GEF - UNIDO - BEE PROJECT

on

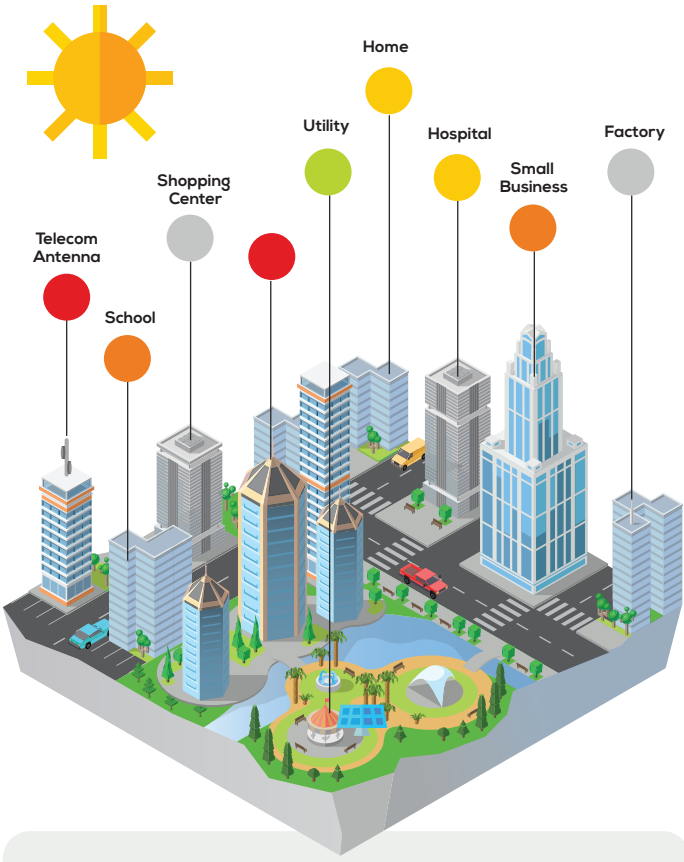
"Promoting EE/RE in selected MSME Clusters in India"

RENEWABLE ENERGY:

SOLAR PHOTO VOLTAIC SYSTEMS

UNIDO | gef | Confederation of Indian Industry

Varied Applications of Solar Photovoltaic



Small Off - Grid	Small On - Grid	Large Off - Grid	Large On- Grid	Utility Scale Power

What is Solar Power

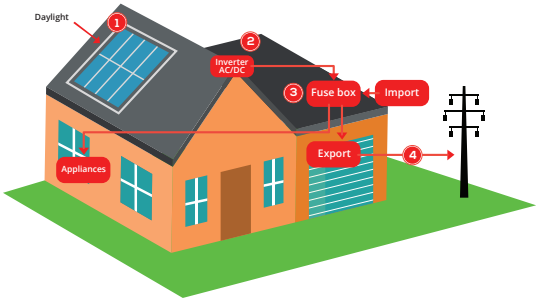
Types

- Solar Photovoltaic is the conversion of Ligh (photons) into electricity(volts)
- Solar Thermal is the conversion of light to heat and electricity(volts)

Solar Photovoltaic (PV)

Solar Thermal

Solar PV System



1 Solar cells - Solar cells within the PV panels act as a semi conductor that converts daylight into electricity

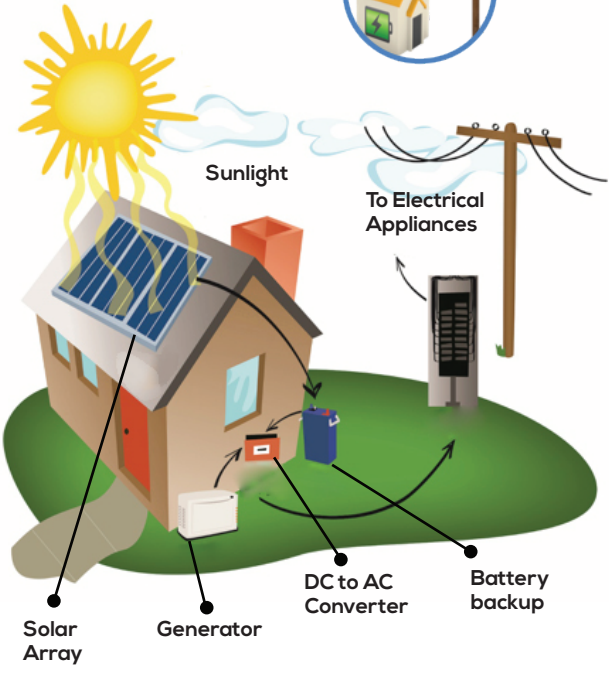
2 Inverter - The electricity generated by the panels is DC (direct current). This is then converted to AC (alternating current), using an inverter so it can be used in the home

3 Electricity - Household appliances can be used as normal via the consumer unit

4 Export - When the household demand is less than supply from the PV system, any spare electricity can be sold back to the electricity supplier and, if eligible, feed in tariffs can be paid

Solar Rooftop System

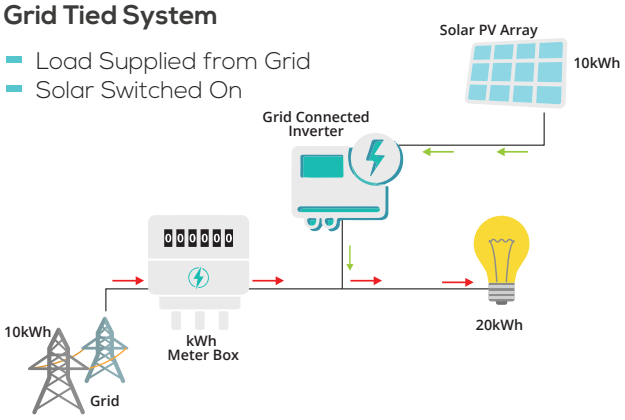
- Grid Tied Systems
- Off Grid Systems
- Hybrid Systems



Solar Rooftop Working

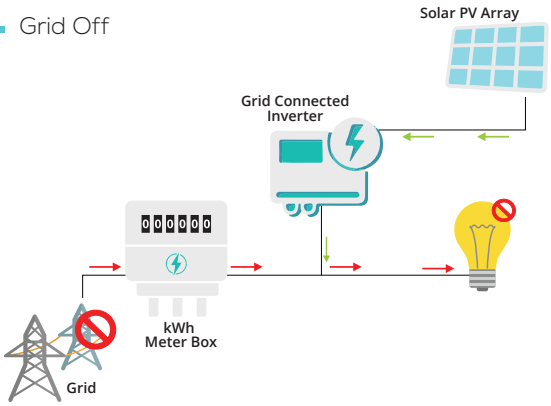
Grid Tied System

- Load Supplied from Grid
- Solar Switched On



Grid Tied System Case 1

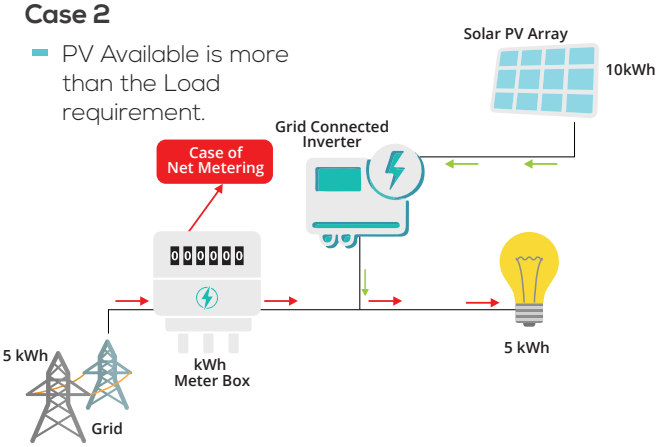
- Grid Off



Inverter trips and system switched off for the sake of safety, this type of safety is termed as Anti-islanding protection of the Inverter.

Grid Tied System Case 2

- PV Available is more than the Load requirement.

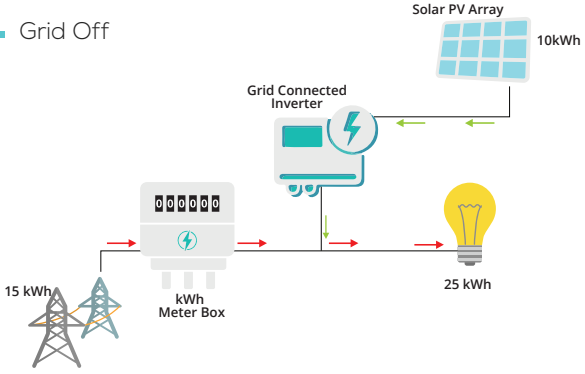


Inverter keeps on exporting power, load being in the priority, the extra power is fed back into the grid.

Solar Rooftop Working

Grid Tied System Case3

- Grid Off



Inverter keeps on exporting power, the additional power is provided by the grid.

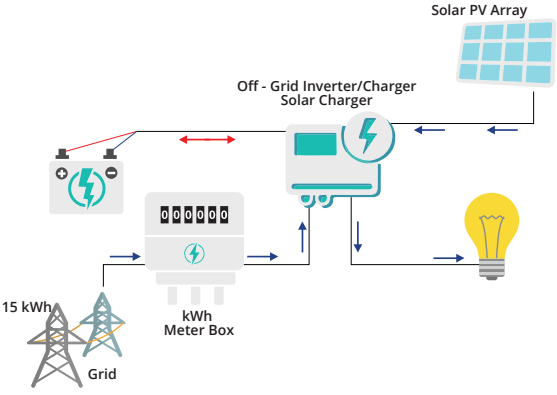
Solar Rooftop Calculation

Shadow free space	Area (sq.ft.) / 100 sq.ft = PV (kWp)
Panels facing South	Directly associated with yield
Latitude	Latitude + / - 30 = tilt angle of panels
Running Load	System Rating has to be = or < than the running load to prevent back feed
Type of Roof	Flat , inclined , RCC , tin sheet, unleveled
Location of LT Panel	For Calculation of Length and size of cables
Type of connection	Single Phase / Three Phase
Rating of DG	DG must be 2.5 – 3 times of the rating of PV or ideally 30% load must be on DG (Typ. PV shall be 50% of grid)
Net Metering	If allowed by local DISCOM

Solar Rooftop Working

Off-Grid System

- System works on Battery inspite of Grid is present. on PV > Battery > Grid priority basis.

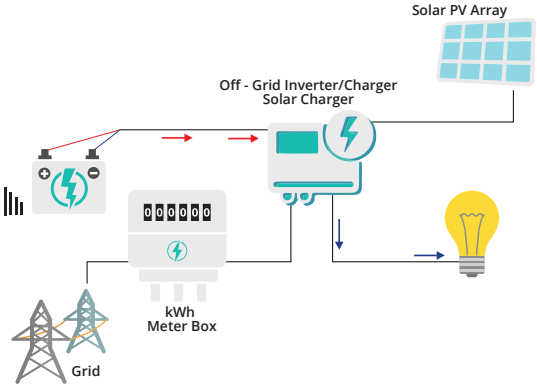


- Battery Charged....discharging...
- Grid Absent.
- PV Absent

Off-Grid System

Case 1

- System working as standalone

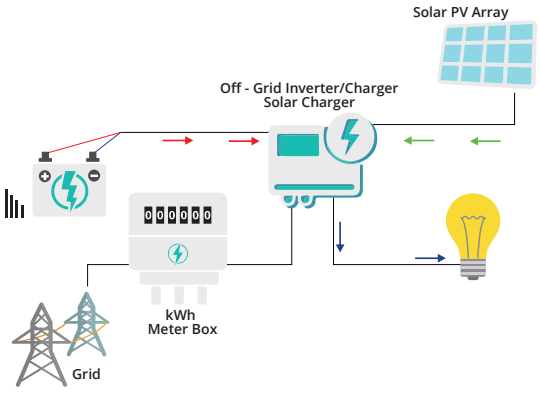


- Battery Charged....discharging...
- Grid Absent.
- PV Absent

Solar Rooftop Working

Off-Grid System
Case 2

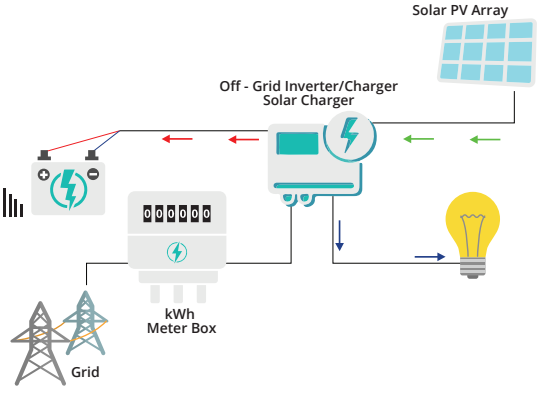
- System working on Solar + Battery.



- Battery discharging.
- PV Present.
- Load is more than Solar Available.
- Grid not present.

Off-Grid System
Case 3

- System working on Solar.

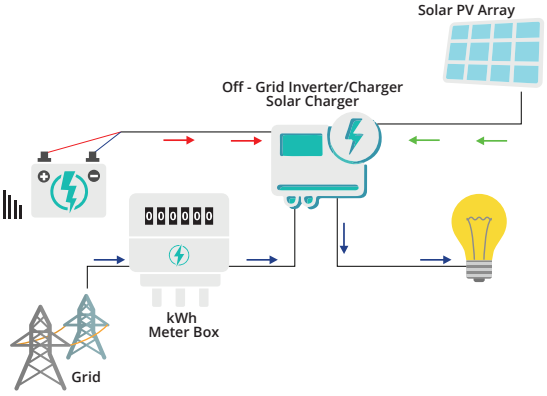


- Battery Charging.
- PV Present.
- Load is less than Solar Available.
- Grid not present.

Solar Rooftop Working

Off-Grid System
Case 4

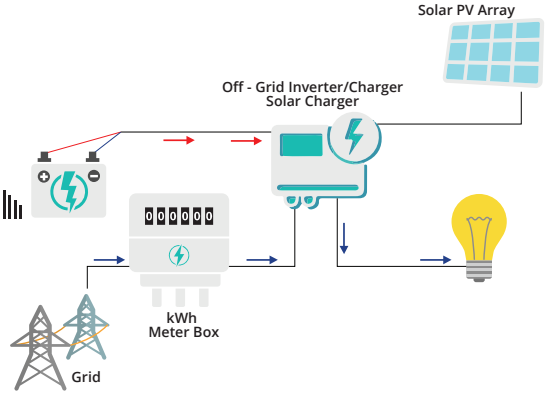
- Transition Stage.



- Battery Discharged to set value.
- PV Present.
- Load is more than Solar Available.
- Grid present.

Off-Grid System
Case 5

- Transition Stage.

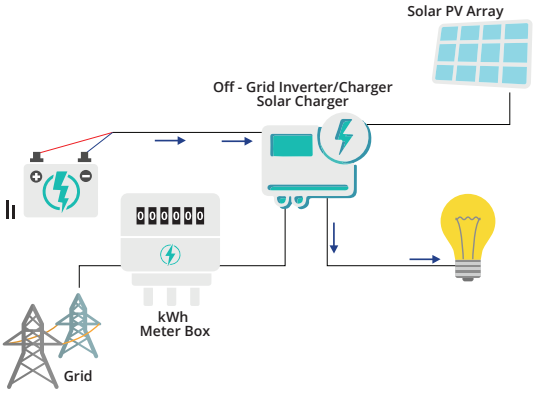


- Battery Discharged to set value.
- PV not Present.
- Load is more than Solar Available.
- Grid present.

Solar Rooftop Working

Off-Grid System
Case 6

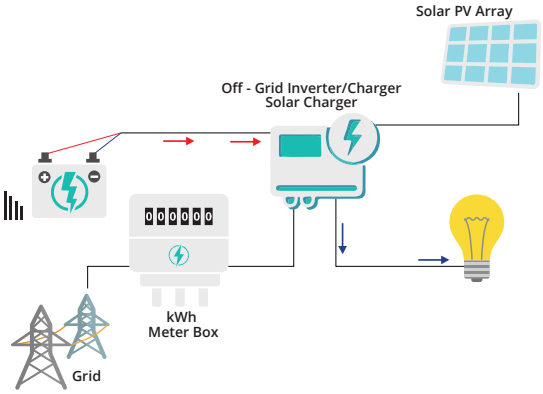
- Transition Stage.



- Battery Charged to a set value.
- PV not present.
- Load is ON.
- Grid present.

Off-Grid System
Case 7

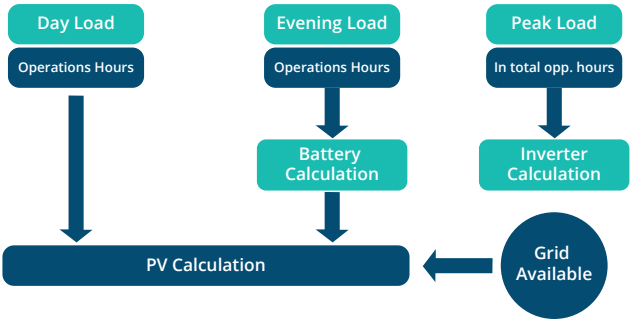
- System working as standalone



- Battery Discharged to 80% of Capacity.
- Grid Absent.
- PV Absent
- Loads Cut off, flickers may be seen.

Solar Rooftop Calculations

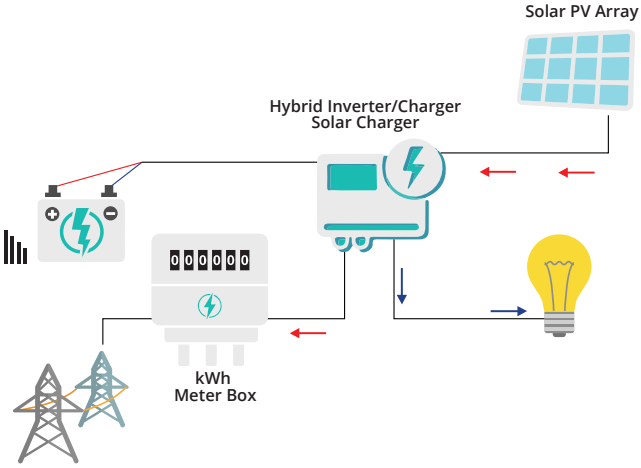
Off-Grid System
Inputs required



Solar Rooftop

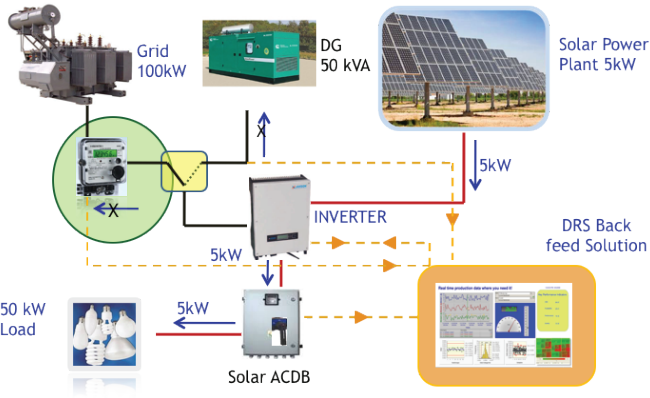
Hybrid System

- System is basically a hybrid of Off-Grid and Grid connected systems.



- All working is like offigrid, accept the property of getting connected with grid when ever grid appears.
- If the Battery is fully charged, the inverter exports power back into the grid.

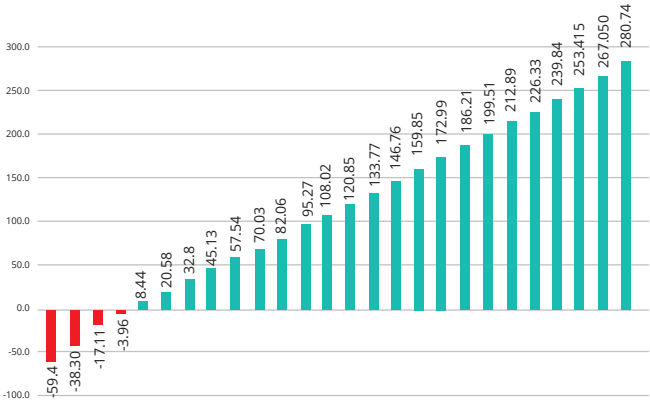
Reverse Power Prevention for Solar Power Plants



Sample Payback Summary

Project Size	kWp	100
Cost/ Watt	per Wp	54
Total Project Cost	INR	54,00,000.00
Accelerated Depreciation (1st Year @ 40%)	INR	21,60,000.00
Accelerated Depreciation (2nd Year @ 40%)	INR	21,60,000.00
Accelerated Depreciation (Balance Years @ 10%)	INR	5,40,000.00
Salvage Value (After 25 years @10%)	INR	5,40,000.00
Income Tax Saving (@34.61%) 1st year	INR	7,47,576.00
Income Tax Saving (@34.61%) 2nd year	INR	7,47,576.00
Income tax saving for balance years	INR	1,86,894.00
Electricity Tariff (Rs/Unit)	INR	8.5
Electricity Generation/KW	kWh /year	1450
Electricity Generation per annum	kWh /year	1,45,000
Electricity Tariff Escalation	%	2%
O&M / KW		600.00
O&M Escalation per annum	INR	
Plant Insurance: 0.5% of Asset value	%	5%
Rate of Interest	INR	67,500.00
System Generation Degradation	%	10%
Total units generated over project life	%	1%
Total Project Cost (including all expenses)	kWh	32,21,590
Per Unit Cost	INR	83,31,126.00
IRR	INR	2.59
Payback Time	Years	26.2

Payback Graph



Payback time is appx 3.5 years

Operations and Maintenance

Operations

Plant Supervision

- Performance Monitoring
- Security

Plant Operation

- Energy Forecasting
- Planned Downtime
- Remote Plant Control

Performance Engineering

- Trend Analysis
- Cleaning Cycle Planning
- Failure Detection
- Spare Part Mgmt

O&M is a long term association with the Customers

Operation & Maintenance .. is not just house keeping!

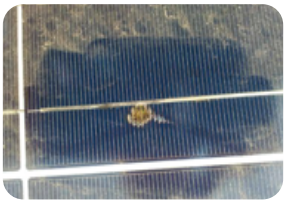
Improper Cable Routing

Cable Heating up

Damage finally!

Ground clearance issues

MC4 Connectors / Y junctions ... poor crimping ?

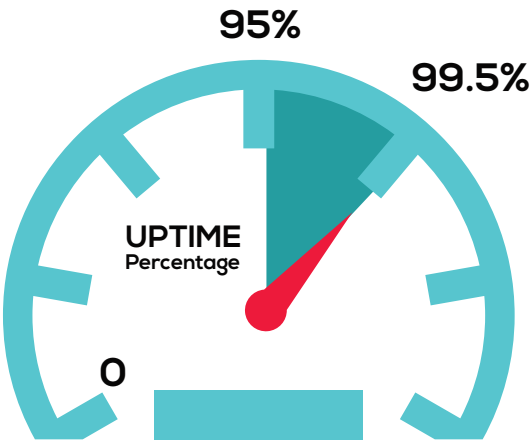


Module issues ..Stray bullets ?

Maximising Plant Uptime

Process and Standards

- **IMS Processes followed and complied to**
  - ISO 9001 Process
  - ISO 140001
  - OHSAS 18001
- **3 Dimensional SOPs focussing on**
  - Quality
  - Safety
  - Environment
- **Operation Excellence – Continual improvement cycle Inputs to Design / Procurement / Construction teams**
- **Job Authorization for Skill Development**



Shutdown Maintenance

- Breakdown impact analysis
- Stringent SLAs with Vendors
- Optimum Spares and Inventory management
- Cluster-wise Provisions for Spares

Preventive Maintenance

- As per Past Experience and OEM guidelines
- Scheduled maintenance
- Need based maintenance

Predictive Maintenance

- Condition based Monitoring
- Data analysis by Domain Experts
- Investigation and experiments
- Equipment Benchmarking
- Plant characterization

Internal Target set to deliver minimum 99.0% Plant Availability

Maximizing Plant Performance

Parameter Benchmarking
(Inter Plant)

- **Plant Uptime**
- **PR %**
- **Specific Yield**
- **Aux. consumption**
- **Generation Losses**
- **Internal Audit Reports**

Equipment Benchmarking
(Inter Plant)

- **PV Module**
  - Efficiency
  - Degradation Trends
- **Inverter**
  - Efficiency
  - Temperature
- **Transformer**
  - Efficiency
  - Temperature
  - Losses

Equipment Benchmarking
(Intra Plant)

- **Zone Monitoring**
  - Efficiency
  - Generation
  - Inverter
  - Transformer
- **Combiner Box Deviation**
  - Specific Yield
- **String Deviation**
  - Current

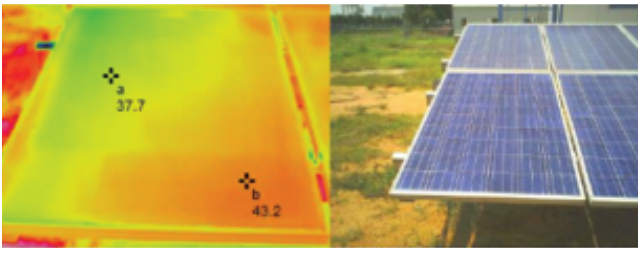
Internal Target set to deliver 101% of the Guaranteed performance

Predictive and Conditional Maintenance

Thermal Imaging of PV Modules

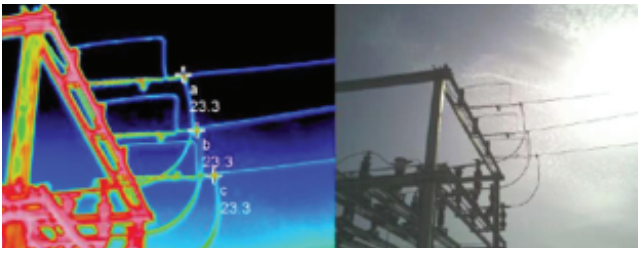
Inspection Images - IR Thermographic & Vsual

Module S/N: 11306040752340, Hot spot defect category: No hot spot



Thermal Imaging of DP Structure

Evacuation Point : No abnormity found



Communication Check of combiner boxes

Inverter parameter monitoring

Key Challenges faced during O&M

Issues	Activity Affected	Mitigations
Grid Issues • Throttling • Grid Variations and Instability	**Equipment Underperformance** • Downtime • Frequent Tripping • Under Efficiency	**Protection** • Contract Management • Local Discom Co-ordination
Margin Pressures • O&M contract rates lowered by about 30 %	**Customer Satisfaction** • Services expectation and Quality remains same in spite of reduce prices • Increased competition	**Cost Optimisation** • Command Centre for central monitoring • Central Spares • New initiatives to reduce manpower, security costs and module cleaning costs
Local Issues • Vandalism and Theft • May cause disruptions • Remote locations	**Module Cleaning /Vehicle Hire / Security** • Arm Twisting for Rates • Minimum employment requirements	**LocalInclusion** • Focus on CSR and Sustainability • Job creation and skill trainings • Water conservation

Indian O&M Scenario calls for plant specific, dynamic, and localised solutions

About Project

Promoting Energy Efficiency & Renewable Energy in Selected MSME Clusters in India

To develop and promote a market environment for introducing energy efficiency and enhanced use of renewable energy technologies in process applications in the selected energy-intensive MSME clusters under GEF UNIDO BEE project.
The main objective of the project is to increase the capacity building of suppliers of EE/RE product and service providers

Desclaimer

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