable, and offer advantages over other technologies.

7.3.2. Optional Performance Requirements

Optional performance requirements presented for solar streetlights include key lighting characteristics, such as total light output, color temperature, illuminance and uniformity. System autonomy (number of days the streetlight can operate without being charged) is another important performance metric that should be specified according to the location and types of activities to be illuminated.

7.3.3. Optional System Requirements

Optional system-level requirements to be considered – including intelligent controls, remote monitoring, product size and packaging – are detailed below in *Table 5*.

7.4. Summary of Minimum and Optional Requirements for Solar Streetlights

The following table compiles practical information about the minimum quality requirements and other optional requirements, which should be considered for any bulk procurement or program that includes solar streetlights in the product scope. The "Details" column of the table presents information about each category of requirement/specification that is intended to help decisionmakers determine if it is appropriate for a given application. The "Supplier Submission" column identifies the documentation and other materials that product suppliers should provide as evidence that a solar streetlight meets each requirement/specification.

Keep in mind that the proposed requirements for solar streetlights in the following table focus on the overall system and key components. While the mounting pole and foundation are mentioned, installation and overall outdoor lighting design are outside the scope of these recommendations. It is highly recommended to employ the services of a qualified lighting professional who can conduct the necessary analyses to ensure that the lighting needs are met.

TABLE 5: PROCUREMENT SPECIFICATION OPTIONS FOR SOLAR STREETLIGHTS

Requirement Category	Specification	Details	Supplier Submission
Minimum Requirements			
Complete Solar Streetlight	Quality and Safety Requirements	The solar streetlight must meet the following quality and safety requirements: • Electrical safety shall comply with IEC 62109-1 or the applicable sections of IEC 60598-2-3 • Must have an ingress protection level equal to or better than IP55, as tested via IEC 60529 • Grounding ("earthing") and lightening protection must be installed on each mounting pole according to local electrical codes	• IEC 62109-1 or IEC 60598-2-3 test report / certificate • IEC 60529 test report
	Consumer-facing Information	The following information must be provided on the solar streetlight, in accompanying documentation, or on product packaging: • Name or trademark of the manufacturer or responsible vendor • Uniquely identifiable product name or model number • Rated luminous flux of the luminaire (lumens [lm]) • Rated luminous efficacy (lumens per watt [lm/W]) • Light distribution type and cutoff • Lighting mode(s), e.g., constant, dimming, sensor based, timer controlled • Rated battery capacity [Ah or Wh] • Battery type (e.g., $LiFePO_4$, AGM, etc.) • Rated solar PV panel peak power [Wp] • Rated operating voltage or voltage range [V] • Rated autonomy in hours (number of hours the light can operate without solar input [h]) • Ingress protection rating of battery enclosure and/or luminaire housing (e.g., IP65)	Mandatory: • Data sheet for solar streetlight data sheet • Battery data sheet • PV module data sheet Optional: • Picture(s) of product and key components • Digital copy of user manual, product packaging, and any included documentation • Product sample(s)
	Warranty	A manufacturer's warranty against manufacturing defects under normal use for at least 2 years shall cover the complete solar streetlight. Some manufacturers' warranties extend to 5 or 10 years. All major system components must also be covered under a manufacturer's warranty. Typical warranty periods for key components include: • PV module: 10-20 years • LED luminaire: 3-5 years • Battery: 2-5 years • Charge controller: 2-5 years	The following may be requested of the supplier: • Digital copy of the consumer-facing warranty terms that will accompany the product • Statement from supplier describing the extended warranty duration (if applicable), and their ability to handle warranty issues in the context of the humanitarian situation, including how users can access warranty and the process they follow
	User Manual	A user manual covering installation, setup, maintenance, and basic troubleshooting shall be provided using language and graphics appropriate for the intended market.	The supplier should provide a digital sample of the user manual, and any proposed modifications to existing materials to comply with procurement-specific requirements.

		The user manual must present instructions for installation, use, and troubleshooting of the system. Installation instructions must include appropriate placement and installation of the appliance. 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	
System Components	PV module	The PV module included with the streetlight must be tested and meet the following standards: • IEC 61215 (all parts): "Crystalline silicon terrestrial PV modules – Design qualification and type approval" • IEC 61730 (all parts): "Photovoltaic (PV) module safety qualification"	• IEC 61215 test report / certificate • IEC 61730 test report / certificate

	Battery	The battery included with the streetlight must meet the following requirements:
		• Lithium batteries
		  ○ Safety during transport: UN 38.3 or IEC 62281 or IEC 62133
		  ○ Safety during operation: IEC 62619 or UL 1973
		• Lead-acid batteries (one of the following applicable standards):
		  ○ Safety & performance for renewable energy systems: IEC 61427
		  ○ Safety for stationary valve-regulated: IEC 60896-11
		  ○ Safety for stationary vented: IEC 60896-22
		• Lead-acid battery cycle life: The rated cycle life must be at least 1,100 cycles down to 50% depth of discharge at standard temperature (typically 20 °C to 25 °C)
			• Battery specification sheet
			• Test reports/certificates for battery:
			  ○ Lithium batteries:
			  ▪ UN 38.3 or IEC 62281 or IEC 62133
			  ▪ IEC 62619 or UL 1973
			  ○ Lead-acid batteries:
			  ▪ IEC 61427 or IEC 60896-11 or 60896-22 (depending on battery type)
			  ▪ Test results from IEC 61427 or IEC 60896 showing rated cycle life of at least 1,100 cycles

	Integrated Battery Management System (BMS)	The BMS integrated in the solar streetlight must: • Protect the battery from short circuit, overcharge, and deep discharge according to levels set in the battery specifications • Be designed to prevent operation outside the battery's specified temperature range for charging and discharging	• BMS specification sheet • BMS for lithium batteries: IEC 62133 or 62619 test report • BMS for lead-acid batteries: IEC 62019 test report

	Luminaire	The LED light source must meet the following requirements:
		• Tested to confirm luminaire luminous flux (lumen [lm]), Color Rendering Index (CRI), and Correlated Color Temperature (CCT) according to one of the following:
		  ○ IEC 62722,
		  ○ IESNA LM-79,
		  ○ IEC TS 62257-12-1,
		  ○ IEC TS 62257-9-5
		  ○ IEC 62612
		• Must have a projected lifetime of at least 50,000 hours based on results from one of the following:
		  ○ ANSI/IES LM-80-20 and ANSI/IES TM-21-21, or
		  ○ ANSI/IES LM-84-20 and ANSI/IES TM-28-20
		• Lighting controls: The light shall automatically turn on at dusk and off at dawn or be programmable based on time
			• Test report showing luminous flux, CRI, and CCT, as listed.
			• Test report showing projected lifetime, as listed
			• Luminaire specifications sheet describing lighting controls

Mounting Structure	Pole	The minimum or desired mounting pole height should be specified. While five meters (5 m) is common, the pole height should be selected according to the luminous flux and light distribution of the luminaire, as well as the area to be illuminated and the activities conducted therein.	Specification sheet for selected mounting pole
	Durability & Construction	Any included poles, brackets, or mounts should meet applicable mechanical load and corrosion resistance requirements for the intended installation environment. Typical requirements include stainless steel hardware, galvanized steel pole and reinforced concrete pedestal.	• Specifications detailing materials and design of all mounting hardware • Technical drawings detailing the dimensions and makeup of the concrete foundation, pole, and fasteners
Optional Component Requirements			
Battery chemistry	Some programs and procuring organizations specify that batteries must be lithium-based to benefit from advantages such as higher energy density, increased life and durability.		Specifications sheet for the battery and/or charge controller
Charge Controller	To improve the efficiency and overall performance of solar streetlights, one may opt to require a Maximum Power Point Tracking (MPPT) charge controller to be integrated into the device's internal electronics.		
Optional Performance Requirements			
Luminaire	Depending on the intended use, it may be necessary to specify the lighting characteristics that the luminaire must meet. If prescriptive lighting requirements are to be set, it is highly recommended that they be based on the outcomes of an assessment conducted by a qualified outdoor lighting designer. The following lighting specifications may be considered: • Minimum light output (luminous flux [lm]) • Correlated Color Temperature (CCT) (degrees Kelvin [K]). To reduce glare, potential health impacts, and light pollution, ≤3000 K is commonly specified for outdoor public spaces. • Average illuminance level (lux [lx]), e.g., 10-20 lx average • Uniformity (i.e., measure of how evenly light is distributed across a surface) is expressed as the ratio of average illuminance to minimum illuminance. A uniformity ratio of 10:1 is common for general pedestrian applications. • Light distribution and cutoff: Best practice for outdoor lighting design specifies characteristics that are suitable for the intended application. Common requirements include "full cutoff" light distribution where no light above 90° exits the luminaire, and light between 80° - 90° is restricted to 10% of the total light output. This minimizes light pollution and glare. • Luminous efficacy (lumens per watt [lm/W]) may be specified if maximizing energy efficiency is priority. Typical levels are at least 100 lm/W, with some luminaires capable of exceeding 150 lm/W.		Relevant test reports shall be provided as evidence that a luminaire meets any minimum performance requirements. Refer to the test methods listed above in the "Luminaire" subsection of the "Minimum Requirements".
Autonomy	Consider requiring a minimum number of days of autonomy according to the expected location and use. Autonomy is the ability of the solar streetlight to operate for a specified number of nights (typically ≥3) without solar charging.		• Specifications sheet for solar streetlight • Streetlight autonomy claims can be checked by a simple estimating calculation of "usable battery capacity (Wh) divided by the daily energy consumption (Wh/day).
Optional System Requirements			

Control & Adaptive Lighting Features	Modern solar streetlights commonly include “intelligent” features such as motion sensors, dimming functions, and smart lighting controls to optimize energy use. While products with these features may come at a slightly higher cost, requiring some or all of these intelligent features may be warranted if optimizing energy efficiency and autonomy is a priority. Motion sensing is also a common feature of solar streetlights. False triggering, poor sensor coverage, and sensor malfunction can be problematic, however, and therefore motion sensing is not recommended.		Specifications sheet for solar streetlight
Remote Monitoring	Some solar streetlights have integrated remote monitoring technology that transmits information via mobile networks or the internet. Remote monitoring may be appropriate if a project or installation needs to track system operation and/or reliability at a regular frequency.		
Size & Packaging	Product size and packaging can be important factors for humanitarian applications. Procuring organizations should consider specifying the following physical aspects of the solar street lights to account for shipping, delivery models, and use cases.		
	Product size and weight	In some instances, it is important to limit the product size and weight depending on users on organization needs	Suppliers should declare their products dimensions and weight Supplier to provide any additional or relevant specifications as needed (e.g., further description of weights and dimensions, shipping details per pallet or container)
	Packaging	Transportation of products to the destination area is a common and important consideration for aid organizations. To comply with logistical constraints (e.g., loading onto pallets or packing for air-dropping), humanitarian organizations may desire to set maximum packaging dimensions, maximum total packaged weight, or minimum number of units per pallet. Agencies may encourage the use of packaging materials that are recyclable biodegradable, and that avoids single use plastics where possible. Agencies may also promote compact packaging to reduce transport volume and environmental impact.	Supplier to provide any additional or relevant specifications as needed (e.g., further description of weights and dimensions, shipping details per pallet or container)
	Custom markings	Aid organizations and programs may require that the supplier afix additional printed content on the product and/or packaging. This may include the logo of the aid organization or program, unique ID numbers, or other custom markings.	Suppliers typically need to provide a written statement that they are capable of meeting any requirements for custom markings. Procuring organizations can request a sample of the product and/or packaging with the requested markings to be used for verification/approval.

8. Product Usability and Field Testing

The process of procuring off- and weak-grid appropriate appliances may include field and usability testing of supplier-furnished samples before purchase. Testing can provide valuable insights into the practicality, performance, and overall quality of an appliance. It allows organizations and programs to make informed purchasing decisions, ensuring that the appliance will meet consumers' needs and that it will be easy to operate in their daily lives.

User Experience: Usability testing evaluates how intuitive an appliance is to operate. A user-friendly product has a clear, user-friendly interface without complicated instructions or cumbersome steps. By observing how quickly and easily users can operate the appliance, organizations can assess its suitability for everyday use. Additionally, product demonstration sessions can be conducted, allowing users to test the appliance for a few days before finalizing the procurement decision.

Field Testing: Testing the appliance's performance is crucial to ensure it performs its tasks as expected and meets its advertised performance standards[23]. If possible, program implementers can conduct tests that simulate extended use (e.g., repeated cycles or usage over days or weeks) to check if the appliance can handle prolonged stress and whether it maintains efficiency throughout.

9. Product Repairability

Appliance procurement programs and consumers make a worthwhile investment when appliances provide reliable, long-term service. Product durability is especially important for incentive programs that support commercial sales to low-income consumers who are sensitive to value. Easily reparable products play a key role in minimizing environmental impact and supporting local economies. The primary goal is to extend a product's lifespan through designs that facilitate repair and repurposing.

IEC 62550:2017 describes requirements for spare parts provisioning as a part of supportability activities that affect dependability performance so that continuity of operation of products, equipment and systems for their intended application can be sustained.
Efficiency for Access published a research paper that outlines findings of current repair practices and key criteria for assessing repairability, as well as repair indices for solar water pumps, fans, and refrigerators.

TABLE 6: RECOMMENDED REQUIREMENTS FOR EASE OF PRODUCT REPAIRABILITY

Requirement Category	Details	Supplier Submission
Optional Supplier Requirements		
Documentation – User/Repair Manual	For an added layer of consumer protection, bulk procurement and energy access programs often require that suppliers have certain additional measures in place to ensure robust after-sales service. These measures may include a well detailed user manual and a local customer service team / call center that can respond to customer questions and complaints.	• Suppliers commonly need to provide a written statement that they are capable of meeting requirements related to after-sales service. • Suppliers should provide evidence of their local presence and services available in the country/region in question. • Suppliers should provide user and repair manuals that are clear, self-explanatory, and easy to understand. They should be easily accessible and should incorporate visual aids and relevant graphics to enhance usability.

[23] Efficiency For Access Evaluating Appliance Performance in the Field: Results from Appliance Testing Accessed on March 27 2025. Evaluating Appliance Performance in the Field: Results from Appliance Testing

Availability of spare parts & components	Procurement agencies and programs must ensure that suppliers' appliances can be repaired locally by requiring evidence of the availability of spare and replacement parts within the country. This ensures that appliances remain functional over their lifespan, reducing downtime and maintenance costs while enhancing user confidence.	Suppliers must provide a list of spare parts along with their specifications and instructions on how to obtain them (spare part distribution channels). All components classified as 'frequently replaced parts' must be available as spare parts. Additionally, if a special tool is required for replacement, it must be included with the spare part.
Designed for disassembly	Procurement agencies and programs must ensure that suppliers' appliances are designed for disassembly. Improving disassembly ease facilitates repair, replacement, recycling, material recovery, value retention, and meaningful reuse. Ease of repairability may need to be balanced against risk of theft of components.	Suppliers commonly need to provide the disassembly process of the appliance, including steps and manipulations. These steps must be clearly documented and quantified.
Skills Availability	Complex repair issues should be managed by a network of qualified experts within the country. These experts must have access to high-quality replacement parts, repair information, and necessary tools. Additionally, the availability of qualified repair technicians or a structured training plan should be well-documented.	Suppliers should provide documentation on local service networks and technical support availability to guarantee long-term product sustainability and minimize reliance on costly or time-consuming imports.

10. Product End-of-life Management

The rapid expansion of the off-grid solar sector over the past decade has been a major milestone in clean energy, reducing CO_2 emissions and providing energy access to hundreds of millions in off- and weak-grid communities. However, this progress has come with the cost of the increasing proliferation of electronic waste (e-waste). This growing challenge poses environmental and health risks to the very communities benefiting from off-grid energy solutions[24].

In June 2022, the 189 Parties to the Basel Convention agreed to regulate international trade in electrical and electronic waste to prevent improper recycling and disposal. This decision aims to ensure that such materials are directed to facilities capable of recovering resources in an environmentally sound manner. Starting January 1, 2025, both hazardous and non-hazardous e-waste and scrap are subject to Basel Convention regulations in all participating countries[25]. The convention seeks to reduce the movement of hazardous waste between countries, to ensure environmentally sound management of hazardous waste at their end of life and to prevent poor e-waste disposal practices that are harmful to human health and the environment.

To ensure effective e-waste management, international cross-sector partnerships are essential. These partnerships should include manufacturers, suppliers, development partners, agencies, and local waste treatment actors. Additionally, integrating end-of-life management requirements into procurement of off- and weak-grid appliances is strongly recommended.

TABLE 7: SUPPLIER SELECTION CRITERIA FOR PRODUCT END-OF-LIFE MANAGEMENT

Requirement Category	Details	Supplier Submission
Optional Supplier Requirements		
End-of-life e-waste management	Procurement agencies and programs may need to comply with certain e-waste requirements, which need to be specified in addition to the quality standards. When setting e-waste requirements, take into account the existing infrastructure (or lack thereof) in the country or region. Strive to hold consumers and suppliers responsible for e-waste, while being realistic about the capacity to properly handle e-waste in emerging markets	Suppliers commonly need to provide an e-waste management plan, describing how non-functional appliance components are responsibly handled.

[24] Efficiency for Access Innovations in Off-Grid Solar E-Waste Management Accesed on March 27 2025. Innovations in Off-Grid Solar E-Waste Management - Efficiency for Access

[25] Basel Convention amendments UNEP-CHW-COP.15-BC-15-18.English.pdf

Service contract with local waste management company	Product suppliers shall provide a nationwide product take-back service for recycling, repair and disposal. Suppliers shall contract a local company for the disposal of end-of-life products.	Suppliers should provide evidence of their local presence or local partners and services available to handle waste management in the country/region in question.

11. Supplier Eligibility Criteria

Selecting a reliable supplier is crucial for ensuring the sustainability of off- and weak-grid appropriate appliances. The ideal supplier will not only deliver the right product but will also enhance the system's longevity through quality workmanship, customer support, and warranty service. If the supplier is contracted to install the equipment, they must not only ensure proper installation, but also abide by local codes, regulations, and best practices for safety, performance testing and system handover.

In this context, the recommendations in this section help guide the evaluation and selection of suppliers for the procurement of off- and weak-grid appliances. Appropriately selected criteria reflect both the strategic priorities of the procuring organization and the practical considerations required to ensure successful project implementation. **Error! Reference source not found.**, below, summarizes recommended supplier requirements and provides details of the information that they should provide as evidence of compliance.

TABLE 8: RECOMMENDED SUPPLIER REQUIREMENTS & SUBMISSIONS FOR OFF-AND WEAK-GRID ENERGY APPLIANCES

Supplier Requirement Category	Details	Supplier Submission
Readiness & Product Stock	Procurement of off- and weak-grid appliances requires that product suppliers be capable of delivery within the required timelines. When procuring appliances, procurement organizations commonly specify a maximum allowable delivery time for a specified quantity of product units.	• Suppliers commonly need to provide a written statement that they are capable of meeting requirements related to the availability of product stock and ability to ship specific product quantities within a specified timeframe. • Suppliers should also provide a track record of prior sales of the same or similar products to end consumers. • Suppliers should also provide a month-by-month projection of sales for the intended procurement. Bidders must demonstrate a viable plan to market and sell eligible products to end consumers by the program deadline.
Technical Capacity	Procurement agencies and programs should ensure that suppliers have the technical capacity to execute the project. This entails checking that the staff is certified and adequately trained and can successfully implement the project or provide after sales support. Has certified trained staff that can provide training to the buyer and users during installation on the handling, operation, management and maintenance of the systems.	• Suppliers should provide team CVs of relevant company staff. • Suppliers should also provide training or demonstration plans for end users.
Financial Stability	Procurement agencies and programs should ensure that suppliers are financially stable to minimize the risk of supply chain disruptions and ensure long-term serviceability. Financially stable suppliers are more likely to meet contractual obligations, maintain consistent product quality, and provide after-sales support, including warranties, spare parts, and repairs.	Suppliers need to provide financial statements, credit ratings, business track records or performance guarantee to show financial viability
Quality Management System	To further mitigate the risk of inconsistent product quality, procuring organizations and programs may choose to require that suppliers have a framework for a Quality Management System (QMS) through certification according to ISO 9001:2015. This certification helps organizations ensure they consistently deliver products and services that meet customer and regulatory requirements, while also aiming to enhance customer satisfaction and drive continuous improvement.	Valid and traceable ISO 9001:2015 certificate

12. Conclusions

To ensure transparency, value for money, and the procurement of quality verified appliances that meet project requirements, it is essential to establish clear and objective appliance and supplier selection criteria. These criteria serve as a benchmark to assess appliances for their ability to meet essential energy service needs, and to evaluate suppliers based on their capacity to deliver reliable products and services in alignment with the technical and operational needs of the project.

The selection process is designed to promote competitiveness and fairness, while prioritizing quality verified appliances and suppliers with a proven track record. By applying these criteria consistently, the procurement process not only supports effective decision-making but also minimizes risks related to product performance, delivery timelines, and after-sales support. Ultimately, this approach contributes to achieving long-term sustainability goals and ensures that procurement efforts generate maximum impact.