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Development of Zero Energy Consumption Building an Approach towards Green Campus

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Abstract. The conversion of energy is the key objective of this paper. To achieve this installation of grid connected rooftop solar power plant is proposed at Elitte College of Engineering, Kolkata campus. The main purpose to choose rooftop power plant is to use unutilized roof space of the campus for generation green electricity to convert zero energy consumption building. This approach will help our country to reduce carbon foot print and also help in sustainable development. This paper also presents cost- benefit analysis of proposed roof top solar power plant for making a green campus.

Keywords. Roof-top Photovoltaic; Green Energy; Grid connected; Annual Energy consumption

1. Introduction

Sustainable development is important parameter for maintaining energy security and economic growth for any country [1-2]. Energy security is linked with seventeen sustainable energy goals. To be more precise, energy security now days depend on right energy mix between conventional and nonconventional energy application [3-5].India is currently focused on solar power by lunching the Jawaharlal Nehru National Solar Mission (JNNSM) with a target of 175 GW renewable energy additions by 2022. Out of 175 GW, 100GW of energy production through solar energy, 60 GW of Wind and rest are other source of renewable energy. In 2020, union budget for India announced subsidy for Roof-top Photovoltaic (RPV) installation for all residential budding for more induction green energy [6-8]. RPV technology is highly acceptable owing to easy installation, less maintenance, pollution free, environmental friendly source of electricity [9]. The other important aspect of RPV is that it produces low cost electricity utilizing limited space of roof of any new or old established building [10-12].Considering this in this paper a roof top solar power plant is proposed to convert ECE campus a Zero energy green campus.

2. Methods

Methodology used in this work consists of following steps. Figure-1 depicts proposed method of research work done to accomplice the desire objective.

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2.1. Environmental Parameter Analysis for ECE Kolkata Campus

ECE Kolkata campus is situated at 22.7144°North, 88.4175°East. It is under the climatic zone of Tropical wet and dry. Annual average global horizontal insolation is 4.0kWh/ m2 per day which is considered as the major input parameter for photovoltaic generation.

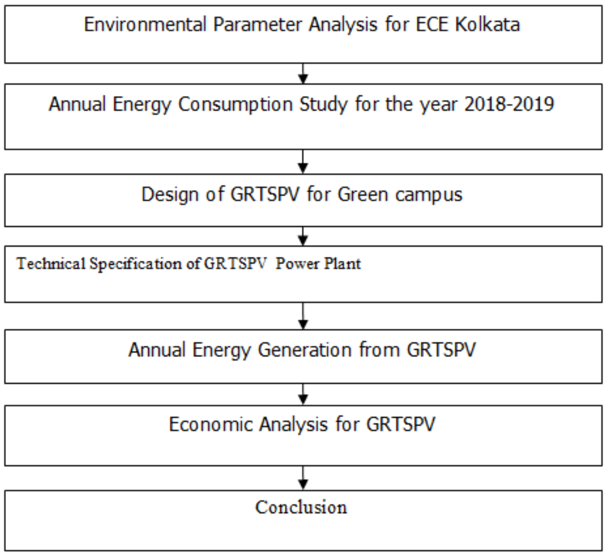

Figure 1. Methodology of Current Research.

2.2. Annual Energy Consumption Study of ECE Kolkata Campus for the year 2018-2019

Energy consumption of ECE Kolkata campus for the year 2018-2019 is depicted in Figure-2. It is clear that the monthly energy consumption maximum is in the month of April with the value of electricity consumption8400 kWh. The total energy consumption for the entire year is 78000 kWh.

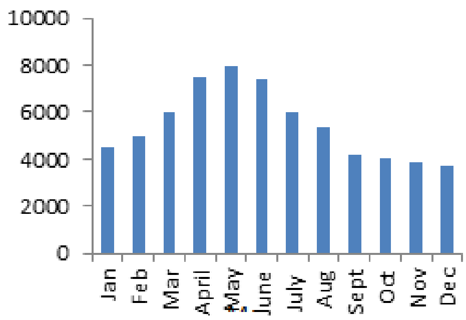

Figure 2. Energy Consumption of ECE Kolkata.

2.3. Design of GRTSPV for Green Campus

In case of Rooftop Photovoltaic Power Plant design first step is to calculate the available area for installation of PV plant. To fulfill this purpose all measurements of the rooftop of ECE Kolkata building were collected from Building roof Plan. The Photograph for ECE Kolkata Campus is depicted in Figure 3.

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Figure 3. Elitte College of Engineering.

After analysis through PVSYST software the available shadow free roof top area of ECE Kolkata campus, is 1375m^2. The available shadow free area is sufficient for installation of 100 kWp GRTSPV power plant.

2.4. Technical Specifications of Component used for GRTSPV Plant

The Grid Connected Rooftop and off grid Solar PV Power Plant shall consist of following major equipment/components.

a. Solar PV modules
b. Module Mounting Structure and civil foundation
c. PV array Junction Box with Array isolator, Fuse and Surge Protection Device (SPD)
d. Grid interactive Power Conditioning Unit with web based data logger
e. Inverter Combiner Panel and Grid Isolation
f. Disconnection Isolator at Point of Coupling
g. Earthing protections.
h. Cables and wires

3. The details of Major Components are as follows

PV Module:

Table 1. Details of Solar Module

Sl no.	Item	Description
1	Type	Mono or poly crystalline
2	Rating at STC	Minimum 300Wp
3	Efficiency	Minimum16%
4	Fill factor	Minimum 70%
5	Withstanding voltage	1000V DC
6	Module Frame	Anodized aluminum

4. Module Mounting Structure and Foundation

Module Mounting Structure and Foundation shall be designed using anchor fastener for grouting of structure on the roof. The PV Module Mounting Structure shall be also designed satisfying that rain water is not logged due to installation of the same, the PV Array should be capable of withstanding a wind load as per IS:875 (180 km/hr after installation) with Design Factor of Safety :1.5.

5. PV Array Junction Box (AJB):

Table 2. Array Junction Box

Sl no.	Item Description	Desired Data

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1	Degree of Protection	IP65 with UV Protected
2	Material	Polycarbonate.
3	Withstanding voltage	1000V DC
4	Withstanding Temp	100 ^{0}C
5	Type of Surge Protecting Device (SPD)	DC , Type B+C
6	Fuse Type	Glass fuse, for PV Use only
7	Rating	1.25 times the rated short circuit current

6. Inverter
The string inverter shall be used to convert DC power produced by SPV modules, in to AC power. Typical technical features of the inverter shall be as follows:

Table 3. Technical Features of Inverter

Sl. No.	Operating Parameter	Desired specification
01	Type	Grid connected String Inverter
02	PV array connectivity capacity	More than 10 kWp
03	MPPT Voltage range	Compatible with the array Voltage
04	Number of MPPT Channel	2 nos (Minimum)
05	Nominal AC Power output	Minimum 15 kW
06	Number of Grid Ph	3Ø
07	Adjustable AC voltage range	360V- 455V
08	Frequency range	47-53 Hz
09	THD	Less than 3%
10	Efficiency (Maximum)	95 %
11	Protection Class	IP 65 or higher
12	Operating ambient temperature	0 ^{0}C to 50^{0}C

Arrangement of Photo Voltaic (PV) Module of GRTSPV Power Plant:
Panel arrangements for RPV plants are indicated in Figure 4. In case of GRTSPV plant a spacing of 0.75m

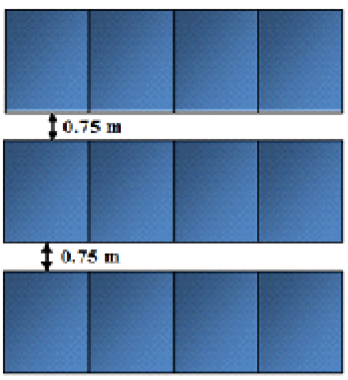

Figure 4. Arrangement of PV Module.

Integration of PV Power with Grid:
The output power from SPV will be fed into the inverter, which converts DC produced by SPV array to AC and feeds it into the 3-phase, 400V AC source. There will be two isolators for feeding power into the grid. The isolators shall be connected at the two ends of the main power supply cable,

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connected between the Inverter and Grid Power Source. In order to monitor performance of PV Power Generating System an import-export meter shall be provided at the output of the inviter depicted in Figure 5.

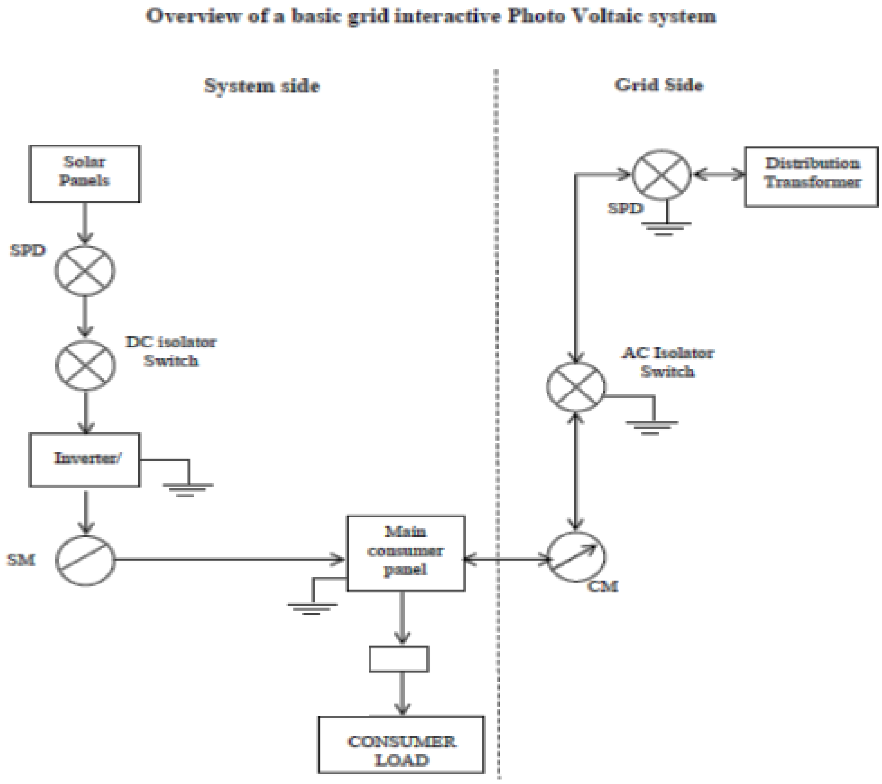

Figure 5. Connectivity with Grid.

7. Annual Energy Generation from GRTSPV

Annual energy generations from RPV plant are calculated considering all the associated losses with Photovoltaic generation [11].

Considering the available shadow free area and need of energy campus of campus 80 kWp GRTSPV power plants is proposed. Consider the climatic condition of Kolkata 1 kWp power plant produce 4 kWh per day. If we consider 300 no sunny day per year then

Annual Energy generation from proposed 70 kWp GRTSPV Power plant= 84000 kWh.

8. Economic Analysis for GRTSPV Power Plant:

Considering the Ministry of New and Renewable Energy Benchmark cost for installation of Rooftop solar plant 1 kWp= Rs 45/Wp
Total cost associated with GRTSPV plant = INR 3150000.00
Annual energy supplied to the grid= Total Annual Energy generation of the plant- Annual Energy consumption of ECE Kolkata campus
Annual Energy supplied to the grid from RPV plant= (84000 – 78000) kWh= 2000 kWh
SOES=Annual Savings from own energy supply.=78000 kWh
CS= Cost of per kWh electricity purchased from the grid from PV plant. In this paper it is considered as INR 6.00/ kWh.
Annual Savings from RPV plant= INR 468000.
Simple payback period=
TC = Total cost associated with the plant.

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SA= Annual saving from the plant.
Pay back= TC/SA=(3150000.00/468000)=6.51
Calculated simple payback period for around 6.5 years

4. Conclusion

Conclusions of the paper are presented below:

- Total shadow free rooftop area available in ECE campus for PV installation is 1375 m^2.
- Proposed GRTSPV plant capacity 70 kWp
- Annual Energy consumption of ECE campus for the year 2018-19 was 78000 kWh.
- Annual energy generations from 70 kWp RPV plant are 84000.00 kWh /Annum
- Cost Saving per year utilizing green energy is Rs. 468000.00
- Normal Plant life is 25 years for 25 years
- Payback period of Grid connected rooftop power plant around 6 years.

Utilizing the roof area ECE campus can be convert the entire campus to zero energy green campus and reduce the carbon foot print significantly.

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