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Ministry of Health & Family Welfare
Government of India

Guidelines for OPERATIONS AND MAINTENANCE of Solar PV Systems for Healthcare Facilities

unicef for every child

NISE National Institute of Solar Energy

National Programme on Climate Change and Human Health

National Centre for Disease Control
Government of India

Acknowledgement

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These Guidelines for Operations and Maintenance of Solar PV Systems for Healthcare Facilities are prepared under the guidance of Dr. Aakash Shrivastava, Additional Director and HoD, National Programme on Climate Change and Human Health (NPCCHH), National Centre for Disease Control (NCDC), support from Dr. Purvi Patel, Sr. Consultant and NPCCHH team. This guidance document supplements the existing Guidelines for Solar Powering Healthcare Facilities (2023) and Guidelines for Green and Climate Resilient Healthcare Facilities (2023) under NPCCHH.

Abbreviations

NCDC	National Center for Disease Control
NPCCHH	National Programme on Climate Change and Human Health
SAPCCHH	State Action Plan on Climate Change and Human Health
DAPCCHH	District Action Plan on Climate Change and Human Health
GCR	Green and climate resilient
GHG	Greenhouse gas
PV	Photo Voltaic
IPHS	Indian Public Health Standards
SOP	Standard Operating Procedure
MoHFW	Ministry of Health and Family Welfare
NISE	National Institute of Solar Energy
MNRE	Ministry of New and Renewable Energy
SNA	State Nodal Agency – Renewable Energy
CMC	Comprehensive Maintenance Contract
SNO	State Nodal Officer
DNO	District Nodal Officer
SPO	State Programme Officer - REDA
DPO	District Programme Officer - REDA
PHCs	Primary Health Centres
MOIC	Medical Officer in-charge
REDA	Renewable Energy Development Agency
WHO	World Health Organization
UNICEF	United Nations Children's Fund

About the Document

Access to reliable and quality energy supply in healthcare facilities (HCFs) is important for quality of health services delivery. National Programme on Climate Change and Human Health (NPCCHH) is a flagship programme of Ministry of Health and Family Welfare, strengthening health system preparedness and response to climate change in the country with goal to reduce morbidity, mortality, injuries, and health vulnerability to climate variability and extreme weather events. Energy is one of the critical components amongst them. As part of the above, HCFs are being solarised across the country to ensure energy reliability for critical loads in the facility. Proper operation and maintenance (O&M) is essential for these solar PV systems to provide optimal power generation. Timely O&M also ensures smooth functioning of the system and extends the life of the equipment ensuring the safety of people. This is a guiding document for the handing over, and operation maintenance of the solar PV system in a health facility. The document will cover the basic operation of a solar PV system, significance of O&M, indicative maintenance protocols, do's and don'ts, for ensuring safety and optimal operation of the solar PV power plant.

Intended Usage and Audience

This document, Guidelines for Operations and Maintenance of the Solar Systems in healthcare settings has been prepared to support the National Programme on Climate Change and Human Health in advancing its efforts to adapt to climate change and build resilient healthcare systems. This may be utilized by the National Health Mission, health departments and renewable energy departments in states, and nodal officers, hospital managers, and facility in charge cadres to support in designing and implementing comprehensive O&M practices to healthcare solarization based on suggestive intervention plans by NPCCHH, Ministry of Health and Family Welfare (MoHFW) and the National Institute of Solar Energy (NISE), Ministry of New and Renewable Energy.

Health and Energy Nexus

Energy, in the form of electricity, is a key resource for the smooth and uninterrupted functioning of public health care facilities. The need for energy back up during the critical hours is also significant for ensuring the lifesaving efforts of medical professionals. Almost all the public health care facilities host numerous points of critical loads such as baby warmers, oxygen concentrators, vaccine storage etc, which are very sensitive and may be required during any hour of the day for provision of safe and quality healthcare services for children. The scale of healthcare infrastructure and operations contributes to substantial energy consumption, water usage, waste generation, and greenhouse gas emissions. In view of the above, under the NPCCHH programme, solarization of health care facilities is being undertaken. The institutionalized procedure for healthcare solarisation includes conduct of energy health assessment, design rationalization, installation, commissioning and handing over of solar photovoltaic power plants in the health care facilities. Systematic operation and maintenance is essential to ensure the optimal and safe functioning of the solar systems for the specified duration of its life. This document provides a brief on the basics of solar PV system, operation and maintenance of the solar photovoltaic power plant. The implementation steps for solarization in a health care facility have also been provided.

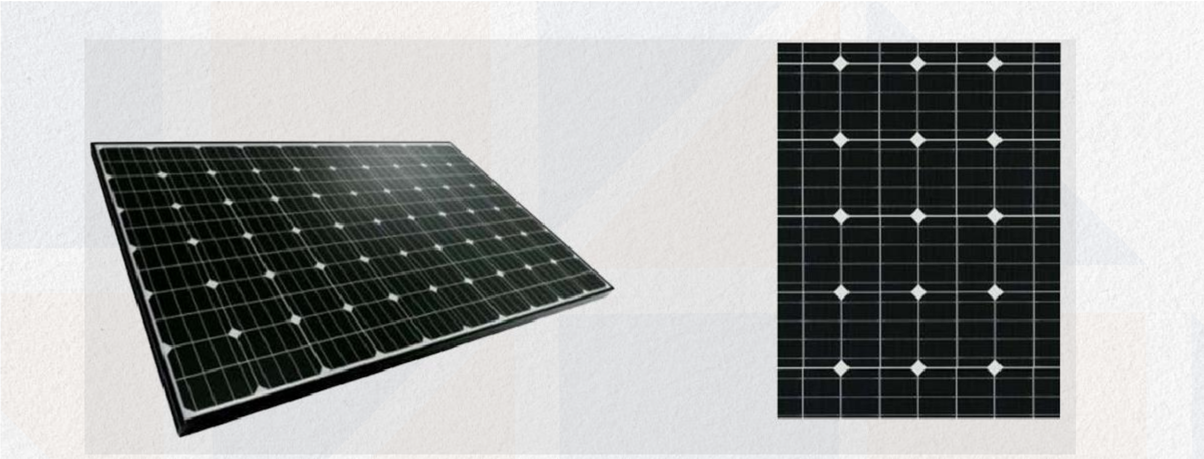
Chapter 01

General overview of a Solar PV power plant

Significance of solar energy

The energy from the sun can be harvested to utilize for various applications. These include utilization in the form of electricity or may be in the form of thermal energy. There are technologies to convert the energy from the sun to electricity. This process of converting sunlight to electricity is called photovoltaic effect. The device which does this conversion is called photovoltaic (PV) module. Figure 1 shows a sample of a PV module.

Figure 1: A solar PV module and the interconnection of cells in a PV module.



Benefits of using solar energy include:

- Infinite source of energy
- Decentralized source of energy
- Reduced energy bills
- Improved energy efficiency
- Provides energy back up
- Contributes to reduction in carbon emission

Components of a solar PV power systems

A solar PV system comprises of interconnection of one or more following components, with one component being a solar PV module (energy generating source). The flow of energy and its control and type, decides the type of system configurations and its applications. The following are the major components in a solar PV system:

Solar photovoltaic module (energy generation device).

» A load (energy consuming device e.g. fan, tube lights, baby warmers etc).

» A storage (e.g. electrochemical battery)

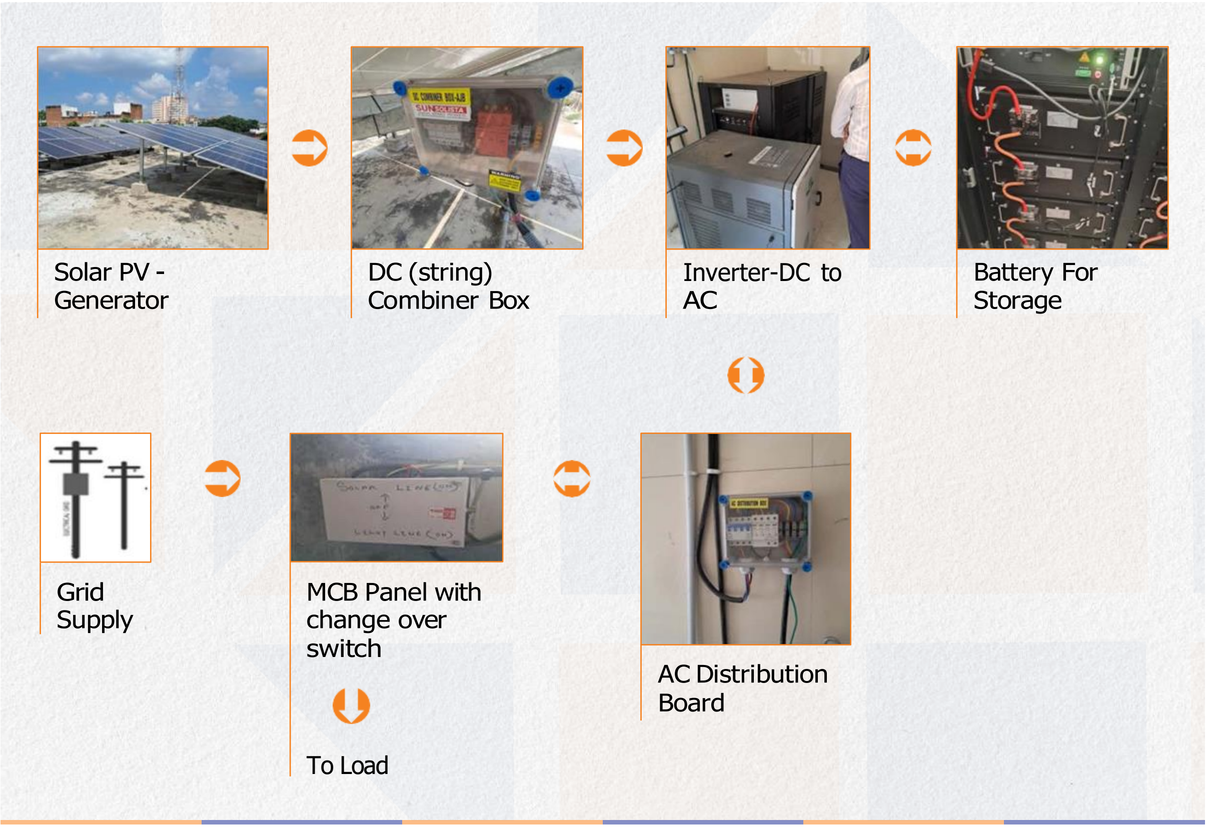
» Power conversion devices (for voltage and frequency transformations)

» Protection devices

» Grid (For energy distribution and transmission)

A schematic of various components in a solar PV power system is given in the Fig.2.

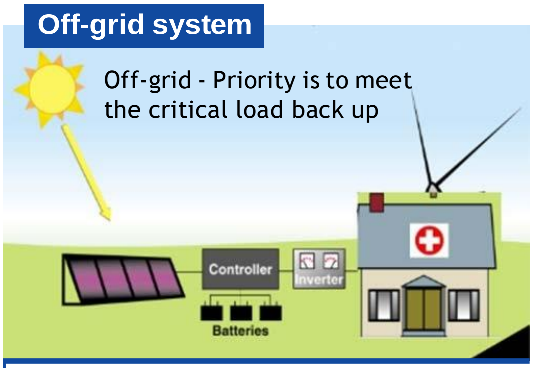
Figure 2: Indicative list of components in an off grid solar PV system



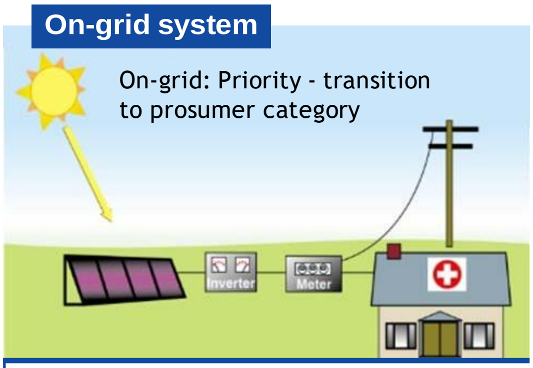
Technology options in Solar PV Systems

Hybrid System

A Hybrid system is a combination of an on-grid and off-grid solar power system. Hybrid systems have a battery backup which helps store the generated energy. Once the battery is fully charged, any excess power generated which is not being utilized will be fed back to the grid.



- Priority: meet critical load back up
- For small/medium capacity
- Can provide energy back up using storage options
- Best suited for Direct Current loads
- Suitable for remote and portable applications



- Priority: meet critical load back up
- For small/medium capacity
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- Best suited for Direct Current loads
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Financing models

In general, there are two financing models are offered.

» **Capital Expenditure (CAPEX):** This requires an upfront payment or take a loan to cover the installation cost. It gives full ownership and maintenance responsibility of the solar power system to the consumer. It is important incorporate O&M agreements into primary tender or ensure by separate contract for long functional life of the system. It's popular for residential, commercial, and industrial rooftops, offering lower electricity bills and potential power sale to the grid.

» **Operational Expenditure (OPEX) or Renewable Energy Service Company (RESCO):** In this model, a Renewable Energy Service Company (RESCO) installs a system on a rooftop and owns it. The consumer pays the RESCO for electricity for a set period. Once the term ends, ownership transfers to the consumer. The RESCO finances the system with loans and sells power to you through a long-term Power Purchase Agreements (PPA).

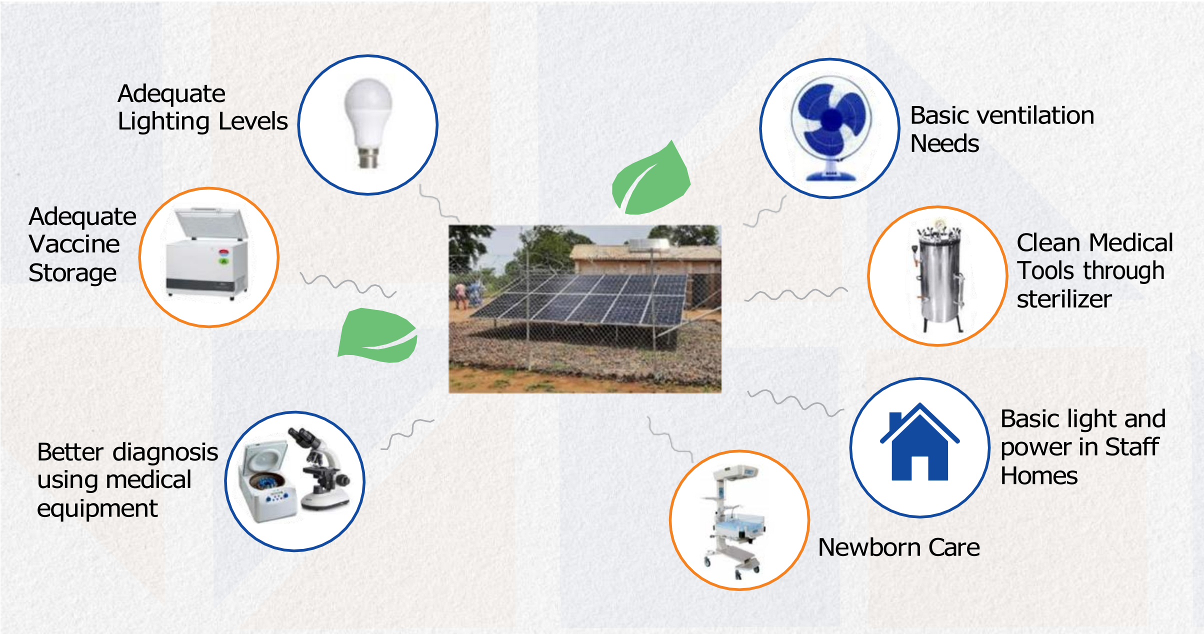
Parameter	Capital Expenditure (CAPEX)	Renewable Energy Service Company (RESCO)/Operational Expenditure (OPEX)
Ownership and investment	Consumer owns 100% investment borne	Developer owns No upfront investment by consumer
O&M	Consumer pays	Developer bears the cost
Technical support	Dedicated team is required at consumer end	Developer manages technical matters
Performance risk	Consumer bears all the performance risk and must manage equipment and downtime losses	Developer bears all the performance risk and incentivized to maximize generation for revenue
Regulatory risk and approvals	Consumer's prerogative	Developer's prerogative

Energy utilization and augmentation

Most of the energy requirements in a facility are in the form of electricity. The required energy is provided by the respective local electricity distribution company. The electricity bill provides insights about the electricity usage pattern in the facility. This is recorded in terms of units (or kWh – kilo watt hour). An appliance of 1000 W operating for 1 hour consumes 1 kWh of energy.

In an off-grid PV system the energy generated is stored in the battery and utilized for meeting the critical energy requirements. It is to be noted that, the off-grid system is designed to, only, meet defined critical loads of the facility. Hence, during these, solar system must be used to run only critical loads in the facility. The solar system is designed for a specific back up duration (up to 4 hours) only. Hence proper care should be taken to ensure only critical loads are operated during critical hours.

Figure 3: Typical energy loads in a healthcare facility



The following is an indicative list of critical loads in the health care facilities.

Table 1: Critical Loads in healthcare facilities (indicative list)

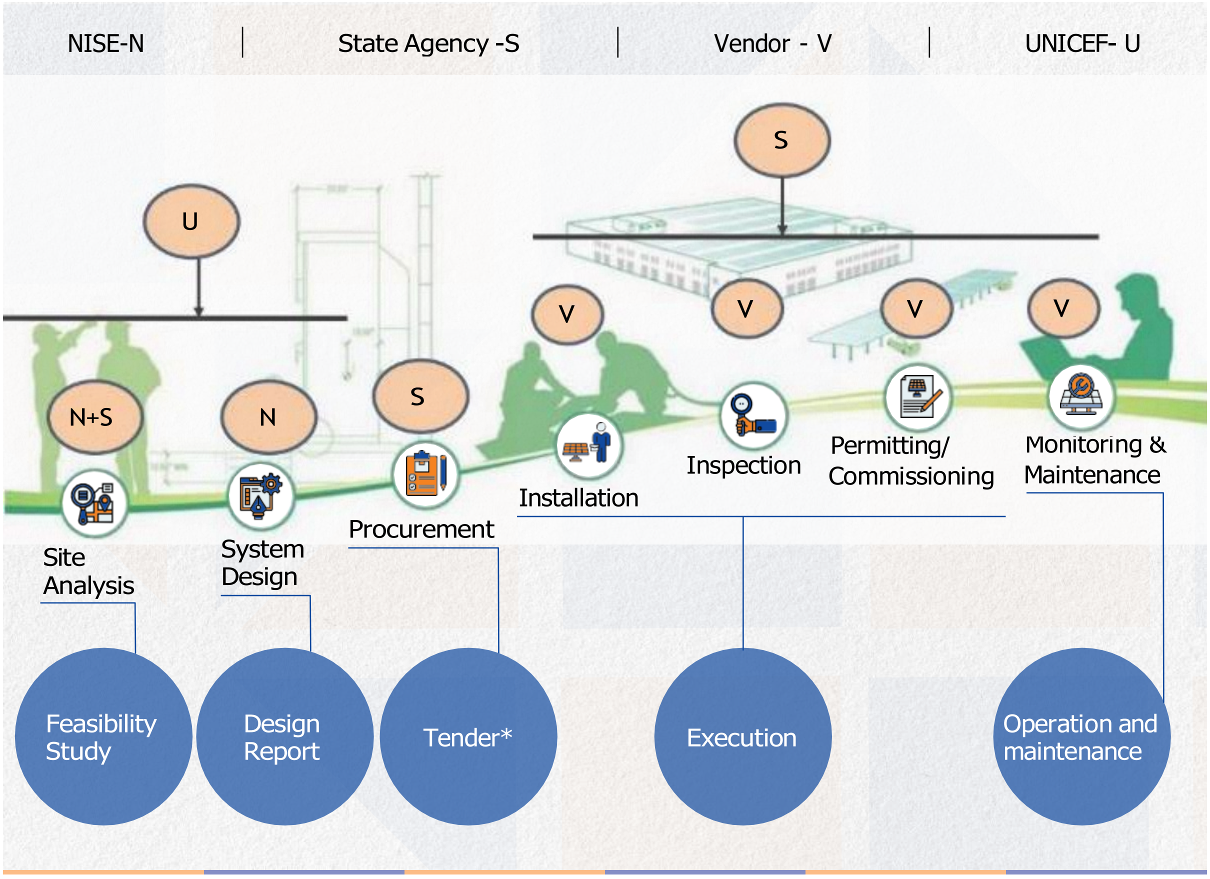
S. No.	Equipment's (Critical Loads)
1	Anaesthesia workstation/Boyles Apparatus
2	OT light, laparoscopy instruments
3	Baby/Radiant Warmer
4	Phototherapy unit
5	ILR /Freezer (Vaccine)
6	Blood bank refrigerator
7	Deep Freezer
8	Nebulizer
9	Light LED Tube Lights
10	Fans
11	Desktop
12	Oxygen Concentrator
13	Water Purifier
14	Fridge
15	Suction Pump
16	Future Expansion- Additional loads

Chapter 02

Facility Solarization Procedure

The following are the major steps involved in the implementation of a solar PV project in a health care facility.

Figure 4: Process Flow of a Solar PV Power plant Installation



Step 1: Pre-solarization health facility assessment

This step involves the gathering of site-specific data from selected health care facilities. The data to include the electrical load data, energy consumption data, space availability, and other data points related to energy efficiency in the facility. This step may be carried out by NISE and facilitated by UNICEF (where available) and the state health departments. Further details of the questionnaire, process, outcome, utilization and monitoring of data collected under this assessment is found in the **Standard Operating Procedure for Solarization of Healthcare Facilities**.

Action point for HCF: Facilitation of the visit, and provision of requested data.

Step 2: Rationalized Design

Based on the data received, a rationalized design is proposed by NISE to the state health department. The state health department in consultation with the state energy department/ any other designated agency, propose for implementing the solar energy systems on selected HCFs. The state designated agency (eg. UPNEDA in UP) will carry out the implementation of these system as per the standard procurement policy.

Action point for HCF: Nil

Step 3: Implementation

The implementation will have following phases:

a. Site survey by the vendors (Pre-bid assessment): The vendors, prior to installation, may visit the HCF for collecting required information and data for the smooth implementation of the Solar system. The site survey data to include the details of nearby shadings on the roof, strength of the roof, the space measurements, and also to assess the provisions for safe keeping the system components.

   Action point for HCF: To facilitate the access to the vendors for data gathering.

Figure 5: Areas of site survey in a healthcare facility

b. Installation of Solar PV power plant: The successful bidders will install the solar PV power plant on the roof of the HCFs as per the work order from the state agency. The state agency will provide the list of successful bidder/s and their contact details, along with the contact details of the district project officers of the state agency to the DNO-NPCCHH/ SNO-NPCCHH.

Action point for HCF: To facilitate the access to the vendors for installation. Coordinate with the DNO-NPCCHH/ SNO-NPCCHH for verifying the details of the vendor.

c. Commissioning of Solar PV power plant: The installer will facilitate the commissioning of the solar PV power plant in presence of the state agency.

Action point for HCF: To facilitate the access to the vendors for commissioning.

d. Handing over of Solar PV power plant: The installer will hand over the solar PV power plant to the HCF after the installation and commissioning.

Action point for HCF: Verification during handing over. Ensure proper training is provided by the installer to the HCF staff in case of emergency and repairs.

- ☐ Ensure the following documents have been provided by the installer prior to hand over:
- ☐ Contact details of the installer (Mobile, email and address)
- ☐ List of bills of materials with specifications.
- ☐ Photographs of installed solar PV system.
- ☐ O&M manual.
- ☐ Remote data access. (energy generated data, battery voltage level etc.)
- ☐ Design lay out and single line diagram.

e. Operation and maintenance: The installer is responsible for the 5-year CMC of the entire solar PV power plant. However, timely supervision and monitoring is required from the HCF to ensure the PV systems is maintained as per the indicative maintenance protocol in section below

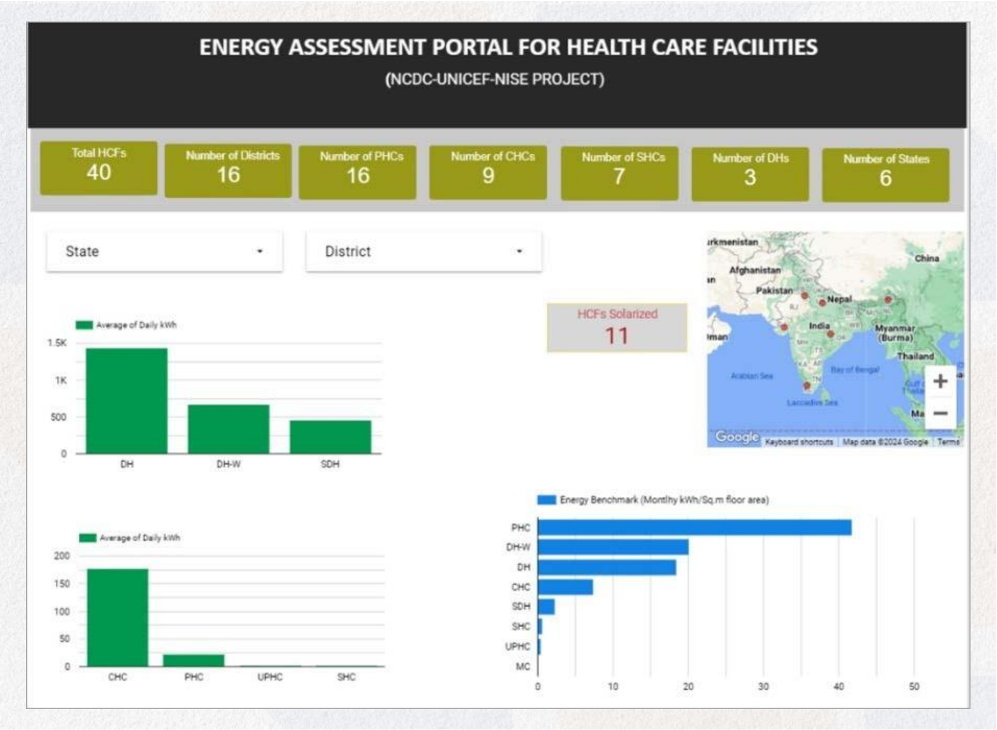
Table 2: Indicative list of major Solar PV system equipment

S. No.	Indicative list of major equipments in a Solar PV system
1	PV modules
2	Off grid Inverter
3	Batteries
4	DC combiner box
5	AC distribution box
6	MCB panel change over switch with

S. No.	Indicative list of major equipments in a Solar PV system
7	AC and DC cables
8	Earthing
9	Lightning arrestor

Digital system for assessment and monitoring of Solar PV installation

An **energy assessment portal** (https://nise.res.in/ncdc_portal/) is developed to record and monitor the health facility solarization process. It establishes a baseline against which future energy usage; cost savings may be tracked. To begin with, the pre-solarization health facility assessment is conducted through a linked digital mobile application. The digital data collection allows standardization of the data collection, analysis, and report generation. Refer to **Standard Operating Procedure for Solarization of Healthcare Facilities** for details.



Chapter 03

Maintenance of a solar PV power plant

Significance of maintenance in a solar PV power plant

Maintenance of solar PV power plant includes upkeep of all the components in the system to ensure the desired performance of the system and also ensuring the safety of the associated personnel. Hence, maintenance is an integral part of the solar PV system. Apart from an energy generating device, solar PV power plant is also an asset to the owner which has a defined life of 25 to 30 years. The following are the major benefits of operating and maintaining a solar PV power plant:

- Increased energy generation (kWh generated from each kW of solar PV power plant)
- Reduced maintenance cost (Cost spent per kW on maintenance can be optimized)
- Increasing the asset life (up to 25 to 30 years)
- Decreasing the down time (break down hours in a year- directly impacts the system reliability)
- Ensuring the safety of the personnel and facility.

Preventive maintenance

This includes routine inspection, cleaning and servicing which has to occur at regular intervals. Usually, this type of maintenance is pre-approved and has to be done during non-solar hours. Following are some of the activities involved in a preventive maintenance:

- Obstruction control (trimming of near-by vegetation etc.)
- Cleaning of PV modules
- Dusting of other equipment's
- Check for cable connections
- Checking the integrity of the structure

» Review of the logbooks

» Ensuring the water level in the battery.

» Service checks of major equipment's like inverter, battery, array junction box etc.

PV module cleaning methods

Figure 6: Cleaning of PV modules

Wet cleaning method wherein water is utilized for the removal of the dust from the surface of PV module. Usually, a soft cloth, brush, non-abrasive detergent and clean water are used. It is to be ensured that, de-ionized water is used for the cleaning purpose. Water from the RO may also be used. The water TDS may be ensured below 200 ppm, and free from dirt or other physical contaminants. The soft cloth or brush may be used remove the bird droppings or any stains on the PV module. As excess pressure is not ideal for PV module, water pressure may be kept near 35 bar at nozzle. It may also be ensured to maintain the temperature of the water similar to the ambient temperature. Never use any corrosive materials or chemicals or steam for the cleaning. In general, it takes approximate two litres of water to clean every PV module.

Maintenance call

The following procedure may be adopted during any event of fault or break down of the solar PV system.

Table 3: Action points to address breakdown or faults

S. No.	Action point
1	Contact the installer – refer the documentation manuals.
2	If the problem is not resolved within a certain duration, contact the district project officer of state agency for renewable power
3	If the problem is not resolved within a certain duration, contact the State project officer of State renewable power agency

Indicative maintenance protocol

It is important to have a maintenance protocol of a solar PV system, so that it allows for regular check for the compliance of the O&M requirements of the solar PV system. The following table provides an indicative list of preventive maintenance check which are to be carried out in regular intervals:

Table 4: Details of Indicative Maintenance Protocol

S. No.	Description of activity	Frequency	Responsibility	Remarks
1	Resolving the faults, alarm indications, if any.	Daily	HCF- Hospital manager/ MOIC	Status report with a record in the maintenance register.
2	Remote monitoring of plant performance using the dashboard data from the inverter.	Weekly	HCF- Hospital manager/ MOIC	Report for deviations, if any.
3	PV modules cleaning for dust, debris, and any other temporary obstructions on the PV module	Weekly	HCF- Hospital manager/ MOIC	Status report with a record in the maintenance register.
4	General Cleanliness of roof, power plant, and nearby places	Quarterly	HCF- Hospital manager/ MOIC	Status report with a record in the maintenance register.
5	Inspection of SMBs, batteries and inverter for faults, or performance deviations.	Quarterly	Installer	Quarterly report
6	Visual inspection of PV modules- selected randomly in each of the power plant	Quarterly	Installer	Quarterly report
7	Integrity of Module mounting structure, including the civil structure.	Quarterly	Installer	Quarterly report
8	Inspection and verification of all other BoS including isolators, cables, disconnect switches, LA, and earthing. For continuity, functionality, integrity and safety.	Quarterly	DPO/SPO- REDA	Quarterly report
9	Measurement of earth resistance	Quarterly	Installer	Quarterly report
10	Take prevention against corrosion for all system components in the field.	Quarterly	Installer	Quarterly report
11	Visual checks, Walk through in every power plant, every BoS including PV modules and inverters for damage, faults, and any deviations.	Bi-Monthly	Installer	Bi-monthly report
12	Functional test on inverter strings currents, voltage, and PV module electrical parameters.	Quarterly	Installer	Quarterly report
13	Cleaning of inverter housing / and inverter air filter.	Half yearly	Installer	Half yearly report
14	Battery voltage levels, including the check on the interconnections	Quarterly	Installer	Quarterly report

Note: The activities to be carried out by the installer are to be monitored by the HCF Hospital Manager or MOIC in-charge may monitor and ensure that installer carries out the said maintenance activities.

Chapter 04

Simple direct maintenance tips for major components in a solar PV system

- **Solar PV Module:** Clean the solar PV module periodically (preferably once a week) to remove dust and bird droppings. If the nearby trees have grown and cast a shadow, trim it to ensure free incidence of light on the module. Inspect the cable connections on the module terminal box once in 3 months to make sure the cable is tight terminals are not corroded.

- **Inverter:** Check the LEDs in the inverter, which indicates the operating condition of the inverter. Take appropriate steps as mentioned in the manual provided with the inverter.

- **Battery:** Clean the battery top and the battery terminals with a piece of clean cloth once a month. Apply petroleum jelly to the battery terminals periodically once in 3-4 months, use critical loads only during the critical hours to ensure battery is not fully discharged.

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