BID SPECIFICATION TEMPLATES FOR OFF-GRID SOLAR SYSTEMS FOR PUBLIC FACILITIES

WITH A FOCUS ON PRIVATE-SECTOR-SUPPORTED SERVICE DELIVERY MODELS

LIGHTING AFRICA
Catalyzing markets for modern off-grid energy

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Schatz Energy Research Center

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Foreword

These bid specification templates are intended to be used in conjunction with the *Requirements and Guidelines for Installation of Off-grid Solar Systems for Public Facilities,* a quality assurance framework prepared under the World Bank's Lighting Africa program. Further, the *Off-grid Public Facilities PV System Design Tool* may be used to assist with designing the systems described in the bid specifications. These bid specification templates were prepared by Kevin Gauna (Sunbrothers) with support from the Schatz Energy Research Center.

While care has been taken to ensure this guideline is free from omission and error, no responsibility can be taken for the use of this information in the design, procurement, installation, or maintenance of any off-grid photovoltaic system.

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Bid Specification Templates for Off-grid Solar Systems for Public Facilities

with a focus on private-sector-supported service delivery models

1 Introduction

These Bid Specification Guidelines (Bid Spec Guidelines) are intended to assist project developers to compose initial request for proposals (RFPs) for off-grid electrification programs for public facilities with a focus on private-sector-supported service delivery models.They contain summary instructions on the necessary technical information that should be contained in a bid specification (bid spec) as well as templates and template examples that can be used by a project developer as part of the RFP process.

Project developers are directed to create a classification system for different facilities according to the facility function (e.g. health clinics, schools, etc.). These classifications, labelled as 'facility types', are then used to define the energy needs that must be met by an off-grid PV system design to service that facility type. This allows prospective project implementers (bidders) to develop cost estimates for a small number of facility types without requiring separate bids for each individual location. This approach is intended to reduce the burden on project implementers during the initial bid stage and simplify the overall project by reducing the number of individual designs required to service a large number of project sites.

After the facility type designations for a project are established, the project developer will develop a bid spec for that facility type with enough information to enable a project implementer to propose a design and quote a cost. The quotation is expected to include the cost of all necessary equipment, the cost to install and commission a fully functioning system, and the cost to monitor, maintain, and service the system under a service delivery contract. One important consideration is whether or not each individual location has existing infrastructure such as proper electrical equipment rooms and satisfactory pre-existing wiring that can be utilized during the installation. To allow the use of existing infrastructure, an allowance is made for pre-wired or non-wired categorization.

To formulate an RFP, a project developer will fill out templates that include the technical information a project implementer needs to design a PV system for each facility type included in the project. This includes the energy requirements of the facility type, limitations or design requirements that the project developer would like to place on the equipment choices and system configuration, and the assumptions that must be used by the project implementer in calculations used to describe system performance. The bid spec templates in this document are formatted to help project implementers return consistent, comparable bids for systems that will satisfy the performance requirements and service delivery of the various facility types.

Guidance for filling out the bid spec templates can be found in the lead document *Requirements and Guidelines for Installation of Off-grid Solar Systems for Public Facilities* under the referenced sections of that document. Energy services calculations can be made with the *Off-grid Public Facilities PV System Design Tool* or can be performed independently by a PV system design professional. In addition to these resources, there may be country-specific standard equipment requirements or guidance for different facility types, often published by the relevant ministry or similar government agency.

2 Scope

These guidelines are intended to help project developers write bid specifications for small and midsize public facilities such as rural schools and health clinics. An emphasis has been given to projects that include 10s or 100s of similar facilities that may be serviced by a small number of different PV system designs.

Each facility type will have a number of buildings and rooms that require some level of electrical service. Instructions are provided for the project developer to identify load requirements that may include lights, fans, computer/printer equipment, mobile phone charging, refrigeration, and possibly specialized medical equipment as necessary. Typical off-grid solar systems that provide energy service for these facility types will often power AC loads of the types mentioned above and have solar power generation capabilities in the 1-20 kW range, though larger systems are also feasible under the framework provided here.

The guidelines include templates to be filled out by the project developer as part of a bid specification. The templates include technical information that a project implementer will need to design a PV system for each facility type. Limited guidance is provided for project implementers on how to properly respond to a bid specification. For more information on what a project implementer should include in a bid document, see *Requirements and Guidelines for Installation of Off-grid Solar Systems for Public Facilities* Section 5.5.

3 Use of this document

The templates presented below may be copied into a bid specification from a project developer that is part of a larger RFP. Instructions are included for the type and format of each metric or element that is required. The templates may be modified as necessary to fit the particular needs of the RFP.

The instructions and templates presented here are derived from more detailed information found in the lead document *Requirements and Guidelines for Installation of Off-grid Solar Systems for Public Facilities*. References are provided to relevant sections in the lead document. The lead document should be used in conjunction with the templates to develop the technical specifications of the PV systems design requirements for each facility type.

Some information that is required in the bid spec must be calculated based on a load profile. A design tool has been developed to assist in these calculations titled *Off-grid Public Facilities PV System Design Tool*. Project developers may choose to use this tool to estimate the required size of PV systems, but this is not a requirement; other tools and PV system design professionals are available that can perform these calculations.

Text within the sample templates that is red is instructional and should not be included in the bid specification. Identical blank templates in landscape format are provided in Section 12.

4 Terms and definitions

The terms '**project developer**' and '**project implementer**' are used throughout this bid spec document to differentiate the entity that manages the PV program and formulates the bid

specification (project developer) from the entity that responds to the bid spec with a PV system design and cost estimate or quote (project implementer). The broader definitions for these entities are:

project developer
The organization, company, or person who defines and promotes the off-grid solar electricity project, assigns the project implementer, determines compliance with the specifications and is responsible for obtaining resources for financing the project. The project developer may dictate the system design (or aspects of it), or assign the responsibility of system design to the project implementer. This can include local regulatory bodies and/or other government and non-government organizations with a primary role in facilitating the planning, purchase, and maintenance of the system. There can be more than one project developer for a single off-grid solar electricity system installation.

The project developer is also referred to as the **employer** or **proposer** by World Bank procurement guidelines and may have other names in other procurement systems.

project implementer
The organization, company or person entrusted by the project developer to perform the work (which may include system design) or have this work performed pursuant to the general specification, possibly through some subcontractors (IEC TS 62257-3, 2015).

The project implementer is also referred to as the **bidder**, **contractor**, or **supplier** by World Bank procurement guidelines.

5 Developing the bid specification

5.1 General

The lead document *Requirements and Guidelines for Installation of Off-grid Solar Systems for Public Facilities, Sections 5.4 and 5.5,* outlines the technical documentation requirements that project developers should include in the bid specification and how these requirements fit into the overall process of soliciting bids from project implementers. Project developers may use either a single or multi-stage bidding process according to the size and timing of the electrification project, with consideration given to the work required from prospective project implementers such that the initial RFP requirements do not impose an undue burden and reduce the number of applicants. Smaller projects in particular may allow a single-stage bidding process where more detailed information is required from a project implementer in its initial bid response. The lead document outlines this process and lists documentation requirements for both a ‘bid stage’ and ‘full-design stage’ in Section 5.5.

Other necessary elements of a comprehensive RFP are not discussed in detail by this document but should include, at minimum and at the discretion of the project developer, the following items:

- timelines of different stages of the project including various submission deadlines for project developers and project implementers as well as construction schedules, if available, and other timelines known or planned.
- company specific requirements such as key personnel minimum technical requirements, experience with similar projects, company size and team organization structure, staffing plan requirements, references, etc.
- company minimum financial requirements for installers and equipment O&M servicing companies.
- national and/or local building code requirements
- commissioning requirements

5.2 RFP development tasks

Formulating a comprehensive RFP will necessarily include all of the typical procurement requirements and procedures of the project developer/employer/proposer organization(s). Table 1 summarizes the PV-specific project developer tasks during this process including the necessary steps to identify and assess project sites, group the sites according to function and energy needs, and develop the technical requirements for PV systems that will serve these sites.

Table 1. Developing a bid specification

Project developer task	Personnel	Notes
Identify sites Determine project sites for electrification based on need, existing services, and geographic factors (Section 5.3)	Government agencies and program funders working with development organizations in healthcare, education, and other sector professionals	Sites can be chosen using geospatial analysis, clustering information, local population data to maximize energy access and service benefits
Assess pre-existing infrastructure On-site inspections to assess pre-existing wiring, equipment, and building structures (Section 9.2 below)	Project developer personnel with support from building contractors, electricians, architectural engineers, and/or PV systems experts	Identify wiring and equipment that can be reused with new installation. Identify rooms that can house electrical equipment. Identify suitable PV array mounting options.
Define facility types Create appropriate facility type definitions to service relevant energy needs (Section 6.1, Template 1)	Program managers in consultation with healthcare, education, and electrical energy professionals	Facility type categories are used to simplify the bid process, lower costs, speed installations, and improve long term maintenance and energy delivery
Develop load profiles Develop a load profile for each facility type (Section 7, Template 2)	Project developer personnel with energy expertise in consultation with education or health administration sector professionals	Detailed and accurate load profiles help optimize PV designs and improve service delivery expectations

List PV system design requirements Detail the specific PV system energy requirements and specification details (Section 8, Template 3)	PV system design professionals or contractors with electrical energy expertise	Template 3 summarizes the design requirements for each facility type and will be the primary information source defining the PV system design
List site-specific information Determine site-specific PV mounting options and new/used equipment options (Section 9, Templates 4 & 5)	Project developer personnel with support from building contractors, electricians, architectural engineers, and PV systems experts	Use the site-specific pre-existing infrastructure assessment to determine PV array mounting options and identify existing infrastructure that can be reused
Develop maintenance and service delivery contracts Define the expected lifetime of the PV systems and develop the service delivery and maintenance requirements over the life of the project (Section 10, Template 6)	Program finance administrators in consultation with PV systems professionals, equipment manufacturers, and project implementers	Outline the funding mechanisms and payment intervals over the lifetime of the project using service delivery as a basis for payments.
Develop optimization strategies Define technical and financial optimization parameters that will be used to evaluate submitted bids (Sections 10.5 and 5.4, Template 6)	Technical and financial personnel in consultation with program directors, project funders, and government agency representatives.	Optimization priorities set by the project developer will provide helpful guidance to project implementers as they design systems and respond to bids.

5.3 Site selection

The process of identifying project sites will be strongly influenced by a number of factors. The funding sources and requirements of program sponsors, the local need for services, the existing energy infrastructure and other commercial industries, and the political landscape of the host country will all play a role. Project developers should carefully consider where and what type of systems should be built to respond to these factors, properly serve communities, and make the most efficient use of program funds.

Multi-site PV projects are best served by standardizing the PV system designs as much as practical to simplify the planning, installation, and servicing of those systems. Project developers should develop a site selection strategy with this in mind and consider factors such as geospatial facility clustering, local availability of components, and health/education ministry priorities (e.g., maternal health, schools with particularly large catchment areas, etc.) when choosing project sites. Project developers are encouraged to document this strategy early in the project and share this information with other agencies, stakeholders, and industry representatives to get feedback and validate the overall approach. A robust site selection

strategy will help identify the best sites for PV electrification and increase the probability of successful program outcomes.

5.4 Optimization strategies

Project developers are advised to develop optimization strategies for electrification projects that include several facets of project development including project site selection and service focus, PV system design factors, financial considerations, and any other aspects of the project that are a priority to the project developer and that help to define and focus the effort. These strategies will differ by country, project size, and customer need.

- **PV system design optimization** – Project developers should define aspects of the electrification effort that should influence the types of designs that project implementers will develop and submit to a bid specification. In many instances, a balance will be struck between constraining the system design while also allowing bidders freedom to create their own solutions. A non-prescriptive approach allowing as much design flexibility as possible is generally preferred to leverage project implementer expertise and experience. If, however, there are limiting factors or preferences related to system design, the project developer should identify these limitations/preferences and include them in the bid specification (See Section 8.1.2)

- **Financial optimization** – Many factors influence project budgets and pricing considerations for PV electrification efforts. The number of facilities, functionality, and size of systems, and expected service and system lifetimes are first among multiple other considerations that will influence the bid specification. Project developers should seek bids that properly balance low capital, operating, and replacement costs with high system quality and service guarantees. A clearly articulated financial optimization strategy can help focus the bid specification, improve the quality of bids submitted in response, and avoid over or under-design of systems.

5.5 Bid specification improvements and alterations

Given the potential size and complexity of electrification projects envisioned in this document, a new bid specification formulated from these guidelines may have omissions or oversights that become apparent after the RFP is issued. Project developers should expect that project implementers will have questions and should put in place a support mechanism and make appropriate program personnel available to clarify the project requirements. Questions and feedback should be recorded and used to refine the RFP as necessary or better inform future efforts.

6 Facility types

6.1 General

After the project developer has identified project sites, it should divide these facilities into groups based in part on the size and purpose of each facility (the site selection criteria in Section 5.1

above may also influence this grouping, e.g. facility types may also incorporate geographic regions etc.). Functional tiers, classifications, and other group category definitions are typically already described by government agencies from the host country and may present a good starting point for this process, though these definitions may need to be customized for use in this document. These tiers may be edited, sub-tiered, or alternatively grouped from an energy supply perspective, but should always be mapped back to the official tier to maintain consistency. In many cases, governments already have pre-set lists of equipment for each facility or tier, hours that it is supposed to operate, number of patients or pupils it is supposed to serve, etc., and this information can be used to group facilities and define the energy service requirements.

Each group, defined here as a ‘facility type’, will receive a same/similar PV system design. This ‘facility type’ grouping then becomes an important step in reducing the complexity of the RFP and allowing a limited number of different PV system designs to serve a larger number of facilities.

No two facilities, however, are likely to be identical. There will inevitably be variations from site to site such as the number of buildings or individual rooms that require electrical service, the outdoor security lighting needs, and the local climate and solar energy resource. When defining facility types, the project developer should therefore endeavor to strike a balance between the number of sites in the program and the number of different facility type definitions. This may include a high level rapid survey of the proposed project sites (this could be part of the site selection strategy) to assess the variability between similar sites. The goal is to both minimize the number of facility type definitions while also minimizing the variation, from site-to-site, within each facility type grouping.

This approach will result in some project sites receiving a PV system design that is oversized for that facility. This is not a technical problem but can result in somewhat higher costs. Project developers may consider exploring mechanisms to reduce some of these additional costs by directing project implementers to reduce the size of PV systems, when feasible, during the final design stage or possibly during installations and either reducing the original purchase of the equipment or returning already purchased equipment to the project developer to keep as replacement stock. This is particularly relevant for battery arrays, as some individual sites within a facility type group (those with slightly lower energy needs) could be adequately served with fewer batteries and those battery purchases should be avoided before installation. The same dynamic may also apply to load equipment (lights, fans, etc.) where sites may not have the same number of rooms that require electrical service. Fewer rooms, and therefore fewer lights or fans, for some sites in a facility type group may provide opportunities for cost savings if the project developer has outlined procedures for the project implementer to follow to reduce these expenditures during the full design stage or installation phases of the project.

6.2 Facility type definitions

Template 1 lists the different facility types. Each facility type will require a detailed design requirement to be developed in Template 3. Text in red is provided here for instructional purposes.

Template 2. Facility type definitions

Facility type definitions		
Facility type name	**General Description**	**Reference[1,2]**
Insert facility name here (Below are four example facility types)	Provide a general description of the facility type. Include available relevant information on location (rural, urban), number of people served, and/or a brief overview of the building and load types (# of rooms, lighting, equipment, climate control)	Section 11.1[1] PV System Design Tool[2]
Example 1: Basic Primary Health Clinic	Loads including general lighting, security lighting, fans, a procedural lamp, mobile phone charging, a fetal heart monitor and a portable ultrasound.	--
Example 2: Improved Primary Health Clinic	Similar to Basic Primary Health Clinic plus additional loads and use times; an oxygen concentrator, general purpose refrigerator/freezer, laptop computer and USB modem	--
Example 3: Basic School	Two classrooms and an office with minimal services for school staff and students with loads including general lighting, fans, mobile phone charging, and security lighting	--
Example 4: Improved School	Similar to Basic School plus additional rooms and loads: a laptop computer, USB GSM modem, and printer	--
(1) *Requirements and Guidelines for Installation of Off-grid Solar Systems for Public Facilities* (2) *Off-grid Public Facilities PV System Design Tool*		

7 Load requirements by facility type

7.1 General

Each facility type will have load and electrical outlet requirements based on the intended use of the facility. Lighting fixtures and ceiling fans are common hardwired loads, while computers, printers, and cell phone charging use electrical outlets. Some specialized equipment, either hardwired or using outlets, may also be required to service the facility type. Medical equipment in particular may be specified for health clinics, and this equipment will vary depending on the type of clinic and intended medical services.

The project developer is typically responsible for specifying the hardwired loads and electrical outlets for each facility type. This should include a line-by-line list of each load/device and may or may not include specific product model numbers that the project developer expects the project implementer to buy and install. It is also possible for the project developer to acquire the load equipment itself and then make this available to the project implementer during installation. Some devices, such as light fixtures, light bulbs, and fans, are generic in nature and will be widely commercially available. In these instances, the project developer may provide basic performance requirements and allow the project implementer to source and purchase these

products, generally after approval of submitted specifications. With other specialized equipment, facilities may be better served if the project developer researches and specifies brand and model numbers for the project implementer to install. Specification of specialized equipment should be made in consultation with the relevant ministry or government agency.

The efficiency of every installed electrical device and load is of paramount importance to reducing the size and cost of the PV system. Purchasing new, more efficient equipment is often much less expensive than installing a larger PV system to service less efficient loads. Project developers are strongly encouraged to use new equipment chosen specifically for each facility type whenever possible rather than using older or pre-existing equipment.

After the electrical needs of a given facility type are identified, the project developer shall perform or otherwise require a load analysis for that facility type. The entity performing the load analysis should be responsible to the project developer in such a way as to ensure an honest and accurate assessment, and should be independent of the PV system designer used by the project implementer to size the system and specify the system components.

The development of a proper load analysis and load profile increases the probability of a successful PV installation and can:

- Help ensure the PV system is able to deliver reliable electrical service.
- Accurately set the expectations of end users using the facility.
- Provide a properly sized PV system for each facility type and avoid over- or under-sized systems.
- Allow the identification and elimination of unauthorized loads that may be installed after the PV system is put in service.
- Avoid unnecessary expenditures and system complexity.

7.2 Load profiles

A load profile for each facility type is necessary to determine the size and performance requirements of the PV system, and this load profile requires a load-by-load accounting of each electrical device, its wattage, and an estimate of the number of hours it will be used throughout a 24-hour day. Different design tools are available from various sources to help with PV system design. The project developer is free to choose an appropriate tool or employ the services of another organization to formulate the desired load profile for any given facility type. A custom design tool has also been created as a companion to these instructions and is available as an Excel spreadsheet *Off-grid Public Facilities PV System Design Tool*.

7.3 Load and electrical outlets template

Template 2 is used to specify the performance requirements for the equipment loads that will be installed with the PV system. At its discretion, the project developer may require the project implementer to source and purchase the equipment, or the project developer may arrange an alternate acquisition strategy that could include another entity (or the project developer itself) purchasing and providing the equipment to the project implementer for installation. A third pathway could include the installation of lights, fans, and other hardwired loads by a third party after the PV system has been installed. Whichever strategy is employed, the project developer should develop a detailed plan for both the specific equipment loads and the manner in which these loads will be maintained, serviced, or replaced.

Certain loads such as lights and fans should be specified with clear performance criteria. Lights may be required to have a minimum efficacy and lumen output, maximum wattage, colour temperature range, and distribution profile. Ceiling fan size, wattage, efficiency, and motor type (e.g. brushless DC motor (BLDC)) may be specified for this load type. Project developers may also choose to list specific brand and model numbers as either examples or requirements for equipment that is considered acceptable. For rated power listings, it is recommended that a tolerance be provided to allow for some flexibility when project implementers are sourcing the equipment.

More information about electric loads and equipment can be found in Section 6.6 and Section 11 of the lead document *Requirements and Guidelines for Installation of Off-grid Solar Systems for Public Facilities*. Project developers are strongly encouraged to use this and other reference material to properly specify the equipment loads that will be considered acceptable for use in a PV system design.

Template 2. Load and electrical outlets

Electrical equipment and outlets installation requirements					
Facility Type	**Name of facility type**				
Electrical equipment					
Equipment type	No. of units	Rated power (W)	Minimum efficiency	Notes	Reference[1]
Ceiling light[2]			lm/W		Section 6.6[1]
Outdoor security light[2]			lm/W		Section 6.6[1]
Ceiling fan[2]			m^3/min/W or CFM/W		Section 6.7[1]
other					
Notes:					
Electrical outlets/sockets					
Outlet type	No. of units	Rating (V)	Notes		Reference[1]
AC socket					Section 5.2.12[1]
DC socket					
Notes:					
[(1)]Requirements and Guidelines for Installation of Off-grid Solar Systems for Public Facilities [(2)]List specific requirements for each electrical device. Including specific part numbers (where applicable) or relevant performance parameters. Provide detailed guidance on minimum requirements including efficiency, output, type, designation of critical loads, etc.					

7.4 Critical loads

Some medical equipment is considered critical and project developers may stipulate separate performance requirements for these loads or designate that critical load circuit branches are available from the PV system design to continuously power or prioritize these loads. Sections

5.2.7, 5.3.3, and 5.3.6 of the lead document have information on different approaches to address this by either building a stand-alone, independent subsystem for that load (an option sometimes required for vaccine refrigerators) or adding load limiters or inverter programming features (such as a load shedding feature) to allow some loads or circuits to be prioritized over others. See also Section 11 of the lead document (including 11.4, 11.5, 11.6, and 11.7) for a discussion of critical loads and specialized equipment commonly associated with health and educational facilities. Project developers can specify which loads or sockets are critical and further specify the performance requirements or days of autonomy for those loads in the Notes sections of Template 2, or they may optionally use a separately labelled Template 2 for only critical loads. Project developers may further specify what design approach is required or they may allow project implementers to propose solutions. Critical load designations and requirements should be carefully chosen and specified in consultation with ministries of health, medical associations, or other appropriate organizations as there may be legal restrictions and requirements associated with some equipment.

7.5 Electrical equipment management

Under a service delivery model approach, PV systems are monitored and assessed based on the delivery of energy to electric devices used in each facility. The project implementer or service delivery contractor responsible for system monitoring, servicing, and maintenance may be in a good position to manage and maintain the equipment loads as well. This can mean servicing or managing the replacement of lights, fans, computer equipment, refrigerators, monitoring equipment, etc. and may also include managing and maintaining specialized medical equipment. Under this model, the PV energy system and the loads that it powers are considered as a package or bundle instead of being treated as separate elements. This type of bundle/package may be particularly desirable for rural clinics looking for a single supplier of energy/equipment. Template 2 Notes sections may be used to specify details of this arrangement.

8 PV System design requirements by facility type

8.1 General

The project developer shall specify the performance requirements for each facility type with the Design requirements template (Template 3). The references in the last column pointing to the lead document may be used by both the project developer and the project implementer to better understand the required metrics and should be left in place in any bid spec documents.
The first section of Template 3 titled “Facility energy requirements” is a summary of the key metrics that are generated by the load profile for that facility type. The *Off-Grid Public Facilities PV System Design Tool* has been developed to assist in these calculations. The second section of Template 3 titled “System design specifications” lists important PV system design constraints that the project developer is requiring for each facility type.

8.1.1 Facility energy requirements

The first section of Template 3 (Facility energy requirements) contains the energy service needs of a particular facility type. It will be used by the project implementer to size the PV array and support components and represents the energy service goals of the PV system design.

- The daily energy requirement for a facility type helps establish the minimum PV array electrical service. This information will be used by the project implementer to select the solar modules and design the PV array configuration. Additional factors that influence this design consideration are provided in the next section of the template under *System design specifications*.

  Daily energy requirements are derived from the project developer's load profiles for each facility type. The project developer may choose to include a load growth factor in the daily energy requirement calculation to allow for additional loads to be added to a facility over time. The *Off-grid Public Facilities PV System Design Tool* includes this factor in the Design Load output calculation in the 'Loads and Assumptions' section. The project developer should use this number for the daily energy requirement.

- The average and maximum power draw requirements are also calculated by the *Off-grid Public Facilities PV System Design Tool*. The maximum power draw shall be specified both with and without power surge. The project implementer will need these figures to specify power conversion equipment.

8.1.2 System design specifications

The second section of Template 3 (System design specifications) outlines the detailed performance and equipment requirements the project developer is calling for in the PV system design. Several are self-explanatory and references are provided to more detailed information in *Requirements and Guidelines for Installation of Off-grid Solar Systems for Public Facilities*. Additional guidance is provided here:

- A minimum **PV array oversize factor** can be specified by the project developer and is typically between 20 – 100 %. The oversize factor is influenced by several variables as detailed in *Requirements and Guidelines for Installation of Off-grid Solar Systems for Public Facilities,* Section 5.2.6. Generally speaking, a PV array oversize factor may or may not include a load growth factor. In the examples and instructions given here, a load growth factor is already incorporated into the daily energy requirement and therefor is not included in the PV array oversize factor. The PV array oversize factor is used instead as an additional consideration related to battery chemistry, days of autonomy, and daytime loads.

- The **PV array efficiency losses** listed in the template are chosen by the project developer and are provided as assumptions that the project implementer must use when designing the PV system. This is intended to allow direct comparisons between competing bids from different project implementers. If the project developer is using the *Off-grid Public Facilities PV System Design Tool,* these numbers should be entered in the spreadsheet and used to check submitted bids to confirm adequate PV and battery array sizing.

- *Requirements and Guidelines for Installation of Off-grid Solar Systems for Public Facilities,* Section 5.2.3 Table 2 details losses that are common in PV systems. The power conversion equipment (inverters and charge controllers), battery array, and wiring will all exhibit some level of efficiency loss. These losses are specific to the actual equipment used in the installation and vary according to system configuration, equipment manufacturer, and wire sizing. Good PV system designs will include these losses in system sizing calculations and are normally the responsibility of the project

implementer and/or PV system designer. The project developer is encouraged to require that project implementers include these efficiency losses in their bids. The project developer may optionally choose to specify some of these losses in the "other" space provided in Template 3 but should be aware that this may not accurately reflect the equipment and design choices in any particular design from a project implementer.

- System design preferences or restrictions that are not specifically listed as checkboxes in Template 3 can be communicated in the Notes sections of the table. Examples include preferences for modularity/expandability or design/equipment standardization factors that a project developer expects in the bid responses. Equipment standardization in/across bids may include requirements for specific equipment types or manufacturer brands that are more accessible in-county; standardizing these in the bid specification can make submitted bids easier to compare.

Template 3. Design requirements

Design Requirements			
Facility Type	**Name of facility type**		
Facility energy requirements	Value/description		Reference[1]
Daily energy requirement (kWh/day)	Provide a value for facilities of this type (kWh/day)		Section 5.4[1] Section 11[1] PV Design Tool[2]
Average power draw (kVA)	Provide a value for facilities of this type (kVA)		
Maximum power draw (not including surge) (kVA)	Provide a value for facilities of this type (kVA)		
Maximum power draw (including surge) (kVA)	Provide a value for facilities of this type (kVA)		
System design specifications	Item		Reference[1]
Allowable system configurations (check all that apply)	DC-coupled ☐ AC-coupled ☐ Hybrid ☐ Site-specific ☐	Notes:	Section 5.2.2[1]
Allowable battery chemistry	Lead-acid ☐ Lithium ☐ Other ☐	Notes:	Section 5.3.2[1]
Battery depth of discharge design target (≤ %)	List the battery array maximum depth of discharge to be used for design calculations. For lead-acid batteries, a value between 40 % and 60 % is typical. For lithium-based batteries, a value between 70 % - 90 % is typical. Values should be listed as less than or equal to percent (≤ %).		Section 5.2.9[1]

Load type requirements	AC loads DC loads		AC voltage/frequency DC load voltage(s)	PV Design Tool[2]
Battery array voltage requirements	Battery array minimum		12 V DC typical	Section 5.2.8[1]
	Battery array maximum		48 V DC typical	
PV array mounting options	Pole mount Ground mount Roof mount		Notes: Check all allowable mounting options for this facility type. Site-specific mounting requirements will be detailed in section 8 below	Section 7.3[1]
PV module requirements	Allowable module power tolerance		80 % - 105 % typical	Section 5.2.3[1]
System requirements	Minimum PV array oversize factor		1.1 - 1.3 typical	Section 5.2.6[1]
	Minimum required days of autonomy		3 - 5 days typical, may be longer	Section 5.2.7[1]
PV array efficiency losses	Efficiency loss assumptions the project implementer should make when sizing the PV array.			Section 5.2.3[1]
	Module mismatch loss		0.5 % - 3 %	
	Module degradation factor		0.5 % - 1 % per year typical	
	Efficiency loss from shading		expected shading in region	
	Efficiency loss from soiling		0.5 % - 70 % range	
	Other		Include additional losses (optional)	
	Total PV efficiency loss to use in PV array sizing calculations		Add losses together and report a single number here	
Component warranty minimum requirements	Batteries	warranty length in years, minimum		Section 5.3.2[1]
	Inverters	warranty length in years, minimum		Section 5.3.3[1]
	PV modules	warranty length in years, minimum may include maximum degradation through warranty period		Section 5.3.4[1]
	Charge controllers	warranty length in years, minimum		Section 5.3.5[1]
Exceptions	Design, component and installation requirements are described in Sections 5.3, 6, and 7. If the project developer chooses to reference these sections in the general specifications, but wants to require additional elements or make exceptions to these requirements, those changes should be clearly noted.			Section 5.3[1] Section 6[1] Section 7[1]
Notes: (1)Requirements and Guidelines for Installation of Off-grid Solar Systems for Public Facilities (2) Off-grid Public Facilities PV System Design Tool				

9 Site specific information

9.1 General

The ability of an off-grid solar system to service a daily energy requirement is based in part on the daily solar radiation available at any given geographical location. The project developer is responsible for identifying the locations for PV installations and should also be responsible for specifying a 'minimum monthly average daily solar radiation (kWh/m^2/day)' to be used by

project implementers in sizing the PV array and specifying associated hardware for a given facility type. This solar resource data can be obtained from several online resources (see *Requirements and Guidelines for Installation of Off-grid Solar Systems for Public Facilities* Section 5.2.4) or the *Off-grid Public Facilities PV System Design Tool* (solar resource tab). The minimum and maximum temperature experienced by each site should also be required. The project implementer will need this information to specify the PV array configuration and equipment voltage limits.

Template 4 and Template 5 are provided to list summary information for the sites that are part of the project. Template 4 is a summary template listing the total number of facilities of each facility type as well as an accounting of the number of facilities that will require the installation of new wiring and outlets and the mounting configurations (pole/ground/roof) for PV arrays. Template 5 is provided to list the geographic locations (latitude and longitude) and facility classifications for the all sites that are part of the project. Both templates should be used to provide both a summary and a site-by-site detail of all of the proposed project sites for the program.

9.2 Pre-existing wiring and equipment assessment

Some facilities may have equipment, wiring, and sockets already installed that can be utilized by a new PV energy system installation. Using this pre-existing infrastructure can save time, money, and materials. However, a careful assessment must be made to determine if the wiring and electrical outlets are properly rated for the new system loads, existing equipment meets minimum performance and lifetime requirements, and whether or not this pre-existing installation is of sufficient quality and in sufficiently new and undamaged condition to properly and safely service the facility.

In order to use pre-existing wiring in a new PV system installation, the existing wiring must be thoroughly inspected by a qualified electrician. Cable type, conductor size, and estimated lengths must be known in order to determine if protection devices and circuit capacity at outlets are properly sized. Unless the existing wiring is in good condition and meets all the requirements of a new installation, a preference should be given to the installation of new wiring and electrical outlets (and removal of old wiring and outlets) as this will more likely result in a successful system. If the existing wiring is insufficient, not upgrading the existing wiring in a new system could be a fire risk and result in a catastrophic loss of the system and an acute danger to the people using the facility.

In some circumstances, pre-existing equipment may be determined to be in good, serviceable condition, and the project developer may specify that this equipment be reused. This determination should be made by qualified personnel with adequate knowledge of the equipment type in close consultation with program directors. Equipment tests may likely be necessary. Project developers are advised to show a preference to new equipment, however, as the re-use of old equipment may lead to confusion or disagreement over service failure responsibilities if not adequately addressed by the service delivery contracts in place between the project developer and project implementer/service delivery contractor. Project developers should outline equipment ownership issues in detail as well as investigation and mitigation procedures in the service delivery contract in the event of system malfunctions or failures.

9.3 PV array mounting options

The project developer may prefer to specify the PV array mounting options that are acceptable at each individual facility location. This can include one, two, or all three possibilities (pole, ground, or roof mounts). This may help in situations where enough information is available, on a site-by-site basis, to either eliminate some options or strongly favor others.

9.4 Site-specific summary template

This summary template can be used to provide a quick reference for programs involving a large number of installations. It should include totals for each facility type and a breakdown of wiring and PV array mounting configurations.

Template 4. Site-specific summary requirements

Site-specific summary requirements		Wiring requirements		PV array mounting options			
Facility Type	Total locations	Pre-wired	New wiring	Pole mount only	Ground mount only	Roof mount only	Multiple options

9.5 Facility locations and site-specific requirements template

This template is used to compile a comprehensive list of all the locations a PV system installation program. Instead of listing individual site temperatures and solar resources, the project developer may alternately list temperatures and solar resources for different geographic regions and then match the project sites to the appropriate region (Region 1, Region 2, etc.).

Template 5. Facility locations and site-specific requirements

Facility locations and site-specific requirements									
Site No.	Site Name	Facility Type	Latitude (°W)	Longitude (°N)	Site temp (°C)		Minimum solar resource (kWh/m^2/day)	Pre-wired/ new wiring (pre/new)	PV array mounting options[1]
					min	max			
1	Site name 1								
2	Site name 2								
3	Site name 3								
[(1)]PV array mounting options: P (pole) / G (ground) / R (roof)									

10 Long-term service delivery, monitoring, and system maintenance

10.1 General

The project developer shall develop one or more options to include in a bid specification outlining the types of contracts that will be necessary to ensure PV systems and associated electrical equipment have adequate monitoring, long-term repair, and maintenance service.

The project developer may allow the structure and timing of PV system service contracts to be flexible to allow prospective project implementers enough time to develop realistic terms to properly meet the needs of each facility and the program in general. In some cases, the project implementer who bids and installs the system might not be the same entity that fulfils a service delivery and maintenance contract. Clear guidance from the project developer should be given to the proper roles, responsible parties, and equipment ownership details associated with long-term service.

More information regarding performance monitoring, system maintenance, and service delivery/O&M contracts can be found in the lead document *Requirements and Guidelines for Installation of Off-grid Solar Systems for Public Facilities* in Sections 9 and 10.

10.2 Performance monitoring

Ongoing monitoring of PV systems is essential and a monitoring plan should be required. The project developer states which metrics will be assessed, at what intervals, and over what time period. Monitoring should be required over the entire project period, and a plan should be in place to continue monitoring throughout the system lifetime if the project period is limited. Reporting results, specific compliance criteria, and associated penalties for non-compliance will also need to be stated in the general specifications, procurement contract, or maintenance contracts. Section 10 of the *Requirements and Guidelines for Installation of Off-grid Solar Systems for Public Facilities* provides recommended performance metrics / key performance indicators (KPIs) that can be used to evaluate long-term system performance.

Local data storage (e.g., via SD card) should be enabled for all sites. If the locally stored data are different from what is transferred over the wireless system, procedures for calculating the service metrics from the locally stored data shall be provided. The device used to store data locally shall have no less than 6 months of available storage before overwriting. This locally stored data should also be able to be automatically transferred wirelessly if/when the remote connection is restored.

Remote/live system monitoring, where available, should be required or strongly encouraged as this can enable rapid responses to system malfunctions or failures while also providing valuable system-wide assessments.

10.3 System maintenance and service delivery agreements

An O&M contract or service delivery agreement shall be in place prior to starting a PV installation, and a well-defined plan for the requirements of the service delivery agreement will

need to be in place prior to launching the tender. In order to estimate a cost and bid on any maintenance/service delivery plan, prospective project implementers will need to know the service delivery expectations/requirements that the project developer is seeking and the proposed payment schedule. Template 6 includes the basic O&M/service delivery elements described in the lead document and leaves space for references or other available information that the project implementer should know in evaluating the bid spec and formulating a system design and quote.

The project developer should have budget and funding sources well-defined prior to launching an RFP, and these resources should cover both capital and operating expenses as a single or linked set of packages. Specific funding mechanisms and payment schedules can add clarity and certainty to the project and may help facilitate more realistic and reliable bids. Linking ongoing operating and system maintenance expenses to the capital expenses for the system installation is an integral part of the service delivery model and should be expressly included at the beginning of any PV electrification project that uses some aspects of service delivery performance as payment criteria for project implementers.

Ideally the maintenance/service delivery plan should be required to cover the entire lifetime of the system (10-20 years), and include expected costs for replacement of key components, such as batteries, inverters, and charge controllers. In many cases, the project period may be more limited (often 2-5 years), in which case a plan should be in place for the responsible entity to continue with performance monitoring and maintenance after the initial project has closed.

To support the service delivery model, the project developer will likely want to arrange for inclusion of a risk mitigation instrument, such as a World Bank Guarantee, MIGA Guarantee, or similar backstop to ensure the project implementer will receive payment for their capital, operating, and replacement expenses. If a risk mitigation instrument is in place (or is being arranged), the terms of this guarantee should be clearly presented to the prospective project implementer. Providing this information will both help to attract project implementers and assist prospective bidders in securing debt or equity financing to enable their participation in the project. Use of a risk mitigation instrument may also enable extension of oversight beyond the initial project period to help support long-term operations and maintenance.

During the initial RFP phase, the project developer is seeking quotes from bidders for the installation and service of a PV facility. Project developers should carefully consider the available payment options to support these installations within the context of the host country's existing PV industry, the availability of contractors and builders, and the businesses and business structures that exist that can/will respond to the RFP. Project developers may choose to propose single, specific payment structures and service delivery approaches, or they may allow for different payment mechanism options to encourage more bidders. In any case, project developers should always ensure that operating expenses and ongoing maintenance costs are an integral, well-defined aspect of project funding to ensure the ongoing, long-term successful operation of the installed systems.

10.4 Training programs and end-user support

Project developers should require that project implementers develop training programs for end-users/clients. This includes both functional information of the proper use and safety procedures for the PV equipment and also instruction on the proper use and expectations for the system

loads. Clearly informing end-users of the functional workings and limitations of the system may help mitigate complaints and encourage better load management. Training programs, user manuals, and other technical documentation should also be available to project developer personnel, as appropriate, to help manage the ongoing operation of the systems.

Specialized equipment included in this training will require manufacturer support and may be treated separately from other equipment on a case-by-case basis according to normal handling procedures and training processes for that equipment.

10.5 Financial assumptions and optimization

The documentation should clearly indicate the anticipated payment structure for the long-term O&M, including whether the capital costs will be paid upon installation, in installments, or as part of a service-based lease agreement or similar long-term payment plan. Accordingly, this section should clarify whether the project implementer should quote the costs in terms of a routine (e.g. monthly) payment, a total capital cost with a separate O&M fee, or alternate values. The project developer should state any assumptions that prospective project implementers should use in their cost estimates to ensure estimates are comparable across bids. For instance, if costs are being quoted in terms of monthly payments for a service-based payment structure, the project implementer would likely need to conduct life-cycle cost analysis to determine an appropriate cost. Parameters for this analysis, such as the assumed inflation rate, which should not vary between bids, should be provided by the project developer.

PV system designers will need to know how to prioritize cost factors. Capital expenses (CAPEX) and operating expenses (OPEX) in the form of monitoring, service, maintenance, and replacement costs will vary according to component choice and the overall system and service design. Lowest CAPEX, for example, may or may not be preferable to lowest 15-year OPEX as a priority for the program, or the two may be given equal weight as financial priorities. Whatever the priorities are, project developers are advised to formulate a financial optimization strategy and communicate this in the bid specification.

Given the different payment structure options, project developers are further encouraged to modify this section of Template 6 as necessary to clearly identify how the project implementer should properly quote their bids.

Template 6. Long-term service delivery, monitoring, and system maintenance

Long-term service delivery, monitoring, and system maintenance template		
Performance monitoring	These metrics shall be monitored to assess system performance: Check all that apply. Available Energy (E_a) ☐ Low Voltage Disconnect (LVD) ☐ Solar System Functionality (T_f) ☐ State of Charge (SoC) ☐ Depth of Discharge (DoD) ☐ Days Fully Charged (DFC) ☐	Section 10.2[1]
Monitoring interval	List the required logging interval and monitoring interval for data collection (i.e. data shall be recorded at a frequency of at least every 15 minutes with the minimum, maximum or total recorded at least every 24 hours)	Section 10.2[1]

Operations and maintenance service delivery contract	O&M contract (Option 1) ☐ Lease/extended service contract (Option 2) ☐ Contract length ☐ Service delivery/maintenance plan must include: Live system monitoring…… ☐ Emergency response criteria/response time ☐ Corrective maintenance procedures……. ☐ Preventative maintenance schedule……. ☐ System testing schedule…… ☐ Array/panel cleaning…… ☐ Weed/vegetation control…… ☐ Warranty fulfillment procedure……... ☐ End-user training programs……..... ☐ End-of-life disposal…….. ☐ Other…….. ☐ Other…….. ☐ Other…….. ☐ Notes: Any requirements for provision of user or technician training, spare parts, component replacement, and end-of-life disposal should be described.	See Section 9[1] for details on creating a maintenance contract
Financial assumptions	Capital cost payments from project developer Upfront ☐ Installments ☐ Per service delivery contract ☐ Installment schedule ☐ Project implementers should quote Capital costs and O&M contract as separate payments ☐ Monthly payment schedule…….. ☐ Total capital costs…… ☐ Total installation costs…….. ☐ Monthly O&M cost…… ☐ Expected replacement costs……... ☐ Disposal costs…… ☐ Other…… ☐ Other…… ☐ Annual inflation rate for calculations ☐ Currency used for quotes ☐	--

Contract summary	Details or references can be provided here directing the project implementer to specific contract language and giving instruction on the process to be used in developing and quoting an O&M contract. In particular, the draft contract language should describe the payment intervals, performance requirements for receiving payments, and any penalties for under-performance.	
Other notes	Use this space to include any other information relevant to the monitoring or maintenance of the PV systems.	--
[1]Requirements and Guidelines for Installation of Off-grid Solar Systems for Public Facilities		

11 Instructions and support for project implementers responding to a bid specification

11.1 Instructions and support

If otherwise not included in a project developer's standard procedures, the following elements should be incorporated into a bid specification:

Requirements and regulations - Project developers are advised to stipulate that proposals from project implementers meet the requirements in *Requirements and Guidelines for Installation of Off-grid Solar Systems for Public Facilities* (all parts). Exceptions are permitted, however, and these may be specified in Template 3 or in separate language outlining the project developer's expectations for the RFP. In addition, project developers are advised to explicitly state that all systems and installations shall comply with local and national building and safety codes, and properly detail any additional compliance requirements associated with the project to avoid bid rejections or evaluation delays.

Instructions - Project developers should provide project implementers with detailed instructions on how to properly respond to the RFP. This *Bid Specification Templates for Off-Grid Solar Systems for Public Facilities* document should also be provided in whole or in part to project implementers along with the completed Templates. It is recommended, however, that the example (fictitious) templates in Section 12 be removed to avoid confusion, and the project developer may also wish to further edit different sections of this document, if made available to project implementers, to suit the needs and structure of the overall bid specification.

Information resources - Project developers should also provide project implementers with resources to answer questions that may arise during the bidding process, including contact information for in-house personnel or independent consultants contracted as project advisers. Investments by project developers in advertising/presenting the RFP and educating project implementers (with workshops, slide decks etc.) may save considerable time and confusion and improve the number and quality of submitted bids.

Evaluation procedures - The Project developer should provide as much information as possible to project implementers indicating how bids will be evaluated. If they will be scoring

submitted bids, the relevant weighting factors should be explained, including both technical and financial scoring systems as applicable.

11.2 Minimum bid response requirements

A bid from a project implementer shall include both system design information and system component information. At a minimum, project implementers should be instructed to provide the following technical information when responding to an RFP:

- Overall PV system efficiency
- PV system design information including system topology and voltages (battery, PV array, inverter, lights, fans, etc.)
- Comprehensive list of all proposed PV equipment including:
    - Major system components (PV modules, inverters, batteries, charge controllers, monitoring equipment, lights, fans, etc.)
    - System hardware (enclosures, racks, switches, conduit, etc.)
    - PV array mounting hardware
    - Wiring (including wire ratings)
    - Circuit protection (fuses, breakers, etc.)
    - Monitoring equipment
- Component datasheets for all major system components (PV modules, batteries, inverters, charge controllers, monitoring equipment, etc.)
- Component warranty documentation
- Cost estimates including materials, labor, equipment, and operations and maintenance costs.

More information on bid submissions can be found in the lead document *Requirements and Guidelines for Installation of Off-grid Solar Systems for Public Facilities* Section 5.5.

12 Evaluating bids from project implementers

It is assumed that project developers already have standardized bid evaluation procedures in place for procurement projects. In addition and in combination with these standard procedures, project developers should assess received bids from project implementers (companies) based on:

- an evaluation of a company's business experience qualifications and the technical proficiency of its personnel (in particular, a company's ability to secure financing or otherwise implement a service-based model should be considered);
- the quality and degree of technical detail in the bid, including the inclusion of all required information and documentation such as component datasheets and performance calculations;
- pricing factors indicating that the proposed PV system designs are capable of adequately servicing the energy requirements, service life, and system functionality at acceptable CAPEX , OPEX, and replacement costs.

12.1 Company evaluations

Evaluation of a company's ability to deliver and service a PV procurement should follow all of the project developer's standard procedures. PV specific elements in this evaluation should focus on the following company level assessments:

- the number of successfully completed PV projects AND the years of service provided by these projects. Are past installations still in service, and has the company provided proof of performance and/or customer referrals that verify successful service delivery?
- the range of different project types, PV system wattages, and PV design configurations. Has the company serviced a narrow range of projects from an installed wattage and system configuration type (DC-coupled, AC coupled, PV array mounting configurations, battery technology types, etc.) or does the company have experience with a variety of system sizes, configurations, and component types (including using different component manufacturers)? Companies that have previously installed and serviced the proposed PV designs in their bid should be given preference, as should companies with a broad range of PV system design experience.
- the in-house technical proficiency and energy systems experience and accreditation of a company's personnel. Personnel CV's should include staff with appropriate education, training, and experience including, for example, electrical engineering expertise and fieldwork experience with PV installations.
- experience and proficiency with using remote monitoring platforms to provide responsive operations and maintenance should be considered.
- if the proposed service-based model will require companies to secure investment or otherwise cover capital costs and be repaid over time, then documentation or evidence of their ability to obtain debt or equity investment or otherwise manage the proposed cash flow should be presented.

The project developer personnel evaluating a project implementer company according to these criteria are not required to have extensive PV system technical knowledge. It is recommended, however, that these personnel are at least familiar with the basics of PV system design and that other in-house personnel or independent outside contractors with more extensive PV expertise are available for consultation.

12.2 Technical evaluations

Evaluation of a company's technical ability to deliver and service a PV procurement should also follow all of the project developer's standard procedures. PV specific elements in this evaluation should focus on:

- the quality and level of detail provided in the bid response. Does the bid include clear and complete information responding to all of the elements in the bid specification (component datasheets, warranties, system design specifications and diagrams, performance calculations, special requirements such as equipment standardization or expandability, etc.)? Project implementers are expected to submit their own documentation style and formatting when responding to a bid. This provided information should be clearly organized and easily understood. Project developers are encouraged to perform a line-by-line comparison of *Table 3. Design requirements* with each bid response to ensure that proposals have addressed every technical requirement of the procurement.

- the ability of the proposed system design to efficiently service the energy requirements of the procurement at an optimized level. An optimized system design will include appropriate tolerances, neither too big nor too small, in each system component or component subgroup, such that the engineering provides enough functioning performance headroom without an overdesign of that aspect. A balance of system (BOS) approach to the PV design dictates that the various components are properly matched to each other to avoid unnecessary costs while also ensuring durable performance.
- the ability of the system to be efficiently expanded according to the requirements of the specification.
- for projects that require the project implementer (bidder) to provide the electrical load equipment (lights, fans, medical equipment etc.), the project developer should ensure that this equipment is properly specified (Template 2) and that any equipment in a bid proposal is adequately documented and reviewed by personnel familiar with this equipment. For medical equipment, this may require consultation with healthcare professionals to ensure the equipment is able to meet the expectation of the end-use application.
- The monitoring, service delivery, and O&M elements of the procurement must be realistic. Submitted servicing bids from project implementers will need to be evaluated from technical and financial perspectives. Monitoring equipment must be able to deliver the required reporting performance, maintenance schedules must have adequate frequency, and the project implementer's business structure must be able demonstrate an ability to deliver on the service contract, including the ability to respond to system failures in an appropriate timeframe. Evaluations of these aspects of a bid should be performed by project developer staff or contractors encompassing both technical and financial experience.

The technical evaluation of proposed bids requires a detailed knowledge of electrical performance and PV system design. Outside contracting with independent PV professionals should be utilized in situations where in-house expertise in not adequate to thoroughly understand and evaluate the technical aspects of a proposed PV system designs. The equipment included in a bid should also be carefully reviewed, including physical evaluations when possible, to verify performance.

12.3 Financial evaluations

Evaluating the financials of bid proposals requires both technical and financial expertise to assess the relative strengths and weaknesses of submitted bids. The project developer is advised to prioritize the long-term reliability of PV systems over upfront costs by emphasizing equipment quality and installation durability. A smaller number of installations, with better equipment and construction standards, will offer a higher investment value over time. A service delivery financial structure inherently strengthens this dynamic by providing a strong incentive for system reliability and discourages designs that use lower quality equipment and/or cost-cutting, cheaper installation practices.

Capital expenses – These expenses include common elements of a bid such as component and installation costs and will typically be evaluated after the technical evaluations of a bid have been performed. The importance of reliable service delivery for PV installations favors the use of durable, quality equipment, and this will often come at an increased upfront cost. While it is

important that CAPEX costs are kept low, the tendency to reduce these costs should be given a lower priority when considered against equipment quality and durability. Equipment warranty details, component specs, and manufacturer reputation may be used to evaluate equipment quality.

Operating expenses – The operating expenses of an installation include ongoing monitoring, planned maintenance and inspection, emergency (system offline) servicing, end user training, warranty service, and other service delivery evaluations that may require action from the project implementer. Project developers should expect these costs, though not precisely knowable due to unpredictable equipment and installation failures, to be properly and realistically estimated. A low OPEX or service delivery bid from a project implementer may indicate an unrealistic or inadequate estimate of the work required to keep a system running and may ultimately lead to poor system performance over time.

Replacement costs – Anticipated replacement costs may include both system equipment and load equipment. Batteries in particular will (in most cases) need to be replaced over the lifetime of a PV system, and this and other known replacement costs, combined with a replacement schedule, shall be listed.

Life cycle cost analysis – Project developers may wish to have bidders estimate the total cost of each PV system over its lifetime. This includes the above expenses plus any residual value the equipment and installation will have after its rated service life. Include any factors or assumptions the project implementer should make in performing the analysis.

13 Example templates for an ‘Improved Primary Health Clinic’ facility

The following templates have been filled out as an example of an ‘Improved Primary Health Clinic’ in a project that includes four facility types (Basic PHC, Improved PHC, Basic school, and Improved school). Template 2 and Template 3 (Load and Design templates) for these facility types are not shown but would also be included in a fully developed RFP.

Example Template 3. Facility type definitions

Facility type definitions		
Facility type name	**General Description**	**Reference[1,2]**
Basic Primary Health Clinic (Basic PHC)	1-2 buildings, 1-5 rooms per building, with loads including general lighting, security lighting, fans, a procedural lamp, mobile phone charging, a fetal heart monitor and a portable ultrasound.	Section 11.1[1] PV System Design Tool[2]
Improved Primary Health Clinic (Improved PHC)	Similar to Basic Primary Health Clinic plus additional rooms, loads, and use times; an oxygen concentrator, general purpose refrigerator/freezer, laptop computer and USB modem	Section 11.1[1] PV System Design Tool[2]
Basic School	1-2 classrooms and an office with minimal services for school staff and students with loads including general lighting, fans, mobile phone charging, and security lighting	Section 11.1[1] PV System Design Tool[2]
Improved School	Similar to Basic School plus additional rooms and loads: a laptop computer, USB modem, and printer	Section 11.1[1] PV System Design Tool[2]

(1) *Requirements and Guidelines for Installation of Off-grid Solar Systems for Public Facilities*
(2) *Off-grid Public Facilities PV System Design Tool*

Example Template 2. Load and electrical outlets

Electrical equipment and outlets installation requirements					
Facility Type	**Improved Primary Health Clinic (Improved PHC)**				
Electrical equipment					
Equipment type	No. of units	Rated power (W)	Minimum efficiency	Notes	Reference[1]
Ceiling light[2]	75	10 W ± 1 W	90 lm/W	CCT ≤ 4000 °K, CRI ≥ 70 Lamps and luminaires shall meet the requirements in Section 6.6.3[1] in the lead document	Section 6.6[1]
Outdoor security light[2]	10	10 W ± 1 W	90 lm/W	CCT ≤ 3500 °K Lamps and luminaires shall meet the requirements in Section 6.6.3[1] in the lead document	Section 6.6[1]
Ceiling fan[2]	20	≤ 70 W	2.75 m^3/min/W	High-speed airflow ≥ 86 m^3/min BLDC motors preferred See Table 7[1] for performance calculations based on 1200 mm blade diameter	Section 6.7[1]
Electrical outlets/sockets					
Outlet type	No. of units	Rating (V)	Notes		Reference[1]
AC socket	10	230 V	Type G (BS 1363) 1 socket per room installed in the following room types: Offices, pharmacies, conference rooms, medical exam rooms, and operating rooms Sockets and electrical wiring shall comply with local electrical codes and regulations		Section 5.2.12[1]
Notes: AC socket installation locations are subject to change. Final socket placements will be determined prior to installation at the direction of the project manager. All wiring and socket hardware in a finished PV installation shall comply with local codes and regulations. This includes pre-wired sites where existing hardware is used.					
(1)Requirements and Guidelines for Installation of Off-grid Solar Systems for Public Facilities (2)List specific requirements for each electrical device. Including specific part numbers (where applicable) or relevant performance parameters. Provide detailed guidance on minimum requirements including efficiency, output, type, designation of critical loads, etc.					

In this fictitious example shown in Template 3, the project developer has chosen to restrict the PV array mounting options for Improved PHCs to roof mount and pole mount only and the project implementer is allowed to choose which options to quote. The example assumes that the project developer has assessed the Improved PHC project sites and determined that pole mount and roof mount PV arrays are appropriate and that the building roofs at each site are generally capable of supporting a PV array. Project implementers are then advised that final installations will still require approval by a structural engineer.

Example Template 3. Design requirements

Design Requirements			
Facility Type	**Improved Primary Health Clinic (Improved PHC)**		
Facility energy requirements	Value/description		Reference[1]
Daily energy requirement (kWh/day)	19.4 kWh/day (includes a 1.1 (10 %) load growth factor)		Section 5.4[1] Section 11[1] PV Design Tool[2]
Average power draw (kVA)	0.9 kVA		
Maximum power draw (not including surge) (kVA)	3.41 kVA		
Maximum power draw (including surge) (kVA)	3.77 kVA		
System design specifications	Item		Reference[1]
Allowable system configurations (check all that apply)	DC-coupled [x] AC-coupled [ ] Hybrid [ ] Site-specific [ ]	Notes:	Section 5.2.2[1]
Allowable battery chemistry	Lead-acid [x] Lithium [ ] Other [ ]	Notes:	Section 5.3.2[1]
Battery depth of discharge design target (≤ %)	≤ 50 %		Section 5.2.9[1]

Load type requirements	AC loads [x] DC loads [ ]	AC voltage/frequency: 230 V AC / 50 Hz DC load voltage(s):		PV Design Tool[2]
Battery array voltage requirements	Battery array minimum		24 V DC	Section 5.2.8[1]
	Battery array maximum		48 V DC	
PV array mounting requirements	Pole mount [x] Ground mount [ ] Roof mount [x]	Notes: Site-specific requirements for individual project sites are listed in Template 5. For sites with multiple PV array mounting options, the project implementer may choose the PV array mounting configuration. Roof mounted PV arrays must be approved by a structural engineer after an on-site inspection prior to installation.		Section 7.3[1]
PV module requirements	Allowable module power tolerance		95 % – 105 %	Section 5.2.3[1]
System requirements	Minimum PV array oversize factor		20 %	Section 5.2.6[1]
	Minimum required days of autonomy		3 days	Section 5.2.7[1]
PV array efficiency losses: Efficiency loss assumptions the project implementer should make when sizing the PV array	Module mismatch loss		3 %	Section 5.2.3[1]
	Module degradation factor		0.5 % per year	
	Efficiency loss from shading		5 %	
	Efficiency loss from soiling		3 %	
	Other		n/a	
	Total PV efficiency loss to use in PV array sizing calculations		11.5 %	
Component warranty minimum requirements	Batteries	5 years minimum		Section 5.3.2[1]
	Inverters	10 years minimum		Section 5.3.3[1]
	PV modules	80 % original maximum power at 25 years minimum		Section 5.3.4[1]
	Charge controllers	3 years minimum		Section 5.3.5[1]
Exceptions				Section 5.3[1] Section 6[1] Section 7[1]

(1) Requirements and Guidelines for Installation of Off-grid Solar Systems for Public Facilities
(2) Off-grid Public Facilities PV System Design Tool

Example Template 4. Site-specific summary requirements

Site-specific summary requirements		Wiring requirements		PV array mounting options			
Facility Type	Total locations	Pre-wired	New wiring	Pole mount only	Ground mount only	Roof mount only	Multiple options
Basic PHC							
Improved PHC	20	3	17	1	0	0	19
Basic school							
Improved school							

Example Template 5. Facility locations and site-specific requirements

Facility locations and site-specific requirements									
Site No.	Site Name	Facility Type	Latitude (°W)	Longitude (°N)	Site temp (°C)		Minimum solar resource ($kWh/m^2/day$)	wiring (pre/new)	PV array mounting options[1]
					min	max			
1	Facility 1	Improved PHC	9.18484	7.46855	7	43	4.5	pre	P
2	Facility 2	Improved PHC	40.7450	123.8695	0	32	5.0	new	P/R
3	Facility 3	Improved PHC	37.9161	122.3108	-3	40	4.2	new	P/R
	…additional sites 4-100…								
[1]PV array mounting options: P (pole) / G (ground) / R (roof)									

The *Draft Example Service Contract* referred to in Template 6 is hypothetical and an example is not provided as part of this document. However, it is highly recommended that an example contract be drafted prior to soliciting bids to ensure that all relevant requirements are considered in the bid documents and presented to the potential bidders. A service contract should describe the payment schedule, the payment structure (i.e., how will payments for the capital, installation, O&M and replacement costs be disbursed), the performance requirements, the methods for monitoring and assessing compliance with the performance requirements, penalties or payment delays for under-performance, any relevant risk guarantees to ensure payment, and methods for managing missing/invalid data and disputes. Contracts may also include requirements regarding training of on-site users and local technicians, required frequency of site visits, stock quantities of spare parts, management of funds for replacement of large components (e.g., creation of an escrow account for expected battery replacements), and end-of-life disposal of components.

Refer to Sections 9 and 10 of the *Requirements and Guidelines for Installation of Off-grid Solar Systems for Public Facilities* for more guidance on O&M and performance-based service contracts.

Example Template 6. Long-term service delivery, monitoring, and system maintenance

Long-term service delivery, monitoring, and system maintenance template		
Performance monitoring	These metrics shall be monitored to assess system performance: Available Energy (E_a) [x] Low Voltage Disconnect (LVD) [x] Solar System Functionality (T_f) [x] State of Charge (SoC) [x] Depth of Discharge (DoD) [x] Days Fully Charged (DFC) [x]	Section 10.2[1]
Monitoring interval	Data shall be recorded at a frequency of at least every 15 minutes with the minimum, maximum or total recorded at least every 24 hours	Section 10.2[1]
Operations and maintenance service delivery contract	O&M contract (Option 1) [ ] Lease/extended service contract (Option 2) [x] Contract length [20 years] Service delivery/maintenance plan must include:	See Section 9[1] for details on creating a maintenance contract

	Live system monitoring…… x Emergency response criteria/response time x Corrective maintenance procedures……. x Preventative maintenance schedule……. x System testing schedule…… x Array/panel cleaning…… x Weed/vegetation control…… Warranty fulfillment procedure……... x End-user training programs……..... x End-of-life disposal…….. x Other…….. Other…….. Other…….. Notes: Please see details outlined in the *Draft Example Service Contract*	
Financial assumptions	Capital cost payments from project developer Upfront 25 % Installments Per service delivery contract 75 % Installment schedule monthly over 15 years Project implementers should quote Capital costs and O&M contract as separate payments Monthly payment schedule…….. x Total capital costs…… x Total installation costs…….. x Monthly O&M cost……. x Expected replacement costs……... x Disposal costs…… x Other…… Other……	--

	Annual inflation rate for calculations: 3% annual Currency used for quotes: USD	
Contract summary	As indicated in the *Draft Example Service Contract,* 25% of the capital and installation costs of the systems will be paid upon installation, while the remaining 75% if the capital and installation costs will be amortized over the 15-year project period and included in monthly payments along with the O&M costs and the funding for component replacement. Project costs should be quoted in the following terms: • Total capital costs (for each system type and in total) [USD] • Total installation costs (for each system type and in total) [USD] • Monthly O&M cost (in total across all systems. Ensure that required site visits, initial and on-going trainings, spare parts, data charges for the remote monitoring systems, and all other O&M costs are included in this figure.) [USD/month] • Expected component replacement costs over the 15-year period (in total across all systems) [USD] • Expected end-of-life disposal costs and/or salvage value for components (in total across all systems) [USD] • Total monthly payment cost considering that 75% of the capital/installation costs and all of the O&M and replacement costs will be distributed over the 15-year project life. Include any financing costs specific to your firm and assume a 5% rate of inflation. [USD/month]	
Other notes		--
[1]Requirements and Guidelines for Installation of Off-grid Solar Systems for Public Facilities		

14 Blank templates

Template 4. Facility type definitions

Facility type definitions		
Facility type name	**General Description**	**Reference[1,2]**
		Section 11.1[1] PV System Design Tool[2]
		Section 11.1[1] PV System Design Tool[2]
		Section 11.1[1] PV System Design Tool[2]

(1) *Requirements and Guidelines for Installation of Off-grid Solar Systems for Public Facilities*
(2) *Off-grid Public Facilities PV System Design Tool*

Template 2. Load and electrical outlets

Electrical equipment and outlets installation requirements					
Facility Type					
Electrical equipment					
Equipment type	No. of units	Rated power (W)	Minimum efficiency	Notes	Reference[1]
Ceiling light[2]			lm/W		Section 6.6[1]
Outdoor security light[2]			lm/W		Section 6.6[1]
Ceiling fan[2]			m^3/min/W or CFM/W		Section 6.7[1]
other					
Electrical outlets/sockets					
Outlet type	No. of units	Rating (V)	Notes		Reference[1]
AC socket					Section 5.2.12[1]
DC socket					

(1)Requirements and Guidelines for Installation of Off-grid Solar Systems for Public Facilities
(2)List specific requirements for each electrical device. Including specific part numbers (where applicable) or relevant performance parameters. Provide detailed guidance on minimum requirements including efficiency, output, type, designation of critical loads, etc.

Template 3. Design requirements

Design Requirements				
Facility Type				
Facility energy requirements	Value/description			Reference[1]
Daily energy requirement (kWh/day)				Section 5.4[1] Section 11[1] PV Design Tool[2]
Average power draw (kVA)				
Maximum power draw (not including surge) (kVA)				
Maximum power draw (including surge) (kVA)				
System design specifications	Item			Reference[1]
Allowable system configurations (check all that apply)	DC-coupled ☐ AC-coupled ☐ Hybrid ☐ Site-specific ☐	Notes:		Section 5.2.2[1]
Allowable battery chemistry	Lead-acid ☐ Lithium ☐ Other ☐	Notes:		Section 5.3.2[1]
Battery depth of discharge design target (≤ %)				Section 5.2.9[1]
Load type requirements	AC loads ☐ DC loads ☐	AC voltage/frequency DC load voltage(s)		PV Design Tool[2]
Battery array voltage requirements	Battery array minimum		V DC	Section 5.2.8[1]
	Battery array maximum		V DC	

PV array mounting requirements	Pole mount Ground mount Roof mount	 	Notes:	Section 7.3[1]
PV module requirements	Allowable module power tolerance			Section 5.2.3[1]
System requirements	Minimum PV array oversize factor			Section 5.2.6[1]
	Minimum required days of autonomy			Section 5.2.7[1]
PV array efficiency losses: Efficiency loss assumptions the project implementer shall make when sizing the PV array	Module mismatch loss			Section 5.2.3[1]
	Module degradation factor			
	Efficiency loss from shading			
	Efficiency loss from soiling			
	Other			
	Total PV efficiency loss for PV array sizing calculations			
Component warranty minimum requirements	Batteries			Section 5.3.2[1]
	Inverters			Section 5.3.3[1]
	PV modules			Section 5.3.4[1]
	Charge controllers			Section 5.3.5[1]
Exceptions				Section 5.3[1] Section 6[1] Section 7[1]

(1)Requirements and Guidelines for Installation of Off-grid Solar Systems for Public Facilities
(2) Off-grid Public Facilities PV System Design Tool

Template 4. Site-specific summary requirements

Site-specific summary requirements		Wiring requirements		PV array mounting options			
Facility Type	Total locations	Pre-wired	New wiring	Pole mount only	Ground mount only	Roof mount only	Multiple options
Basic PHC							
Improved PHC							
Basic school							
Improved school							

Template 5. Facility locations and site-specific requirements

Facility locations and site-specific requirements									
Site No.	Site Name	Facility Type	Latitude (°W)	Longitude (°N)	Site temp (°C)		Minimum solar resource (kWh/m^2/day)	wiring (pre/new)	PV array mounting options[1]
					min	max			
1									
2									
3									
4+									
(1)PV array mounting options: P (pole) / G (ground) / R (roof)									

Template 6. Long-term service delivery, monitoring, and system maintenance

Long-term service delivery, monitoring, and system maintenance template		
Performance monitoring	These metrics shall be monitored to assess system performance: Available Energy (E_a) ☐ Low Voltage Disconnect (LVD) ☐ Solar System Functionality (T_f) ☐ State of Charge (SoC) ☐ Depth of Discharge (DoD) ☐ Days Fully Charged (DFC) ☐	Section 10.2[1]
Monitoring interval		Section 10.2[1]
Operations and maintenance service delivery contract	O&M contract (Option 1) ☐ Lease/extended service contract (Option 2) ☐ Contract length ☐ Service delivery/maintenance plan must include: Live system monitoring…… ☐ Emergency response criteria/response time ☐ Corrective maintenance procedures……. ☐ Preventative maintenance schedule……. ☐ System testing schedule…… ☐ Array/panel cleaning…… ☐ Weed/vegetation control…… ☐ Warranty fulfillment procedure……... ☐ End-user training programs……..... ☐ End-of-life disposal…….. ☐ Other…….. ☐ Other…….. ☐ Other…….. ☐	See Section 9[1] for details on creating a maintenance contract

	Notes:	
Financial assumptions	Capital cost payments from project developer Upfront ☐ Installments ☐ Per service delivery contract ☐ Installment schedule ☐ Project implementers should quote Capital costs and O&M contract as separate payments ☐ Monthly payment schedule…….. ☐ Total capital costs……. ☐ Total installation costs…….. ☐ Monthly O&M cost…….. ☐ Expected replacement costs……... ☐ Disposal costs…… ☐ Other…… ☐ Other…… ☐ Annual inflation rate for calculations ☐ Currency used for quotes ☐	--
Contract summary		
Other notes		--
[1]Requirements and Guidelines for Installation of Off-grid Solar Systems for Public Facilities		