

DETAILED PROJECT REPORT

For

**Installation & Commissioning
Of
25kWp Standalone Roof Top Solar PV system
Under JNNSM Program**

At

Passport Office, Patto, Panjim, Goa

Prepared for

Goa Energy Development Agency
Goa

Prepared by

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September 2014

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25kWp Stand Alone Roof Top Solar Photovoltaic system at Passport Office, Patto, Panjim, Goa

1. INTRODUCTION

Harnessing of non polluting renewable energy resources to control green house gases is receiving impetus from the government of India. The solar mission, which is part of the National Action Plan on Climate Change has been set up to promote the development and use of solar energy in for power generation and other uses with the ultimate objective of making solar energy competitive with fossil-based energy options. The mission is a major initiative of the Government of India and State Governments to promote ecologically sustainable growth while addressing India's energy security challenge. It will also constitute a major contribution by India to the global effort to meet the challenges of climate change. The solar photovoltaic device systems for power generation had been deployed in the various parts in the country for electrification where the grid connectivity is either not feasible or not cost effective as also some times in conjunction with diesel based generating stations in isolated places and communication transmitters at remote locations.

The immediate aim of the Mission is to focus on setting up an enabling environment for solar technology penetration in the country both at a centralized and decentralized level. The Second phase (up to March 2017) will, inter alia, focus on promoting off-grid systems.

With the downward trend in the cost of solar energy and appreciation for the need for development of solar power, solar power projects have recently been implemented. A significant part of the large potential of solar energy in the country could be developed by promoting solar photovoltaic power systems of varying sizes as per the need, affordability and area availability kilowatt level solar photovoltaic power plant of adequate capacity can be proposed for the location.

It has been proposed to set up a **25 kWp** standalone solar photovoltaic system on the roof top of Passport Office, Patto, Panjim, Goa which will generate power and supply to the internal grid of the building.

The **25 kWp** Solar PV System to be installed in building is estimated to generate power of **37.96 MWh** and operate at a capacity factor of 17.3%. The SPV system estimated to cost **Rs. 42.50 lakh** including the cost of installation and commissioning.

2. OBJECTIVES OF THE PROGRAMME

The objectives are as follows:

- To promote grid applications of solar energy for meeting the targets set in the Jawaharlal Nehru National Solar Mission for Phase-I.
- To create awareness and to demonstrate effective and innovative use of Solar systems for individual, community, institutional and industrial applications.
- To encourage innovation in addressing market needs and promoting sustainable business models.
- To provide support to channel partners and potential beneficiaries, within the framework of boundary conditions and in a flexible demand driven mode.
- To create a paradigm shift needed for commoditization of grid decentralized solar applications.
- To support consultancy services, seminars, symposia, capacity building, awareness campaigns, human resource development, etc.
- To encourage replacement of kerosene& diesel, wherever possible.

3. SCOPE OF THE SCHEME

The scheme would be applicable to all parts of India and would, to begin with, be co-terminus with Phase-I of the Jawaharlal Nehru National Solar Mission and will, inter alia, focus on promoting grid connected and decentralized systems.

Various grid connected solar photo voltaic systems/ applications up to a maximum capacity of 100 kWp per site and decentralized solar thermal applications, to meet / supplement lighting, electricity/power, heating and cooling energy requirements would be eligible for being covered under the Scheme.

4. SALIENT FEATURES

1. Location

- | | |
|---------------|-------------------------------------|
| i. State | Goa |
| ii. City | Panjim |
| iii. Location | Passport Office, Patto, Panjim, Goa |
| iv. Latitude | 15° 29' 43" N |
| v. Longitude | 73° 50' 07" E |

2. Area and Type for SPV Plant

- | | |
|------------------------|--------------------------------|
| i. Area | 250 sq meter |
| ii. Type | Roof Top System |
| iii. Specific Location | On roof top of Passport Office |

3. SPV Power Plant

- | | |
|--------------------|-------------------------------|
| i. Capacity | 25 kWp |
| ii. No. of modules | 108 |
| iii. Connections | in series 4
in parallel 27 |
| iv. DC BUS | 1 No. |

4. Technical details of a SPV Module

- a) PV Module type** Poly crystalline

b) Electrical Parameter

- | | |
|---------------------------|--------|
| i. Maximum Power Rating | 250 Wp |
| ii. Rated Current | 4.25 A |
| iii. Rated Voltage | 12 V |
| iv. Short Circuit Current | 5 A |
| v. Open Circuit Voltage | 21 V |

5. Mounting Arrangement

- i. Mounting Fixed Type
- ii. Tilt angle(slope) 15°
- iii. Position Roof Top mounted

6. Inverter/ Power Conditioning Unit (PCU)

- i. Number of units 1
- ii. Rated Capacity 25 kW
- iii. Input Voltage range 170 V (Max.)
- iv. Output Voltage 415 V AC
- v. Frequency 50 Hz
- vi. Efficiency 95%

7. Grid Connection Details

- i. Electrical parameters for interconnection 415 V, 3Ph ,50 Hz

8. Annual Energy Generation

- i. Annual Energy 37.96 MWh

9. Cost Estimate

- i. Estimated Cost Solar PV System Rs. 42.50 lakh

10. Construction Time 4 months

5. EXISTING ELECTRICAL LOADS

5.1. Connected Loads

The major connected loads for of Passport Office, Patto, Panjim, Goa are as follows:

Table 1: Total connected load of the building

S. No.	Appliances	Rating	Unit	Number	Total Rating in W	Operational Hours in a Day	kWh / Day
1.	Tube lights	40	W	300	12000	10	120
2.	Fan	60	W	60	3600	10	36
3.	Computer	100	W	60	6000	10	60
4.	Printer	150	W	20	3000	2	6
5.	Motor	7500	W	1	7500	2	15
6.	Air Conditioner	2000	W	27	54000	8	432
7.	Water Cooler	100	W	5	500	24	12
8.	Television	100	W	15	1500	10	15
9.	Refrigerator	250	W	8	2000	12	24
10.	Incandescent lamp	60	W	3	180	10	1.8
11.	Other Lighting	250		30	7500	10	75
12.	Other Lighting 1	60	W	33	1980	10	19.8
	Total				99760		816.6

The total connected load of the building is 816.6kW which is operated for time duration of 10 hours in a day.

5.2. Energy Consumption

The total number of units consumed by the building comes out to be 816kWh in a day, the total energy consumption accounts to be 18000kWh in a month. The type of load is study in nature and is continuous kind of load. The annual energy consumption for the building is as follows:

Table 2: Annual Energy Consumption

S. No.	Month	Units (kWh)	Rs.
1	Jan	21552	98142/-
2	Feb	20150	95661/--
3	Mar	19985	90396/-
4	Apr	18552/-	89112/-
5	May	19125	90112/-
6	Jun	18663	88712/-
7	Jul	18512	87532/-
8	Aug	17512	85332/-

9	Sep	17100	84885/-
10	Oct	17500	85632/-
11	Nov	17995	87654/-
12	Dec	19322	89532/-

6. PROJECT PROPOSAL

As per the observation based on the data collected on area availability and shadow free area of 250 sq meter, it is proposed to install around 25 KWp standalone Solar PV system in the roof top of Passport Office.

Passport Office Building has an open roof space of 250 sq meter which can be utilized for solar PV system. It is proposed to install a 25 kWp standalone Solar PV Roof Top System on the open space available at the roof top. The system will be connected to available internal grid and the generated electricity will be utilized by internal connected loads of the building.

The **25 kWp** SPV system at roof-top of Passport Office building is estimated to afford annual energy generation of **37.97 MWh** (i.e. 0.037 million units) and operate at a capacity factor of 17.3%. The SPV system estimated to cost Rs. 1.7 Lakhs/ kWp with battery bank for which 30% capital Subsidy is available from MNRE. The total system cost will be **Rs. 42.5 Lakh**, which will include system cost with installation and commissioning.

7. SITE DESCRIPTION

The Passport Office has sufficient vacant roof top space without any obstacle for sunlight, which can be used for Solar PV installations. It is proposed to utilize a vacant area available of about 250 sq meters on this roof top to accommodate a cumulative capacity of 25 kWp of solar PV modules.

The above mentioned standalone rooftop solar PV power plant would also be considered as the demonstration system and for public awareness.

8. FUNCTIONAL DESCRIPTION OF SPV POWER SYSTEM

The solar PV system shall be designed with either mono/ poly crystalline silicon modules or using thin film photovoltaic cells or any other superior technology having higher efficiency.

Three key elements in a solar cell form the basis of their manufacturing technology. The first is the semiconductor, which absorbs light and converts it into electron-hole pairs. The second is the semiconductor junction, which separates the photo-generated carriers (electrons and holes), and the third is the contacts on the front and back of the cell that allow the current to flow to the external circuit. The two main categories of technology are defined by the choice of the semiconductor: either crystalline silicon in a wafer form or thin films of other materials.

The stand alone roof top solar PV system generally comprises the following equipment.

- I. Solar Panels (PV) Modules
- II. Charge Controllers
- III. Inverters
- IV. Battery Bank
- V. Mounting Structure
- VI. AC and DC Cables
- VII. Earthing equipment /material
- VIII. Junction Boxes or combiners
- IX. Instruments and protection equipments

8.1. Solar Panels (PV) Modules

The DC electricity produced by the solar panel or module(s) is used to charge batteries via a solar charge controller. Any DC appliances that are connected to the battery will need to be fused. DC lights are normally connected to the charge controller. Any AC appliances are powered via an inverter connected directly to the batteries. NOTE: inverters used in grid tie and standalone systems are different and should not be interchanged.

Most Stand Alone PV Systems need to be managed properly. Users need to know the limitations of a system and tailor energy consumption according to how sunny it is and the State of Charge (SOC) of the battery.

8.2. Configuration

The solar panels need to be configured to match the system DC voltage, which is determined by the battery. System voltages are typically, 12V DC and 24V DC, larger systems will operate at 48V DC.

The operating voltage of a solar panel in a stand-alone system must be high enough to charge the batteries. For example, a 12V battery will require 14.4V to charge it. The solar panel must be able to deliver this voltage to the battery after power losses and voltage drop in the cables and charge controller and in conditions in which the solar cells operate at a high temperature. A solar panel with a Voc of about 20V is required to reliably charge a 12V battery.

8.3. Charge Controllers

A charge controller is designed to protect the battery and ensure it has a long working life without impairing the system efficiency. Batteries should not be overcharged and the function of the charge controller is to ensure that the battery is not over charged. Charge controllers are designed to function as follows:

- Protect the battery from over-discharge, normally referred to as Low Voltage Disconnect (LVD) that disconnects the battery from the load when the battery reaches a certain depth of discharge (DOD).
- Protect the battery from over-charging by limiting the charging voltage – this is important with sealed batteries – it is usually referred to as High Voltage Disconnect (HVD).
- Prevent current flowing back into the solar panel during the night, so called reverse current.

8.4. Inverters

Inverters are used for DC voltage to AC voltage conversion. Inverter input voltage depends on inverter power, for small power of some 100 W the voltage is 12 or 24 V, and 48 V or even more for higher powers. For large systems 3-phase inverters are available. Storage batteries use and store DC – Direct Current and have a low voltage output usually in the range of 12 – 24 volts. Virtually all modern appliances operate on AC – Alternating Current and work on 240 volts. An inverter is a device that takes the power from your DC battery source and through special technology boosts it to household AC electricity giving you the

power to run appliances such as televisions, lights, computers, and power tools wherever you may be. Simply, an inverter increases 12/24/48-volt battery power to 110/240 AC power.

8.5. Battery Bank

The power requirements of standalone PV systems are rarely in sync with the battery charging. Appliances and loads need to be powered when there is sufficient solar radiation, during overcast weather and during the night. Bad weather may last for several days and the daily charging and discharging of the batteries takes its toll on them. Batteries that are able to handle the constant charging and discharging are known as deep cycle batteries. Batteries need to have a good charging efficiency, low charging currents and low self-discharge.

8.6. Cables and Accessories

Cables need to be UV resistant and suitable for outdoor applications. It is very important to keep power losses and voltage drop in the cable to a minimum. It is recommended that this be less than 3% between the array and the batteries and less than 5% between the battery and DC loads.

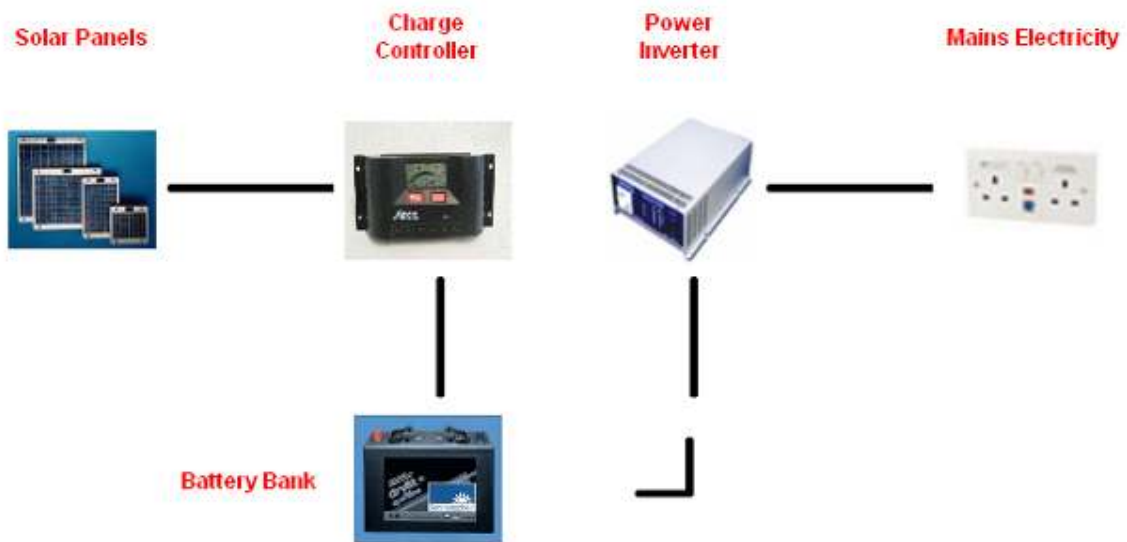


Figure 1: Components of a Stand Alone Solar PV System

9. ANNUAL ENERGY GENERATION

The annual energy generation from the SPV power plant has been worked out based on the data on mean global solar radiant exposure over Panjim, Goa. The mean global solar radiant exposure varies from 3.99 kWh/m²/day in the month of Jul to 6.76 kWh/m²/day in the month of April. The month-wise mean global solar radiant exposure is given at Annexure-I. Considering the efficiency of PV module at 14% and temperature coefficient of 0.4 % per °C, the annual energy generation is estimated as 37.96 MWh (i.e. 0.037 million units). This takes into consideration an efficiency of the Power Conditioning Unit (PCU) as 95% and losses in the DC and AC system as 5% each up to the point of interconnection. The month wise energy generation during the year is given at Annexure-II and shown below.

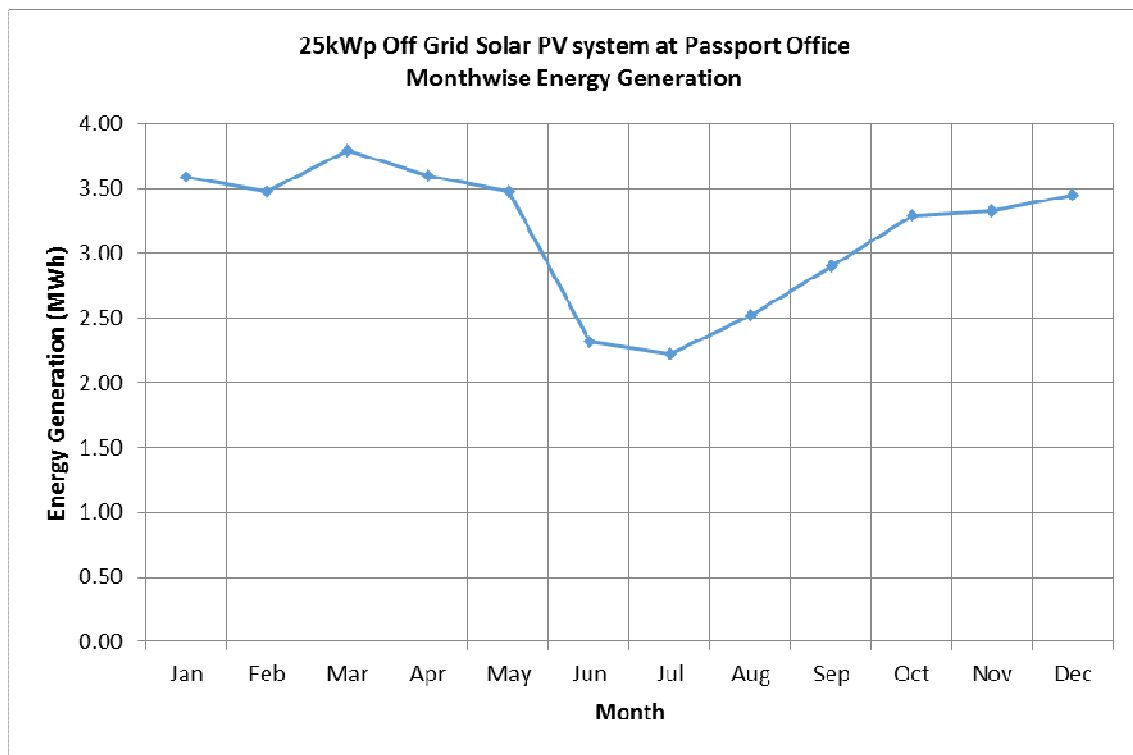


Figure 2: Month wise Energy Generation

The energy available from the Plant would vary from a minimum of 2.22 MWh during the month of July to a maximum of 3.79 MWh during the month of March. The annual capacity utilization factor works out as 17.3%.

The Energy Generation simulation for the Passport Office Building is given in Annexure-III.

10. ESTIMATES OF COST

10.1. Stand Alone Solar PV Power Plant

As per the present market conditions the cost for 25kWp standalone solar power plant including installation and commissioning is Rs. 1.7 Lakh/ kWp. Therefore, the cost of 25kWP system is estimated as Rs. 42.50 Lakh. The detailed specification with Bill of materials giving indicative cost of major equipments is provided in Annexure – IV.

The reputed make of the major equipments for standalone solar PV roof top system is provided in Annexure – V.

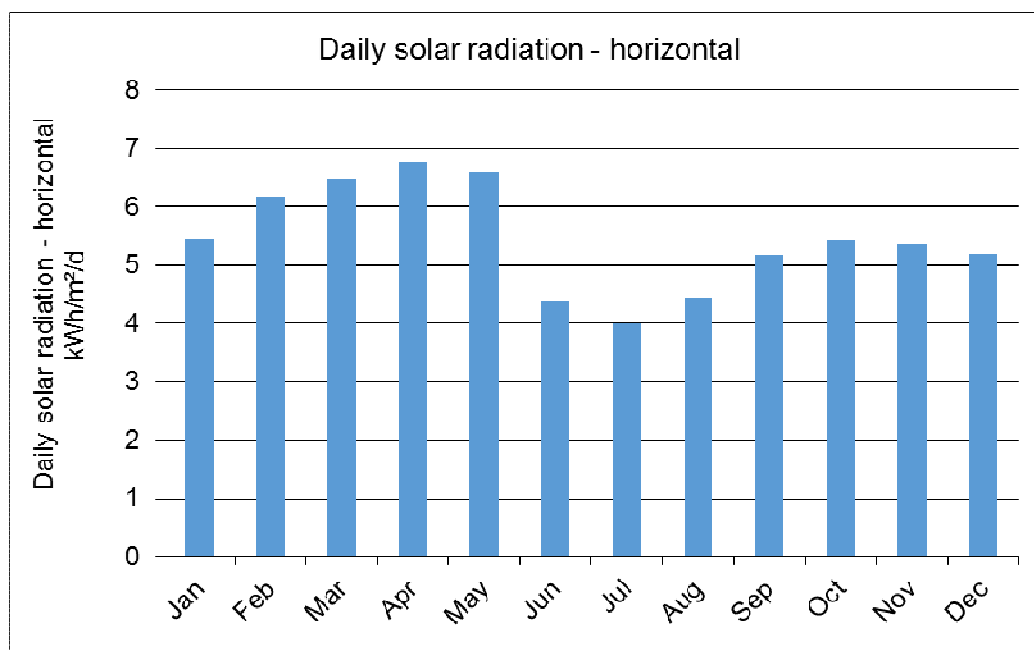
11. AREA AVAILABILITY

11.1. Roof Area Availability for Stand Alone Solar Power Plant

The total roof space available at Passport Office Building is about 250 sq meter which is presently vacant and can be utilized for solar roof top system. There is no nearby upcoming project which may block the way of sun the roof space is an ideal place for installation of SPV system. The proposed system of 25 kWp require a roof space of about 250 sq meters.

Annexure I: Mean Global Solar Radiant Exposure, Panjim, Goa

Month	Daily solar radiation - horizontal kWh/m ² /d
Jan	5.46
Feb	6.19
Mar	6.5
Apr	6.76
May	6.59
Jun	4.38
Jul	3.99
Aug	4.45
Sep	5.17
Oct	5.44
Nov	5.36
Dec	5.19
Annual	5.45



Annexure II: 50 kWp Roof Top Solar PV System at Passport Office, Panjim,
Goa

Month	Energy Generation (MWh)
Jan	7.17
Feb	6.96
Mar	7.59
Apr	7.19
May	6.96
Jun	4.64
Jul	4.45
Aug	5.03
Sep	5.80
Oct	6.59
Nov	6.66
Dec	6.90
Annual	75.93

Annexure III: Energy Generation simulation for the Passport Office, Panjim, Goa

Project information [See project database](#)

Project name: 25 kWp Standalone Roof Top Solar PV System
 Project location: Panaji, Goa

Prepared for: Goa Energy Development Agency
 Prepared by: Darashaw & Co. Pvt. Ltd.

Project type: Power
 Technology: Photovoltaic
 Grid type: Central-grid
 Analysis type: Method 2
 Heating value reference: Higher heating value (HHV)

Show settings

Site reference conditions [Select climate data location](#)

	Unit	Climate data location	Project location
Latitude	°N	15.5	15.5
Longitude	°E	73.8	73.8
Elevation	m	60	60
Heating design temperature	°C	20.3	
Cooling design temperature	°C	33.3	
Earth temperature amplitude	°C	6.6	

Month	Air temperature °C	Relative humidity %	Daily solar radiation - horizontal kWh/m ² /d	Atmospheric pressure kPa	Wind speed m/s	Earth temperature °C	Heating degree-days °C-d	Cooling degree-days °C-d
January	28.0	87.6%	5.46	100.5	2.5	27.5	0	486
February	26.3	88.8%	6.19	100.4	2.8	28.6	0	456
March	27.7	74.0%	6.50	100.3	2.8	30.2	0	549
April	28.3	73.3%	9.76	100.1	3.1	31.0	0	679
May	30.0	74.7%	6.50	100.0	3.3	30.8	0	620
June	27.6	86.3%	4.38	99.9	4.2	28.1	0	628
July	28.7	89.5%	3.99	99.9	4.4	29.9	0	518
August	26.4	88.8%	4.45	100.0	3.9	26.6	0	608
September	26.0	88.9%	5.77	100.1	2.5	26.9	0	507
October	27.9	82.0%	6.44	100.2	2.2	27.7	0	666
November	27.6	72.0%	5.36	100.4	2.5	28.0	0	528
December	26.9	87.2%	6.19	100.5	2.6	27.4	0	624
Annual	27.4	77.6%	5.45	100.2	3.1	28.3	0	6,368
Measured at	m				10.0	0.0		

Detailed Project Report
25 kWp Stand Alone Roof Top Solar PV System
Passport Office

RETScreen Energy Model - Power project

Proposed case power system

Technology Photovoltaic

Analysis type Method 1
 Method 2

Resource assessment

Solar tracking mode Fixed
 Slope 15.0
 Azimuth 0.0

Show data

Month	Daily solar radiation - horizontal kWh/m ² /d	Daily solar radiation - tilted kWh/m ² /d	Electricity export rate \$/MWh	Electricity exported to grid MWh
January	5.46	6.30		3.587
February	6.19	6.81		3.479
March	6.50	6.74		3.794
April	6.76	6.63		3.595
May	6.59	6.21		3.480
June	4.38	4.14		2.319
July	3.99	3.81		2.223
August	4.45	4.32		2.517
September	5.17	5.22		2.899
October	5.44	5.81		3.296
November	5.36	6.08		3.329
December	5.19	6.07		3.447
Annual	5.45	5.67	0.00	37.966

Annual solar radiation - horizontal MWh/m² 1.99
 Annual solar radiation - tilted MWh/m² 2.07

Photovoltaic

Type poly-Si
 Power capacity kW 25.00
 Manufacturer
 Model
 Efficiency % 14.0%
 Nominal operating cell temperature °C 45
 Temperature coefficient % / °C 0.40%
 Solar collector area m² 179
 Miscellaneous losses % 10.0%

Inverter

Efficiency % 95.0%
 Capacity kW 25.0
 Miscellaneous losses % 5.0%

Summary

Capacity factor % 17.3%
 Electricity exported to grid MWh 37.966

Annexure IV: Bill of Material for 25 kWp Roof top SPV System

Sl. No.	Component Name	Type and / or Model No.	Description of Components	Quantity/ System	Amount in `
1.	SPV Module (Poly Crystalline)	240 Wp or equivalent	30 V, 7.8 Amps/ module	Sets of 108 nos. SPV module (27 in parallel and 4 in series)	12,00,000
2.	Structure	Module type	MS Hot dip galvanized steel	LS	3,70,000
3.	Inverter Rating	96 V D/C – input 415 V AC – output	25 kW power rating with synchronizer & meter equipped with data logging facilities	1 no.	3,00,000
4.	Battery Bank	1800 Ah, 12V	Low Maintenance Tubular Batteries	56 nos.	18,00,000
5.	Field Junction Box	Reputed make	Dust & water proof		5,00,000 (Lump Sum)
6.	Main Junction Box	Reputed make	Dust & water proof		
7.	Ground Fault Protection System		Included at inverter	1 no.	
8.	Cables	Conforming to BIS	25 sq mm PVC cables	As per site conditions	
9.	Lightening Arresters			1 no.	
10.	Earthing	Reputed make		1 set	
	Total Systems Hardware				
11.	Civil works and electrical works			LS	20,000
12.	Installation and commissioning			LS	20,000
13.	Annual Maintenance for 5 years			LS	25,000
14.	Transportation and insurance			LS	15,000
	Total				42,50,000

Annexure V: Reputed Make of Major Equipments for Roof Top SPV System

Sl. No.	Component Name	Reputed Make
1.	SPV Module (Poly Crystalline)	BHEL, CEL India, Moserbaer, Titan Solar
2.	Inverter	DB Electronics, Megatech, Su-Kam, SMA
3.	Battery Bank	Exide, Amara Raja

Annexure VI: Snapshots of Roof Space Available at Building



