DETAILED PROJECT REPORT

For

Installation & Commissioning
Of
50kWp Standalone Roof Top Solar PV system
Under JNNSM Program

At

National Institute of Oceanography, Dona Paula, Panjim, Goa

Prepared for

Goa Energy Development Agency
Goa

Prepared by
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50kWp Stand Alone Roof Top Solar Photovoltaic system at National Institute of Oceanography, Dona Paula, 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 **50 kWp** standalone solar photovoltaic system on the roof top of National Institute of Oceanography, Dona Paula, Panjim, Goa which will generate power and supply to the internal grid of the building.

The **50 kWp** Solar PV System to be installed in building is estimated to generate power of **75.93 MWh** and operate at a capacity factor of 17.3%. The SPV system estimated to cost **Rs. 85.00 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	National Institute of Oceanography, Dona Paula, Panjim, Goa
iv.	Latitude	15° 27' 21” N
v.	Longitude	73° 48' 07” E

2. Area and Type for SPV Plant

i.	Area	700 sq meter
ii.	Type	Roof Top System
iii.	Specific Location	On roof top of National Institute of Oceanography

3. SPV Power Plant

i.	Capacity	50 kWp
ii.	No. of modules	212
iii.	Connections	in series 4 in parallel 53
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	50 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	75.93 MWh

9. Cost Estimate

i.	Estimated Cost Solar PV System	Rs. 85.00 lakh

10. Construction Time 4 months

5. EXISTING ELECTRICAL LOADS

5.1. Connected Loads

The major connected loads for of National Institute of Oceanography, Dona Paula, 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	1500	60000	10	600
2.	Fan	60	W	600	36000	10	360
3.	Computer	100	W	700	70000	10	700
4.	Printer	150	W	400	60000	2	120
5.	Motor	7500	W	1	7500	2	15
6.	Air Conditioner	2000	W	40	80000	8	640
7.	Water Cooler	60	W	5	300	24	7.2
8.	Refrigerator	250	W	100	25000	12	300
9.	Other Lighting	150	W	4	600	10	6
10.	Other Lighting 1	36	W	150	5400	10	54
	Total				**344800**		**2802.2**

The total connected load of the building is 344.8kW 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 2802kWh in a day, the total energy consumption accounts to be 273000kWh 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	287470	11,31,243/-
2	Feb	237350	9,81,961/-
3	Mar	238660	9,69,237/-
4	Apr	231900	9,44,278/-
5	May	231070	9,37/585/-
6	Jun	241590	9,78,846/-
7	Jul	273470	10,31,417/-
8	Aug	210050	8,35/423/-
9	Sep	239560	9,34,541/-
10	Oct	242180	9,61,333/-

11	Nov	237555	9,71,335/-
12	Dec	208280	10,91,907/-

6. PROJECT PROPOSAL

As per the observation based on the data collected on area availability and shadow free area of 700 sq meter, it is proposed to install around 50 KWp standalone Solar PV system in the roof top of National Institute of Oceanography.

National Institute of Oceanography Building has an open roof space of 700 sq meter which can be utilized for solar PV system. It is proposed to install a 50 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 **50 kWp** SPV system at roof-top of National Institute of Oceanography building is estimated to afford annual energy generation of **75.93 MWh** (i.e. 0.075 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. 85 Lakh**, which will include system cost with installation and commissioning.

7. SITE DESCRIPTION

The National Institute of Oceanography 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 700 sq meters on this roof top to accommodate a cumulative capacity of 50 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.

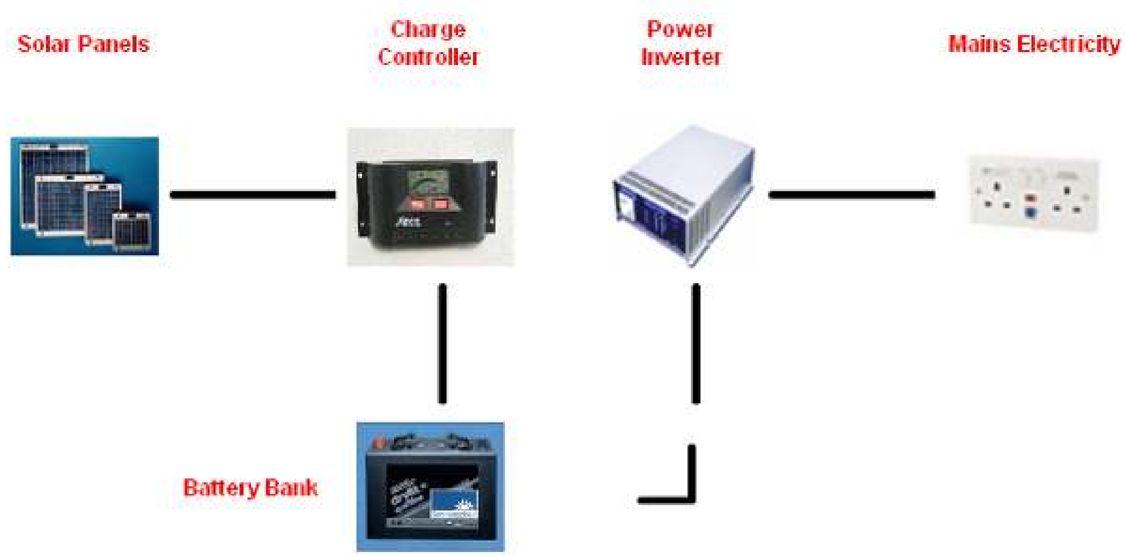


Figure 1: Components of a Stand Alone Solar PV System

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/m^2/day in the month of Jul to 6.76 kWh/m^2/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 75.93 MWh (i.e. 0.075 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.

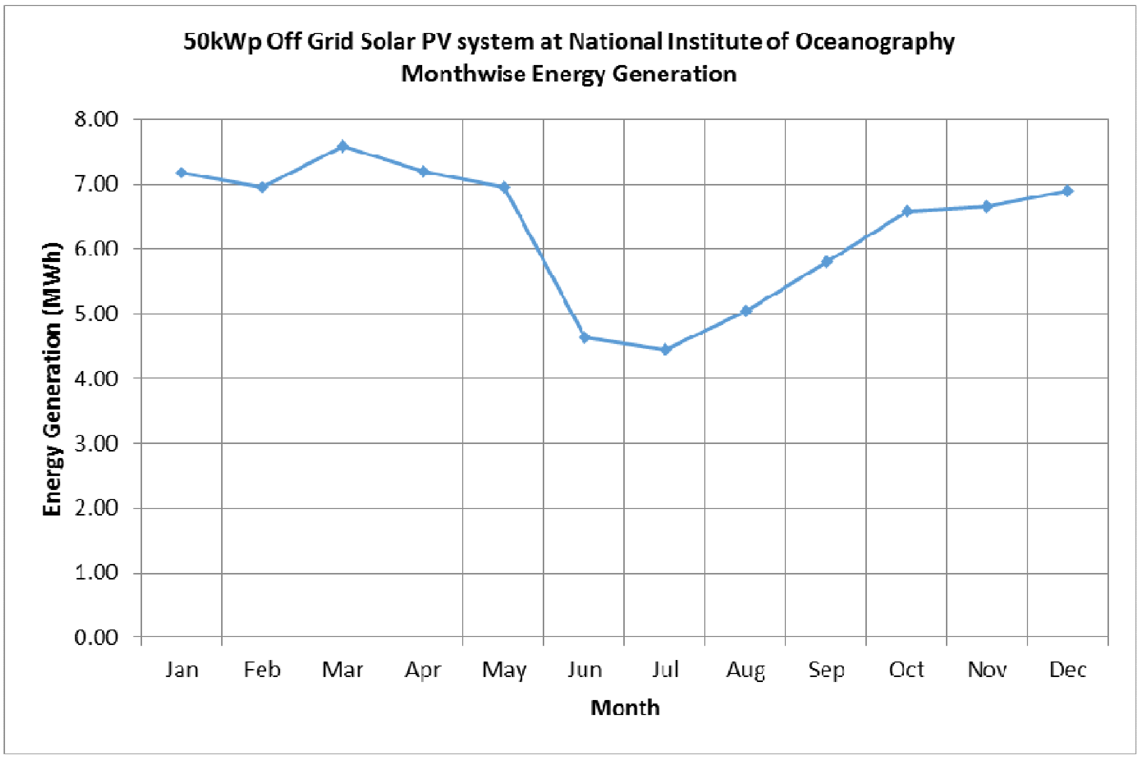


Figure 2: Month wise Energy Generation

The energy available from the Plant would vary from a minimum of 4.45 MWh during the month of July to a maximum of 7.59 MWh during the month of May. The annual capacity utilization factor works out as 17.3%.

The Energy Generation simulation for the National Institute of Oceanography 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 50kWp standalone solar power plant including installation and commissioning is Rs. 1.7 Lakh/ kWp. Therefore, the cost of 50kWP system is estimated as Rs. 85.00 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.

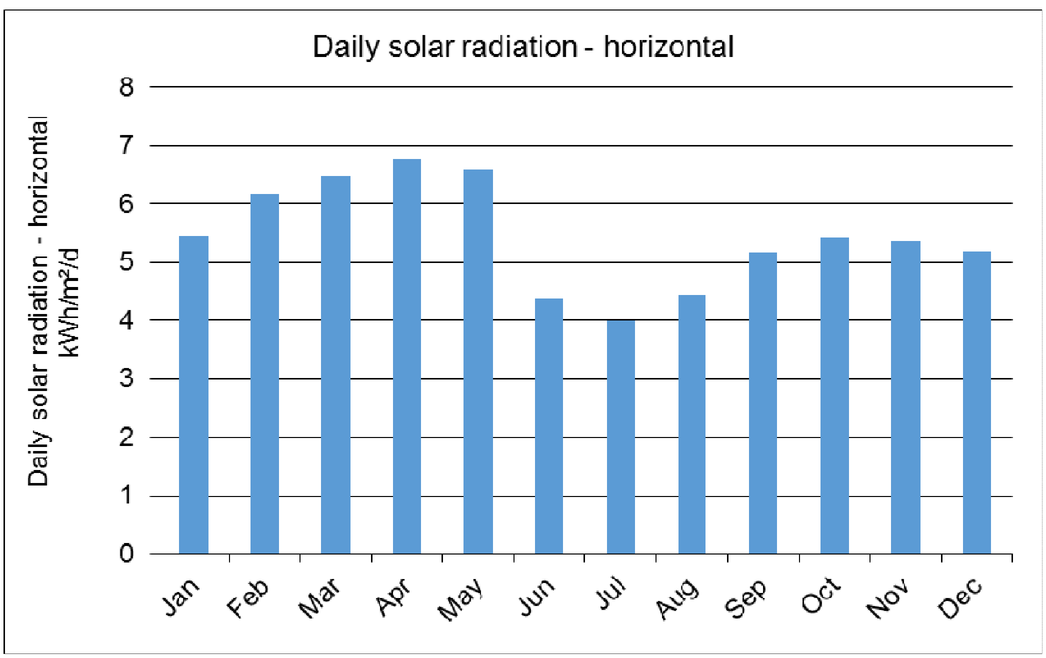
11. AREA AVAILABILITY

11.1. Roof Area Availability for Stand Alone Solar Power Plant

The total roof space available at National Institute of Oceanography Building is about 700 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 50 kWp require a roof space of about 500 sq meters.

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

Month	Daily solar radiation - horizontal kWh/m²/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 National Institute of Oceanography, 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 National Institute of Oceanography, Panjim, Goa

Natural Resources Canada   Ressources naturelles Canada

RETScreen® International
www.retscreen.net

Clean Energy Project Analysis Software

Project information

See project database

Project name	50 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	Relative humidity	Daily solar radiation - horizontal	Atmospheric pressure	Wind speed	Earth temperature	Heating degree-days	Cooling degree-days
		°C	%	kWh/m²/d	kPa	m/s	°C	°C-d	°C-d
January		26.0	67.6%	5.46	100.5	2.5	27.5	0	496
February		26.3	68.8%	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%	6.76	100.1	3.1	31.0	0	579
May		30.0	74.7%	6.59	100.0	3.3	30.6	0	620
June		27.6	85.3%	4.38	99.9	4.2	28.1	0	528
July		26.7	89.5%	3.90	99.9	4.4	26.9	0	518
August		26.4	88.8%	4.45	100.0	3.9	26.6	0	508
September		26.9	86.9%	5.17	100.1	2.5	26.9	0	507
October		27.9	82.5%	5.44	100.2	2.2	27.7	0	555
November		27.6	72.0%	5.36	100.4	2.5	28.0	0	528
December		26.9	67.2%	5.19	100.5	2.5	27.4	0	524
Annual		27.4	77.8%	5.45	100.2	3.1	28.3	0	6,368
Measured at	m					10.0	0.0		

Complete Energy Model sheet

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/m²/d	Daily solar radiation - tilted kWh/m²/d	Electricity export rate $/MWh	Electricity exported to grid MWh
January	5.46	6.30		7.174
February	6.19	6.81		6.959
March	6.50	6.74		7.588
April	6.76	6.63		7.190
May	6.59	6.21		6.960
June	4.38	4.14		4.639
July	3.99	3.81		4.445
August	4.45	4.32		5.034
September	5.17	5.22		5.799
October	5.44	5.81		6.592
November	5.36	6.08		6.659
December	5.19	6.07		6.895
Annual	**5.45**	**5.67**	**0.00**	**75.933**

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

Photovoltaic

Type		poly-Si
Power capacity	kW	50.00
Manufacturer		
Model		
Efficiency	%	14.0%
Nominal operating cell temperature	°C	45
Temperature coefficient	% / °C	0.40%
Solar collector area	m²	357
Miscellaneous losses	%	10.0%

Inverter

Efficiency	%	95.0%
Capacity	kW	50.0
Miscellaneous losses	%	5.0%

Summary

Capacity factor	%	17.3%
Electricity exported to grid	MWh	75.933

Annexure IV: Bill of Material for 50 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 212 nos. SPV module (53 in parallel and 4 in series)	25,00,000
2.	Structure	Module type	MS Hot dip galvanized steel	LS	7,50,000
3.	Inverter Rating	96 V D/C – input 415 V AC – output	50 kW power rating with synchronizer & meter equipped with data logging facilities	1 no.	6,00,000
4.	Battery Bank	1800 Ah, 12V	Low Maintenance Tubular Batteries	56 nos.	35,00,000
5.	Field Junction Box	Reputed make	Dust & water proof		10,00,000 (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				**83,50,000**
11.	Civil works and electrical works			LS	40,000
12.	Installation and commissioning			LS	30,000
13.	Annual Maintenance for 5 years			LS	50,000
14.	Transportation and insurance			LS	30,000
	Total				**85,00,000**

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