International Medical Corps

Solarization of Facilities

Operational guidance

Global Logistics & Supply Chain
August 2024

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1. General Overview

International Medical Corps is committed to helping reduce the organization's carbon footprint and any other negative impact we have on the environment. These efforts are part of our commitment to sustainability, as described in International Medical Corps' program statement, to urgently work to address climate change.

Solarization of facilities is the process of installing solar panels and other related components to generate electricity from sunlight. This sustainable and cost-effective solution reduces reliance on traditional energy sources and minimizes their environmental impact. By using the power of the sun, we can generate clean and renewable energy to meet our electricity needs. These actions should not be considered only in remote or off-grid locations but should be a part of International Medical Corps' efforts to establish sustainable sources of energy for our facilities wherever possible. This means replacement or decreased use of traditional sources of electricity on all suitable sites.

By taking this approach we can expect the following benefits:

- **Cost savings:** By generating our own electricity, we eliminate our reliance on expensive fossil fuels or grid-based electricity. Over time, this can result in significant cost savings on fuel and energy bills.
- **Reduce negative impact on the environment:** Solar energy is a clean and renewable source of power, producing no greenhouse gas emissions during operation. By utilizing solar power, the reliance on fossil fuels is reduced, leading to a decrease in carbon dioxide and other harmful emissions. This way we can reduce our carbon footprint and present our achievements to stakeholders.
- **Energy independence and security**: Solarization can increase energy supply security by providing a reliable source of energy that is not subject to the same risks and vulnerabilities as traditional energy sources. This can be particularly important in off-grid locations where access to a reliable utility grid or fuel for generators is limited.

This guidance provides instructions on the solarization process, including planning, sourcing, installation and maintenance. It serves as a guide for country teams (Logistics Coordinators, technicians, engineers, Procurement Officers) and other stakeholders involved in this process.

2. Facility Selection

This section details the elements to consider before selecting facilities for installation of solar energy systems, including:

1. Prioritization of facilities
2. Legal considerations
3. Technical considerations
4. Financial considerations
5. Financing options

2.1 Prioritization of Facilities

It is important to consider the background (current situation) and goals of solarization (e.g., increasing reliability of power supply, reducing carbon emissions, achieving energy independence, reducing operational costs) when evaluating which facilities will be given priority for solar energy system costs. The following factors should be considered:

- **Time perspective:** Estimating the expected duration of programs in the area concerned is important when selecting a facility for solarization. The duration of programs can vary widely depending on their nature and objectives. For instance, if the programs are long-term initiatives, a facility with a long-term lease may be more suitable for solarization. Main offices and warehouses are usually rented for a longer period; therefore, it is recommended to consider them for solarization.
- **Energy security and reliability:** Different parts of the world, especially remote or less developed areas, have difficulty providing reliable electricity. As a result, communities and facilities in these areas often face difficulties in meeting their energy needs for daily operations. Solarization of facilities in these locations is a possible solution, not only for ensuring a constant source of energy but also for reducing dependence on external energy sources that are often unreliable or unavailable.
- **Environmental impact:** Solarization can significantly reduce the carbon footprint of a facility by replacing traditional fossil fuel-based energy sources with clean, renewable energy. When determining which facilities should be prioritized for solarization, it is important to consider facilities with high use of generators and/or utility grid powered by fossil energies (coal, gas and fuel). These facilities should be given priority if possible.
- **Financial viability:** Facilities with higher electricity or fuel costs are prime candidates for solarization. By transitioning to solar energy, these facilities can significantly reduce their operational expenses. When identifying facilities with higher electricity costs, it is essential to conduct a thorough analysis of historical energy consumption patterns and associated expenses. This approach allows us to select the facilities where solarization efforts can generate the most substantial cost savings and long-term benefits.

- **Geographical location:** This assessment should consider factors such as amount of sunlight, climate conditions and the availability of suitable land or rooftops for solar panel installation. Additionally, it is important to evaluate the energy needs of each site as well as the existing electricity distribution infrastructure. Facilities located in regions with a lot of sunlight and minimal shading should have priority. Additional factors such as proximity to reliable solar equipment suppliers, availability of skilled labor for installation and maintenance, and transportation infrastructure should be taken into consideration as well.

2.2 Legal Considerations

Another important step is to ensure that the project accounts for legal and regulatory requirements.

2.2.1 Ownership of the Facility

The ownership structure of the facility plays a significant role in determining who has the authority to make decisions regarding solarization. In cases where the facility is owned by International Medical Corps, decisions related to solarization may be made internally, allowing for more streamlined decision-making processes. If the facility is leased or owned by external entities or government bodies, there is a need to engage in negotiations and collaborations to gain approval for solarization initiatives. In this context it is necessary to:

- check ownership of the facility (public/private), and
- check the contract and willingness of the owner to accept this investment.

At this stage, it might be necessary to involve the Legal department or a local lawyer to consider all legal aspects of investing in property that we do not own. There are two possible scenarios regarding ownership of facility.

Scenario 1: Facility is leased from a private entity

In this scenario, the facility operated by International Medical Corps is leased from a private entity. Installing a solar power system on a leased property involves specific terms and conditions that need to be addressed in the lease contract. These terms and conditions typically cover various aspects such as ownership, installation, maintenance, insurance and financial arrangements. The lease contract may include a buyout option that allows the lessor to purchase the solar power system at a predetermined price after a certain period of time. One of the options is for the lessor to acquire ownership of the solar power system through reduced rent. If there is no agreement on the transfer of ownership, International Medical Corps should have the right to demobilize the installed system and use it for other purposes.

The goal of the lease contract or its amendments is to ensure that the solarization project is conducted legally and responsibly, minimizing potential risks and conflicts.

Scenario 2: Facility is owned by partner organization or government body

In this scenario, it might be necessary to agree on a memorandum of understanding or right-of-use agreement.

A **memorandum of understanding (MoU)** is a formal agreement between two or more parties that outlines the terms and details of a cooperative relationship, including the roles and responsibilities of each party. When we invest in the solarization of a facility, the MoU serves as a document that defines the agreement between our organization and other stakeholders involved in the solarization project. Each party's roles and responsibilities must be clearly outlined to ensure effective collaboration. The MoU may include technical details related to the solarization process, such as equipment specifications, installation requirements and maintenance protocols to ensure optimal performance of the solar infrastructure.

A **right-of-use agreement** is a legal document that grants the right to use a specific property or asset for a defined period. In the context of installing a solar power system, a right-of-use agreement would outline the terms and conditions under which International Medical Corps is allowed to install and operate the solar power system on a particular property. As with a lease contract, it is important to agree on transition of ownership after the end of the project. If there is no such an agreement, International Medical Corps should have the right to demobilize the installed system and use it for other purposes.

2.2.2 Regulatory and Permitting Requirements

Solarization projects may be subject to various regulatory and permitting requirements. These requirements are frequently put in place to ensure that the projects are safe and environmentally friendly and do not negatively impact the surrounding communities. Prior to installation of a solar system, it is necessary to research all relevant regulatory and permitting requirements, as per local legislation requirements. This may include obtaining building permits, electrical permits and any necessary approvals from local authorities. By addressing regulatory and permitting aspects early in the process, potential delays or complications can be minimized.

2.3 Technical and Engineering Considerations

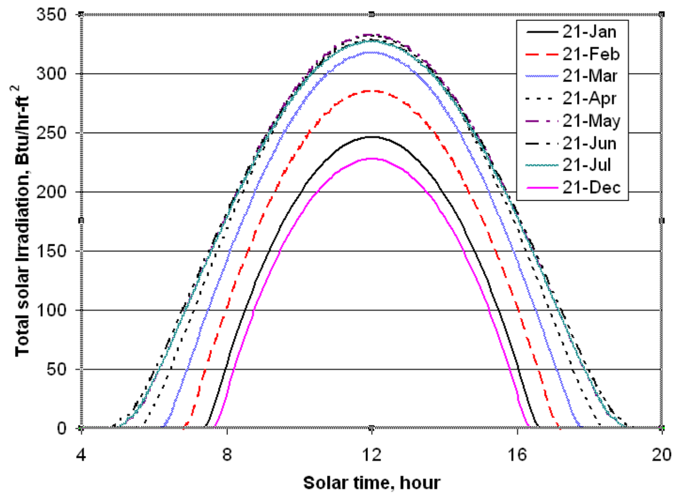
Prior to considering solarization, the following aspects must be considered:

- the current power system;
- solar energy production potential;
- energy consumption and load analysis;
- roof and space availability; and
- building structure and wiring.

2.3.1 Analysis of Existing Power System

Before the installation of a solar source of electricity, it is essential to conduct a thorough analysis of the existing power system to ensure seamless integration and optimal performance. The analysis should encompass various aspects of the current power infrastructure, power sources, grid connectivity and interconnection requirements, synchronization requirements, wiring and possibilities for upgrade.

2.3.2 Solar Energy Production Potential Assessment



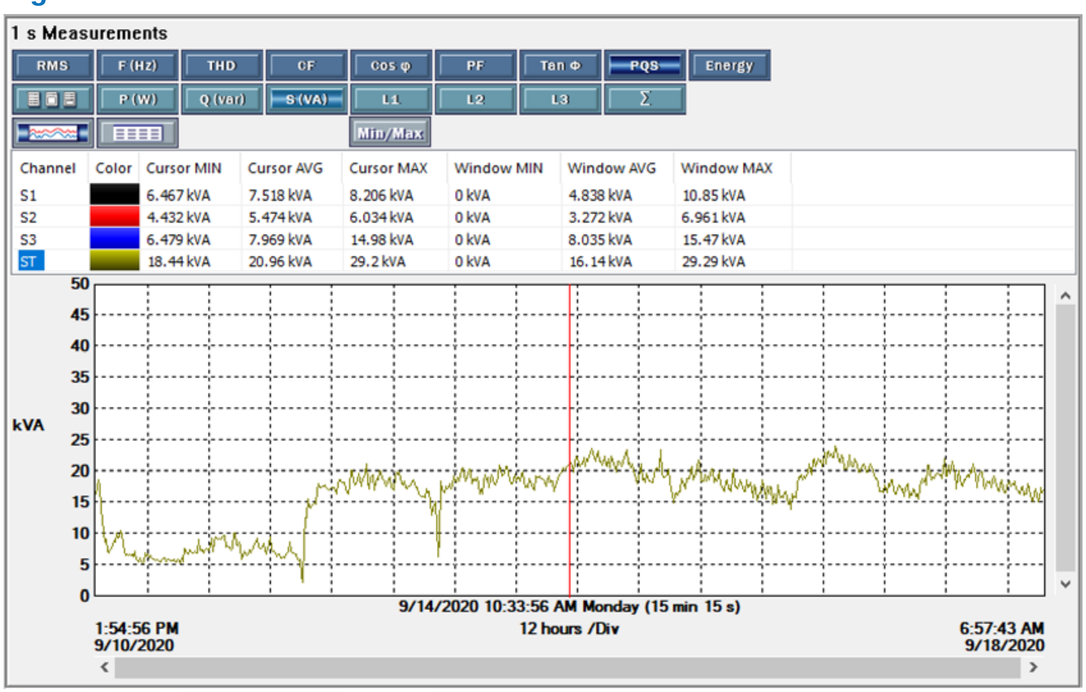
Insolation diagrams provide valuable information about the amount of solar radiation received at a specific location over a period of time. These diagrams are essential for understanding the solar potential of a site, optimizing the design and placement of solar panels, and estimating energy production.

There are online tools on the internet that can be used to get an estimate of solar irradiation for any location. An example of one such tool is Global Solar Atlas, a free web program with a map interface. This tool offers data on solar resource availability and photovoltaic power potential worldwide. It includes reporting tools, streamlined photovoltaic (PV) power calculation, interactive online map tools, and a large download area. The tool can be accessed via the following link: https://globalsolaratlas.info/map.

2.3.3 Energy Consumption and Load Analysis

Understanding energy consumption patterns is important in determining the capacity and configuration of the solar power system. This involves analyzing historical energy usage data to identify peak consumption periods, daily fluctuations and seasonal variations. By gaining insights into the consumption patterns, it becomes feasible to size the solar installation appropriately to meet the demand while optimizing energy generation.

Figure 1: Recorded Power Demand



2.3.4 Roof and Space Availability

Conducting a detailed site assessment is important for identifying suitable locations for solar panel installation, as well as other equipment (inverters, batteries, etc.). Factors such as available space, suitability of the facility's roof or ground, orientation, shading and structural considerations have to be analyzed. Additionally, consider the space required for mounting, wiring and maintenance access.

2.3.5 Building Structure and Wiring

It is necessary to assess the building's structure and integrity to ensure that the solar system can be safely and securely installed. This includes evaluating the roof's load-bearing capacity, electrical infrastructure and potential for integrating with existing systems.

2.4 Financial Considerations

2.4.1 Initial Investment Costs

The initial investment costs in a solarization project can vary widely depending on several factors, including the size of the project, the location and the technology used. There are some typical initial investment costs that need to be considered, including purchase of solar panels, inverters, batteries, monitoring systems, mounting structures, wiring and other necessary equipment, as well as installation and labor costs. It is important to conduct a thorough cost analysis to ensure that all aspects of the project are adequately funded for successful implementation and long-term sustainability.

2.4.2 Operational and Maintenance Expenses

Beyond the initial investment, ongoing operation and maintenance should be considered. This includes regular maintenance of solar equipment, replacement of components over time, technical support for troubleshooting issues and potential expansion or upgrades as technology advances.

2.4.3 Savings and Return on Investment

Investing in a solar power system can result in significant savings and returns over time. The financial benefits of solar energy can be analyzed through factors such as cost savings on electricity bills and/or operating costs of generators. In certain countries, there might be a potential to gain income from selling excess energy back to the grid. Return on investment (ROI) has to be calculated, considering existing costs, payback period and the lifespan of the system. The steps are as follows:

1. **Determine the initial cost of the solar power system.** Establishing the cost of the solar power system is the first step in determining the ROI. This covers the cost of the solar panels, inverters, batteries, mounting equipment and other required parts. Potential installation/permit fees and inspection costs have to be considered as well.

2. **Estimate maintenance costs of the solar power system.** Like any other system, solar power systems require maintenance to ensure optimal performance and longevity. This estimate should include routine inspections, cleaning and minor repairs.
3. **Estimate the energy production of the solar power system.** It is essential to project how much electricity the solar power system will generate over its lifetime to calculate the return on investment. This depends on the system's size, location and orientation. To estimate energy production based on your location and system size, you can use internet tools like PVWatts (https://pvwatts.nrel.gov/index.php).
4. **Determine the cost of electricity from the grid or generator:** This is the amount you currently pay for electricity from your utility provider, or the price of electricity produced by the generator (including cost of purchase, fuel expenses and maintenance costs).
5. **Calculate the savings from using solar power:** To do this, subtract the cost of electricity from the grid or generator from the energy produced by the solar power system.
6. **Calculate the ROI:** Divide the total savings by the initial cost of the solar power system and multiply by 100 to express the ROI as a percentage.

Example of ROI calculation:

Total cost of solar power system (initial cost and maintenance)	**$10,000**
Annual energy production:	8,000 kWh
Cost of electricity from the grid:	$0.15/kWh
Annual savings ($0.15/kWh * 8,000 kWh):	$1,200
ROI calculation: 1.200$/10.000$ x 100 (Annual savings/initial cost) x100	12%
Solar system payback period (10,000 $/1,200 $)	8.3 years

An example of calculating the ROI in relation to the supply of electricity via a generator can be found in Section 5: Comparing Diesel Generators to Solar Power Systems.

2.4.4 Cost-Benefit Analysis

When planning to install a solar power system, it is recommended to conduct a cost-benefit analysis that will cover all aspects of the investment specified above. In addition to financial aspects, environmental impact and achievement of energy independence and security must be included as positive aspects.

2.5 Financing Options

Determine budget requirements: When determining the budget requirements for a solar power system, factors like the size and type of solar power system required, installation costs and maintenance expenses need to be considered. Potential financial incentives or grants available have to be considered before sizing the system. Research and contact potential donors, especially those who have a history of supporting renewable energy projects to get an estimation of feasible budget.

Business case for donors: Make a strong business case for donors to support the installation of a solar power system. The business case should outline the benefits and advantages of transitioning to solar energy, emphasizing the positive impact on our operations, cost savings, environmental sustainability and overall social responsibility. By presenting these arguments, potential donors can recognize the value and significance of supporting such initiatives.

3. Implementing a Solarization Project

3.1 Step 1: Planning Phase

3.1.1 Site Assessment

The first step is to conduct a thorough site assessment to determine the feasibility and potential of solarization. The main steps of the planning phase are listed in the table below:

	Step	Actions
1.	Selection of facility	• Select the most appropriate facilities for installation of solar energy system. Consider factors and guidelines described in Section 2.
2.	Regulatory/ownership steps	• Check the lease contract and enter negotiation with the owner. • Amend the lease contract (if necessary) and/or create right-of-use agreement/memorandum of understanding. • Research and comply with all relevant regulatory and permitting requirements for the solar system installation.
3.	Estimation of necessary budget and possibilities of funding	• Estimate budget requirements. • Research and contact potential donors, especially those who have a history of supporting renewable energy projects to get an estimation of feasible budget.
4.	Assessment of energy requirements	• Perform measurement and analysis of facility's energy consumption needs and patterns.
5.	Identification of feasible solar power system solution	Select from the following options: • **Full solar system:** The system provides 100% of the power from the solar source (batteries, generator or utility grid only as backup). • **Solar controlled system:** Solar system provides 60–90% of the power; generator or utility grid provides the balance. Battery bank stores energy during the day for use during the night. • **Solar system as an additional source of energy**: The solar power system accounts for less than 60% of the electricity source.
6.	Cost-benefit analysis	• Conduct a cost-benefit analysis that will cover all aspects of the investment. Determine the feasibility and ROI of the project.
7.	Business case for donors	• Make a business case for donors to support the installation of a solar power system.

3.1.2 System Design

The design of the system follows after all the steps from the planning phase have been completed. There are two main steps, as indicated in the table below:

	Step	Actions
1.	Design an appropriate solar system for the facility	• Determine number and type of solar panels required, inverters, batteries (if necessary), mounting structures, electrical wiring, etc. • The design should consider factors such as the facility's energy demand, available sunlight hours, shading obstacles (e.g., trees or nearby buildings) and local regulations or permits required for installation.
2.	Technology selection*	• Select the appropriate solar technology—solar panels, batteries, inverters, etc. (Consider efficiency, durability, maintenance requirements, warranty and compatibility with the existing electrical infrastructure.)

**Recommended minimum technical requirements are specified in the Appendix (<u>Recommended minimal technical requirements</u>).*

3.2 Step 2: Installation and Commissioning

The installation process involves mounting solar panels on a designated area (roof or ground) according to specifications. The components, such as inverters, batteries and wiring, are then connected and integrated into the facility's electrical infrastructure.

After the solar power system has been installed and commissioned, it is essential to inspect the system to ensure that it is working correctly, efficiently and in compliance with all electrical codes. The inspection should cover all components of the system, including the solar panels, inverters, mounting structures, wiring and monitoring systems. It is necessary to ensure that all installations adhere to industry standards and safety regulations.

This inspection will help identify any issues or defects that may have arisen during the installation process and ensure that the system is operating at its maximum potential. After the inspection, a report should be prepared that details the findings and recommendations for any necessary repairs or maintenance. The report should also include any issues or defects found during the inspection, along with a plan for addressing them.

3.3 Step 3: Maintenance, Monitoring, Education and Training

3.3.1 Regular Maintenance

Regular maintenance is important for ensuring optimal performance and longevity of the solar power system. This includes cleaning panels, inspecting wiring connections, checking for shading issues, monitoring inverter performance and addressing any equipment malfunctions promptly. A maintenance schedule must be developed that includes periodic inspections, cleaning and performance checks. Safety should always be the top priority when inspecting a solar power system. It is necessary to ensure that all electrical connections are safe and properly insulated and to check for any signs of fire risk, such as overheating or damaged wiring. It is recommended to **train staff** members in basic troubleshooting and maintenance tasks to address minor issues promptly.

3.3.2 Monitoring and Reporting

Monitoring of an installed solar power system is needed to ensure that the system is operating at maximum efficiency and to identify any issues or faults that may arise. When reporting on the results of an implemented solar power system, it is essential to consider various factors, such as energy production, cost-effectiveness, environmental benefits and overall performance.

3.3.3 Education and Training

One of the important steps is to provide proper education and training to users. This includes understanding the functionality of the solar power system, its components, maintenance requirements and safety protocols. Users should be educated on how their energy consumption patterns may need to be adjusted to optimize the benefits of solar power.

4. Solarization Project — Determining Technical Requirements

There are three possible scenarios regarding the technical capacity of International Medical Corps to perform the necessary actions in the solarization project:

4.1 In-House Expertise

In this scenario, International Medical Corps has staff with sufficient technical capacity to perform site assessment and system design for the solarization of a facility. Staff members possess the necessary expertise in solar energy systems, including knowledge of photovoltaic technology, electrical engineering and sustainable energy solutions. They can conduct thorough site assessments to determine the feasibility of solar installation, considering factors such as solar exposure, structural integrity of the facility and energy-consumption patterns. Additionally, they have the capability to design an efficient and effective solar energy system tailored to the specific needs of the facility.

There are several pros and cons for this method:

Pros (+)	Cons (-)
• **Cost: The cost and time for contracting external consultants or engineers can be avoided.** • **Full control over the process: We have full control over the site assessment and system design process, allowing us to tailor the system to our specific needs and requirements.**	• Limited expertise: Staff may lack experience or expertise in solar energy system design, which could result in suboptimal system design or poor performance. • Time-consuming: Site assessment and system design can be time-consuming processes for our staff. • Lack of specialized knowledge: The internal team may not have access to the latest technologies and innovations in solar energy system design, which could lead to a less efficient system.

4.2 Contracting an Engineer

In this scenario, International Medical Corps lacks the internal technical capacity required for site assessment and system design for solarization. To overcome this gap, there is an option to contract an engineer or a company with expertise in solar energy systems.

The engineer will be responsible for conducting site assessments, analyzing energy requirements and designing an optimal solar energy system for the facility. In addition, the same engineer can perform inspection of the solar power system after its installation. This approach allows us to leverage external expertise and ensure that the solarization project is executed with precision and effectiveness.

Pros (+)	Cons (-)
• **Bill of quantities (BOQ): Contracting an external expert enables us to produce BOQ, which will enable us to have clear criteria for the selection of supplier.** • **Expertise: Contracting an engineer with expertise in solar energy systems can provide us with specialized knowledge and skills to design an optimal system.** • **Faster completion: Potentially, external engineers could complete the site assessment and system design more quickly than an in-house team, as they have the necessary expertise and experience.** • **Access to latest technologies: An external engineer can provide us with access to the latest technologies and innovations in solar energy system design.**	• Time and cost: Contracting an external engineer is an additional cost and requires extra time for its selection, as the bidding process has to be organized. • Lack of control: By contracting an external engineer, we may have less control over the site assessment and system design process, as we will be relying on an outside expert.

4.3 Request for Proposal (RFP)

In cases when there is no sufficient technical capacity for site assessment and system design for solarization, we may opt to initiate a bidding process using a request for proposal (RFP). Through this process, we can solicit proposals from qualified engineering firms or contractors specializing in solar energy projects. The RFP will outline the project requirements, including site assessment criteria, system design specifications, reliable power supply and sustainability goals. Interested parties will then submit their proposals detailing how they plan to address these requirements, allowing the organization to select a partner with the expertise needed to execute the solarization project successfully.

Pros (+)	Cons (-)
• **Cost and time savings: No need to engage internal or additional external resources for technical expertise.** • **Access to multiple experts: By soliciting proposals from multiple companies, we can access broader expertise and specialized knowledge.**	• Challenges in selection of supplier: Challenging to establish clear criteria for selection of suppliers, to perform evaluation of offers if technical staff is not available and to justify selection. • Time-consuming: The RFP process can be time-consuming, as it involves evaluating multiple proposals with different solutions. • Lack of control: By relying on external firms or contractors, we may have less control over the site assessment and system design process.

4.3.1 Selection of Solar Power System Suppliers Using Request for Proposal (RFP)

The process of selecting solar power system suppliers by using an RFP involves several key steps to find the most suitable and reliable supplier:

1. **Needs assessment:** The first step in the selection process is to conduct a needs assessment to determine the specific requirements. This includes assessing the energy needs, geographical location, environmental conditions and any specific technical requirements for the solar power system.
2. **Development of RFP document:** Once the needs assessment is completed, we can proceed with developing the RFP document. The RFP should include site description, specifications of the current electricity supply system, description of required solar power system, including capacity, efficiency, durability and any other technical requirements. It should also outline the evaluation criteria that will be used to assess supplier proposals. An example of RFP and related documents can be found in the Tools and Templates section.
3. **Market research into potential suppliers:** Before the RFP is issued, it is necessary to identify potential bidders on the market. This can be done by searching the internet, consulting with other humanitarian organizations or by issuing a request for information.
4. **Call for expression of interests (EOI)** can be used in the process of identification of potential bidders. The primary purpose of a call for expressions of interest is to signal to the market that we are considering procuring certain goods or services. It serves as a preliminary screening mechanism to identify qualified and interested parties before moving on to more detailed tender processes. The EOI represents a document in which a potential supplier demonstrates his intention to bid on the project, as per the requirements outlined in the RFP. Interested parties have to be identified and contacted in the following phase.
5. **Shortlisting of candidates:** Use the eligibility questionnaire (an example can be found in the Tools and Templates section).
6. **Distribution of RFP:** The RFP document is then distributed to potential suppliers who have been identified as capable of meeting requirements. This can be done via direct contact, online procurement platforms, etc.

7. **Meeting for information:** The purpose of this meeting is to present plans and clarify any issues regarding the bidding process and RFP document. It should be organized after the release of RFP. Responses to questions have to be shared with all shortlisted bidders.
8. **Site visit:** Before proposal submission, it is necessary to organize a mandatory site visit so that the bidders can perform an on-site assessment and propose an appropriate solution. When organizing a site visit, it is important to consider that it does not affect the bidding process. It is also recommended that each supplier gets his or her own appointment for the site visit, to avoid interactions. Once the site visit is completed, each supplier is required to sign the site visit certificate (an example can be found in the Tools and Templates section).
9. **Pre-bid meeting:** The purpose of the meeting is to address questions that might arise after the site visit. Based on the discussion at this meeting, International Medical Corps reserves the right to modification in RFP. Responses to questions have to be shared with all bidders.
10. **Supplier proposal submission:** Interested suppliers are given a specified period to prepare and submit their proposals in response to the RFP. The proposals should include detailed information about the supplier's company background, experience, technical capabilities, proposed solar power system design, pricing, warranty terms and any additional value-added services. Offers must be submitted via email to a secure email address or other method as specified in RFP.
11. **Evaluation of proposals:** Once the proposal submission deadline has passed, International Medical Corps' evaluation team reviews each proposal based on the predetermined criteria outlined in the RFP document. This involves scoring each proposal based on factors such as technical compliance, cost-effectiveness, reliability and past performance. Supplier has to meet minimum technical requirements and project return on investment (against existing situation), and offer an acceptable delivery schedule and warranties.
12. **Supplier selection and negotiation:** After evaluating all received proposals, suppliers who meet requirements have to be shortlisted. The shortlisted suppliers may then be invited for further discussions or negotiations to clarify details of their proposals and address any outstanding questions and contractual terms.
13. **Contract award and implementation:** The final step of selection involves awarding the contract to the selected supplier and proceeding with the implementation of the solar power system project. This includes finalizing legal agreements, arranging delivery and installation schedules, and ensuring that all necessary permits and approvals are obtained.
14. **Inspection of installed solar power system:** After the solar power system has been installed and commissioned, it is essential to inspect the system to ensure that it is working correctly, efficiently and in compliance with all electrical codes. The inspection should be done by a licensed electrical inspector after construction is complete. Commissioning tests shall be included in the final inspection. The inspection has to be done by an independent commissioning agent contracted by International Medical Corps.

4.4 Overview of Solarization Tasks According to Technical Capacity

Task	International Medical Corps has sufficient in-house expertise	International Medical Corps has insufficient technical capacity — contracting an engineer	International Medical Corps has insufficient technical capacity — RFP
Facility assessment (structural, technical)	Done by International Medical Corps' engineer(s)	Done by contract engineer(s)	Done by company participating in bidding process
Solar power production potential assessment			
Power requirements assessment			
Identifying the most suitable solar power solution			
Selecting the appropriate technology			
System design			
Calculation of ROI			
Preparation of BOQ	Done by International Medical Corps' engineer(s)	Done by contract engineer(s)	Done by the selected supplier
Installation	Done by the selected supplier	Done by the selected supplier	Done by the selected supplier
Commissioning			
Inspection	Done by International Medical Corps' engineer(s)	Done by contract engineer(s)	Done by independent contract engineer(s)
Maintenance	Done by the selected supplier	Done by the selected supplier	Done by the selected supplier
Monitoring	Done by International Medical Corps staff with assistance of the selected supplier	Done by International Medical Corps staff with assistance of the selected supplier	Done by International Medical Corps staff with assistance of the selected supplier

5. Comparing Diesel Generators to Solar Power Systems

When considering the choice between diesel generators and solar power systems, it is necessary to evaluate and compare factors such as cost, reliability, environmental impact, maintenance requirements, efficiency, etc. Both options have their advantages and disadvantages, so the differences between them have to be understood before making a decision.

5.1 Comparison of Solar Power System and Diesel Generator: Advantages and Disadvantages

a) When comparing solar power systems to diesel generators across several important factors, as shown in table below, it becomes evident that solar power systems offer advantages in terms of sustainability, efficiency and long-term savings, despite high initial investment.

	Solar power system	Diesel generator
Environmental impact	👍	👎
Operating costs	👍	👎
Need for fuel replenishment and maintenance	👍	👎
Initial investment	👎	👍
Cost-effectiveness	👍	👎
Noise pollution	👍	👎

b) Understanding the pros and cons of solar power systems and diesel generators is important before making decisions about their implementation. An overview of the pros and cons of both energy sources is in the table below. By carefully weighing these factors, we can evaluate which solution is right for us in the given context.

Solar Power System	
Pros	**Cons**
• **Clean and renewable energy source** • **Low operating costs,** as they rely on sunlight for energy production • **Long-term investment:** Solar panels have a long lifespan (typically 25 years or more). • **Reliable and independent source of electricity:** Not dependent on fuel, can function independently of the grid or other sources of electricity • **Quiet operation:** Solar power systems operate silently, without generating noise pollution	• **Dependent on sunlight availability:** There can be fluctuations in energy production, especially during nighttime or cloudy weather • **High initial costs:** Cost of purchasing and installing solar panels can be significant. • **Energy storage requirements:** Battery storage systems are needed to store excess energy generated during peak sunlight hours for use when sunlight is not available. • **It can be installed only with the consent of the facility owner.** • **Challenging to demobilize and reinstall the system on another site:** Suitable for locations with long-term programs or sites where the purchase of the system by the owner of the facility can be agreed upon

Diesel Generator	
Pros	**Cons**
• **Reliable power generation:** Diesel generators provide a consistent source of electricity, regardless of external conditions. • **Quick response time:** Generators can start producing power almost immediately after being activated, ensuring rapid restoration of electricity supply.	• **Environmental impact:** Diesel generators emit greenhouse gases and hazardous gases, such as carbon monoxide. • **High operating costs:** Due to fuel costs, fuel delivery costs, maintenance costs, etc. • **Limited lifespan**: Prone to wear and tear • **Fuel dependent:** Need for constant fuel deliveries that can be challenging in remote areas • **Maintenance requirements:** Regular maintenance is essential to ensure the proper functioning of diesel generators, adding to operational costs over time. • **Noise pollution:** Generators can be noisy during operation, causing disturbances to residents or nearby environments. • **Two generators are needed** for 24/7 power supply.

c) Which of these two energy sources is more cost effective in the long run will mostly depend on how much ROI each offers. The below table will give a general overview of the ROI comparison between 80 kVa diesel generator and 80 kWh full solar power system, highlighting the associated costs.

	Cost description	80 kVa diesel generator	80 kWh solar power system
Initial cost	**Diesel generator:** Purchase of diesel generator with corresponding equipment **Solar power system:** Purchase of solar panels, inverters, batteries, mounting and other necessary equipment	$30,000	$100,000
Installation cost	**Diesel generator:** Setting up the generator unit, fuel storage systems, exhaust systems and electrical connections **Solar power system:** Mounting solar panels, installing inverters, batteries, charge controller and other equipment	$6,000	$15,000
Operating costs (12 hours daily operation)	**Diesel generator:** Fuel costs: 4,380 hours yearly x 10 L hourly fuel consumption (1/2 load) x $1.23	$54,000	$0
Maintenance costs per year	**Diesel generator:** Maintenance costs (fuel filters, oil changes) and potential repair costs: $1.20 per operating hour **Solar power system:** Maintenance costs, occasional battery replacements	$6,000	$1,200
Total cost of ownership – Year 1	—	$90,000	$116,200
Running costs + maintenance – Year 2	—	$60,000	$1,200
Running costs + maintenance – Year 3	—	$60,000	$1,200
Total cost over 3 years	Acquisition, running costs and maintenance	$210,000	$118,600
Savings over 3 years			$91,400
Operational annual savings (acquisition costs excluded)			$58,800
Annual ROI: $58,800/$115,000 (Operational annual savings / initial + installation cost) x 100			51%
Solar system payback period (in years) (Solar power system initial investment/operational annual savings: $115,000 /$58,800)			2 years

The initial installation cost of the solar power system is $115,000, while the diesel generator requires an investment of $36,000. Despite this difference—when considering the operating costs, maintenance expenses and total cost of ownership over three years—the solar power system proves to be more cost effective, with a payback period of about two years.

In conclusion, investing in a solar power system yields significant long-term benefits in terms of cost savings and return on investment compared to diesel generators.

6. Using Solar Power for Water Pumping and Heating

Access to clean water is essential for maintaining health and hygiene. **Solar water pumps** are an increasingly recognized solution for providing clean and reliable water supply. These systems use solar energy to pump water from underground sources.

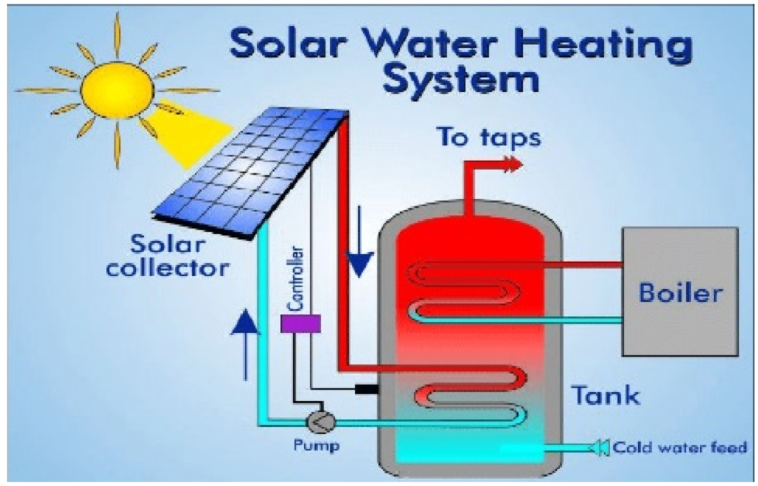
As can be seen in the picture at right, solar panels absorb sunlight and convert it into direct current (DC) electricity. Inverters then convert the DC into alternating current (AC) electricity, which is needed to power the pumps. The pump motor then draws water from a source such as a well or reservoir into the tank. The water goes through the pipes and becomes accessible to users. Water pump systems can have batteries to store excess energy generated during peak hours, which enables continued operation even when sunlight is not available.

The greatest need for solar pumps is in rural areas with limited or no access to electricity and where diesel generators are used to power the pumps. In many cases, the available water is not suitable for consumption without prior heating. In addition, heated water is needed for cooking and personal hygiene. To meet the need for hot water, methods such as heating with the use of wood as fuel or diesel generators were traditionally used. These methods are usually costly and harmful to the environment. On the other hand, solar energy offers a clean, quiet and cost-effective alternative.

Solar water heating systems utilize sunlight to heat water using a solar thermal collector. The primary components of a solar water heating system are **solar collectors** and a **hot water tank**. Additional equipment includes devices like a pump and controller.

Solar collectors absorb sunlight and convert it into thermal energy. In some systems, water is heated under the solar collector directly. The use of this system is deficient in areas where water can freeze, as freezing of water in the system can cause damage. This is the reason why the indirect water heating system is frequently used: Heat transfer fluid absorbs the heat generated by the solar energy and transfers it to the water in a storage tank (without mixing with it). The heated water is stored in the tank until needed for use. In some systems, there may be a backup conventional heater that activates when solar heating is insufficient.

Solar water pumps and heating systems have the following benefits:



- They use sunlight as a **renewable energy source**. This reduces dependence on fossil fuels and minimizes carbon emissions and other pollutants.
- They are **cost-effective**, as burning of wood/fossil fuel or electricity consumption is reduced.
- The need for the **costly transport of fuel** to remote and hard-to-reach areas is significantly reduced.
- They are **durable and reliable**, providing a consistent supply of water even in areas with limited infrastructure.
- They require **minimal maintenance**, reducing the need for frequent repairs and replacements (unlike diesel systems).
- They can be tailored to current power needs and easily expanded by adding PV panels and other related parts.
- As with solar power systems, the **investment payback period** is relatively short, especially if a generator is replaced as the energy source.

Possible disadvantages are as follows:

- It might be challenging to secure funding due to the high initial costs.
- There may be difficulties with accessing specialized technicians/providers in some areas.
- There is a risk of the solar panels being stolen.
- Use of these systems might cause excessive groundwater extraction because of the low cost of operation.

The following factors must be considered before installing solar pumps or water-heating systems:

- **Solar irradiance:** As with solar power systems, the efficiency of these systems depends on the amount of solar energy, and it has to be considered when designing the system.
- **Collector orientation and shading:** The collectors must be oriented in a way to maximize sunlight absorption during the day to achieve optimal performance. Factors such as roof orientation and features that shade the collector daily (trees, buildings, etc.) or seasonally must be considered. Typical local weather patterns during the day must be considered as well (foggy mornings, cloudy afternoons, etc.).
- **Economic viability:** Even though both solar water pumps and solar water heating prove to be cost effective (especially if a diesel generator is being replaced as the energy source), factors like return on investment must be calculated before starting the investment. Since the efficiency of solar pumps and water-heating systems depends largely on the amount of solar energy, these solutions are most competitive in regions with high solar insolation, like Africa, South America, South Asia and Southeast Asia.

7. Appendix

7.1 Recommended Minimal Technical Requirements

7.1.1 Photovoltaic (PV) module (solar panel)

The provided PV module should be of proven source and quality. Minimum functionalities are as follows:

- 15–23% cell efficiency
- Must have an ability to work well with inverters and batteries
- Has to meet the requirement set in applicable IEC (International Electrotechnical Commission) and/or applicable ISO (International Organization for Standardization) standards
- **Limited performance guarantees:** Panel power, in standard conditions, should not be less than 90% of nominal power for the first 10 years of operation and at least 80% for 20 years of operation with a 12-year product warranty and a 25-year linear power warranty.

7.1.2 Inverter

The inverter must provide optimum interaction between the solar power system, generator and utility grid, and must be compatible with the battery storage system. Hybrid or micro inverter has been recommended based on the site design. Minimum functionalities are as follows:

- The load sharing between the solar system with batteries and the generator is handled automatically.
- The possibility to turn on/off the generator manually
- Programmable priority for batteries or diesel generator
- Monitoring software for real-time status display and control
- Built-in possibility of connection to the utility grid
- Inverters should comply with the applicable IEC standards for efficiency and measurements, and IEC or equivalent standard for environmental testing.
- The unit should be able to operate in a high ambient temperature environment (ambient temperature -10° C to 55° C)
- Warranty: five years minimum

Power generated from the solar system during the daytime should be utilized fully by powering the critical building loads and feeding excess power to the batteries. In cases where solar power is not sufficient due to more demand or cloud cover, etc., the building loads should be served by drawing power from the batteries, utility grid or generator. The inverter should always give preference to the solar power and will use power from other sources only when the solar power is insufficient to meet the load requirement. The inverter must have the ability to synchronize with backup systems, like batteries, generator or utility grid. The inverter should continuously monitor the condition of the power supply from solar panels and batteries and, in the event of failure, switch automatically to diesel generator or utility grid supply.

7.1.3 Batteries

It is recommended that the battery bank be housed in a vented compartment that prevents users from coming in contact with battery terminals. This compartment should be strong enough to accommodate the weight of the batteries. The entire enclosure must be durable and should be protected against corrosion.

Batteries of appropriate capacity with a complete battery management system should be offered. Minimum functionalities are as follows:

- The battery must ensure safe and reliable operation in the whole range of ambient temperatures from -10° C to 55° C.
- The battery must have a certificate of compliance, issued by a recognized laboratory.
- The performance guarantee must cover at least five years.
- The batteries must conform to the latest edition of IEC standards (whichever is applicable).
- The battery bank should provide backup to a critical load of building.

The following information must be provided by the bidders:

- Charge/discharge efficiency
- Self-discharge rate
- Cycle life of the batteries

Selection of software for tracking energy generation, consumption and overall system health via display screen or a connected smartphone, PC or laptop.

7.2 References and Resources

Source	Description
International Energy Agency (IEA)	IEA's website provides an overview of solarization technology, benefits of solarization and its challenges and opportunities.
National Renewable Energy Laboratory (NREL)	NREL's website provides a comprehensive explanation of solarization, including its main principles, benefits and industry updates.
Solar Energy Industries Association (SEIA)	SEIA's website contains a wealth of information on solarization, including topics such as solar technology, policy and market trends.
U.S. Department of Energy (DOE) – Solar Energy Technologies Office	This website provides different information about solarization, including its benefits, implementation and potential applications.
Clean Energy States Alliance: Standards and Requirements for Solar Equipment, Installation, and Licensing and Certification	This guide provides valuable information about solarization, including overviews, equipment standards and requirements, solar installation best practices, and licensing and certification.
Why Solar PV Systems in the Humanitarian Sector Fail (and What Players Can Do to Better Manage Them)	Analysis of the reasons behind the failure of solar photovoltaic systems in the humanitarian sector and recommendations for better management.
International Renewable Energy Agency (IRENA)	Website offers information on technical aspects of solarization, solar equipment technologies and innovations.
IEEE Xplore Digital Library	This website contains articles and research papers that discuss various aspects of solarization.
HOMER Energy Software	Software tool designed for analyzing, optimizing and simulating hybrid renewable energy systems. This software can be used to assess the feasibility and performance of various energy system configurations.
World Bank: Solar Pumping – The Basics	Handbook published by the World Bank that introduces solar water pumping. It highlights the fundamental aspects of solar water pumping technology, its applications and its benefits.

ICRC: Renewable Energy Guidance – Solar Water Heating Systems	ICRC’s guidance for the implementation and management of solar water heating systems in humanitarian contexts.