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DESIGN, AND ENERGY ESTIMATION OF 165KWp GRID CONNECTED SOLAR PV PLANT USING HELIOSCOPE.

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Abstract - *The case study aims in Design and Energy estimation of 165KWp grid connected Solar PV plant for VJTI campus located in Mumbai, Maharashtra, towards initiating the institutional campus in search of exploring and utilizing the renewable resources of energy. The 165KWp Plant was designed and simulated on Helioscope, the AI based cutting-edge, industry relevance PV technology software developed by Folsom Labs. During the design process offsite and onsite assessment of the specified proposed location was initiated, by considering various parameters which could further affect the generation capacity. During PV plant assessment several surrounding, environmental and electrical equipment Data Collection was initiated to meet the maximum plant requirement and consumption demand. The location has the average direct solar radiation of 700W/sq.-m and diffused radiation of 160W/sq.-m over 16 acres of land. The PV module Tilt angle is 10° and azimuth angle as 192° facing towards south. Considering the various generation power losses parameter such as mismatch, wiring, soiling, reflection, shading, irradiance, temperature, the software simulation estimated annual average production of 273MWh with PV plant performance efficiency ratio of 77.3%.*

***Key Words*: Solar PV, Plant Design, Energy, solar radiation, electric gird, Helioscope.**

1. INTRODUCTION.

Nowadays the term 'Energy' has become a global concern. since the existence of man on this earth, many forms of energies were discovered, mainly obtained from environment, which were utilized for mankind sustenance and well-being, which also still continues today. Everyday new technologies are being developed to save and sustain the environment, which is consider as the source of ultimate energy. In 21st century, 'Solar' is one of the leading technology which harnesses the sun's energy converting sunlight into electricity. India tapped this PV technology and now is in the 5th global position of solar power deployment. Today India has 370 Gigawatt installed generation capacity. Off this 35% is from all the renewable sources. The solar share is about 9.5 % which accounts for 35 GW of solar energy.[1] The nation is leading to its path towards achieving Jawaharlal Nehru National solar mission, by installing 100GW grid connected solar power by the year 2022 under guidance of Hon. PM Shri Narendra Modi. [2] In view of being one of the most pioneer engineering institute in nation and to contribute towards National solar mission, the design of Grid Connected solar PV Plant was initiated at VJTI campus.

2. PV PLANT SITE LOCATION.

The proposed PV plant site location is located in Matunga, Mumbai-19, Maharashtra, India. Latitude 19° and Longitude 72°. [3] The VJTI Institute has 16 acres, equivalent to 65,000 Sq.-m [4] of land in possession and it comes under the non-forest area, as per the geographical disclosure of institute. Only the rooftop area of various departmental buildings is considered for PV plant design. The site is well connected with Transportation facilities and is located in the Prime Mumbai City of Dadar locality, at a distance of 2 KM, having easy connectivity to central road and railways. The nearest airport to proposed site location is Chhatrapati Shivaji Maharaj International airport at a distance of 12KM. As the proposed site location is situated in Urban area, it doesn't come under any heritage consideration, and doesn't have any redevelopment project in its vicinity which could further affect the generation capacity. Hence there is no difficulty and risk while installing the solar PV Plant which is considered as the most environment friendly and green technology.

Fig-1: PV Plant Location.

3. SELECTION PARAMETER FOR PV PLANT DESIGN.

1. Peak sun Hour (PSH) at proposed location.
2. Average solar irradiation.
3. Offsite Desktop assessment of PV module Shading analysis.
4. Ensure availability of large surface area and suitable roof orientation.
5. The average data of site location, weather conditions from weather at-last webpage.
6. Aerial web base mapping.

7. Power consumption requirement of the Institute.
8. Assessment of Rooftop area.
9. Accessibility of rooftop for easy maintenance purpose.
10. Considering IP-65 enclosure Standard rating for housing inverter facility. [5]
11. Mechanical load on PV structure.

4. SOLAR PHOTOVOLTAIC CONVERSION.

Solar photovoltaic conversion depends on the core construction of the solar cell which is an electronic device that converts the sunlight into electricity. The solar cell consists of semiconductor material silicon which has two junctions called P-type having a shortage of electron and N-type having an excess of electrons. The solar radiation, when falls on the solar cell, energy from light photon enable electron to break free from the junction between them, thus produces both voltage and current to generate electric power. [6] The solar modules are made up of polycrystalline/monocrystalline silicon. The polycrystalline solar PV panel is selected while designing the solar PV plant for proposed site location having an efficiency of 12-14% and durability of 25 years

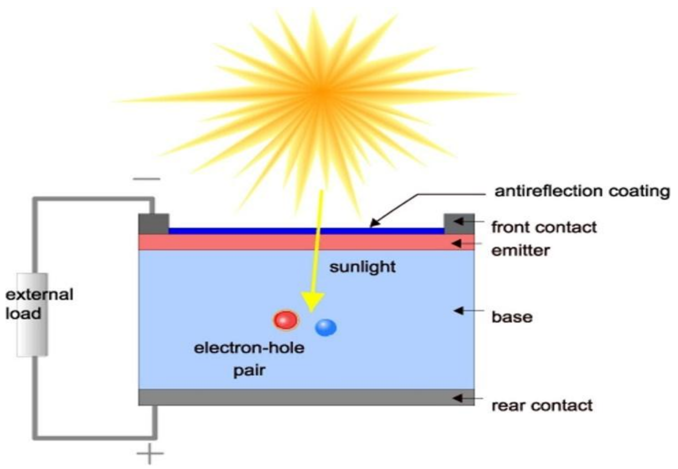

Fig-2: Working of PV Cell, Image Source PVedu.org

5. SOLAR RADIATION MEASUREMENT.

To get the maximum peak output generation from PV module, the determination of solar radiation intensity at the proposed site location was measured in Watt/meter sq. considering the standard test condition of 1000Watt/meter-sq. using a pyranometer device. Pyranometer is the instrument that measures either the global or diffuse radiation in W/m2 falling on an equipment black surface which heats up when exposed to the solar radiation. Following condition, data was observed and collected during practical site assessment. The data was collected in the summers and may vary according to seasonal changes.

Sr.no	Time	Direct Radiation W/sq. m	Diffuse Radiation W/sq. m
1	11:15	703	125
2	11:25	698	135
3	11:35	721	121
4	11:45	703	143
5	11:55	729	153

Table-1: Solar Radiation Data.

Fig-3: Pyranometer Device.

6. COMPONENTS USED IN HELIOSCOPE SIMULATION.

1. PV modules.
2. Solar Inverter.
3. Grid connectivity equipment's.
4. Solar strings.
5. String Protection Tubes.
6. Combiner boxes.
7. Ground mount ballast.
8. Module Cleaning arrangement.
9. Earthing arrangement
10. Net Metering Device.
11. AC Distribution Cables.

7. SOLAR PV MODULE.

Solar photovoltaic modules or panels are referred to as the heart of a solar photovoltaic plant. It is one of the important constitutes which has to be selected very precisely while designing a solar photovoltaic plant. The peak output energy production of any plant depends upon the selection of a specific module according to the generation requirement. Hence selection of Vikram solar Eldora VSP 72 cell 350-Watt

Solar panel is opted and used in the installation of the rooftop while executing the offsite desktop assessment for VJTI campus solar rooftop design. Table-2 gives the specification of the solar PV module under consideration.

Fig-4: Vikram Solar Module, image source Vikram solar.

Table-2: Solar module specification. [7]

Length × width × height	1956 × 992 × 36 mm (77.01 × 39.06 × 1.42 inches)
Weight	19.5 kg (42.99 lbs)
Junction box	IP68/IP67, 3 bypass diodes
Cable & connectors	1200 mm (47.24 inches) length cables, MC4 Compatible/MC4 Connectors/Amphenol
Application class	Class A (Safety class II)
Superstrate.	3.2 mm (0.13 inches) high transmission low iron tempered glass, AR coated.
Cells.	72 Polycrystalline, 5BB solar cells
Cell encapsulant.	EVA (Ethylene Vinyl Acetate)
Back sheet	Composite film.
Frame	Anodized aluminium frame with twin wall profile.
Mechanical load test	5400 Pa (Snow load), 2400 Pa (Wind load)
Maximum series fuse rating.	15 A
Peak power P_{max} (Wp) (0 +4.99Wp)	315
Maximum voltage V_{mpp} (V)	37.5
Maximum current I_{mpp} (A)	8.40
Open circuit voltage V_{oc} (V)	45.8
Short circuit current I_{sc} (A)	8.92
Module efficiency $_{\eta}$(%)	16.23

8. SOLAR INVERTER.

A solar inverter is defined as an electrical converter that changes the DC (direct current) output of a solar panel into an AC (alternating current).

Table-3: Fronius Eco 25, Inverter specification. [8]

Output data	Fronius Eco 25
No of MMPT tracker	1
Max input current	44.2 Amp
Max short circuit current	71.6 Amp
DC input voltage range	580-1000 V
Feed IN start voltage	650 V
No DC connection.	6
Max PV generated output.	37.8 KWp
AC nominal output.	25000W
Max output power.	25000W
Grid connection	380 W
Frequency	50 Hz
Harmonic distortion	< 2%

Fig-5: Fronius Eco 25 inverter.

9. TRANSFORMER.

The transformer is electrical equipment used in the electric power system which transfers the PV plant generated electricity towards the central grid utilities and vice versa. It works on the principle of electromagnetic induction which produces the electromotive force (emf) within the transformer coils. Transformers are of two types, step up and step down which depends upon the number of coils turns in primary and secondary side, to increase and decrease the alternating voltage respectively. [9] At the proposed site location, the power generated by the photovoltaic plant is supplied to Brihanmumbai electric supply and transport undertaking, (BEST) utility grid substation. The table-4 states the standard specification of the transformer's used by (BEST) utility throughout Mumbai city for power distribution.

Table-4: Transformer specification. [10]

Parameter	Data Info
Kva rating	1000 KVA
No of phase	Three both primary and secondary phase
Frequency rating	50 Hz
Primary rated voltage	11 KV phase to phase
Secondary volt. R	415 KV phase to phase
Efficiency	80-90% BIS Std
Cooling.	ONAN
Neutral Terminal	Externally earth.
Insulation Standard.	IS:1180(Part-I)/2014
No of transformer	1

10. DESIGN USING THE HELIOSCOPE SOFTWARE.

The Helioscope simulation software is used for Desktop assessment of designing the entire rooftop for VJTI campus. It is segregated according to the building and roof, which are as follows,

10.1. Rooftop Building- D Humanities Dept.

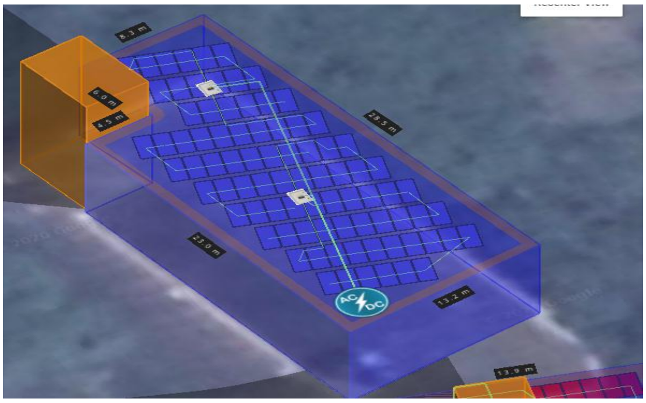

Fig-6: Design Simulation roof -D.

10.2. Rooftop Building – C Non Conventional Lab.

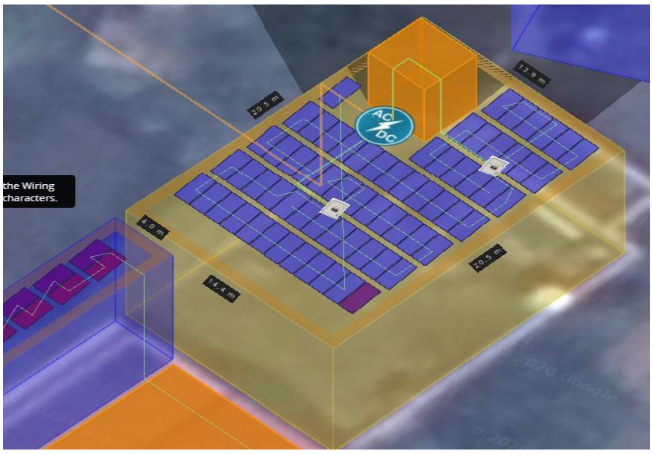

Fig-7: Design Simulation roof -C

10.3. Rooftop Building – C Mech Engineering Dept.

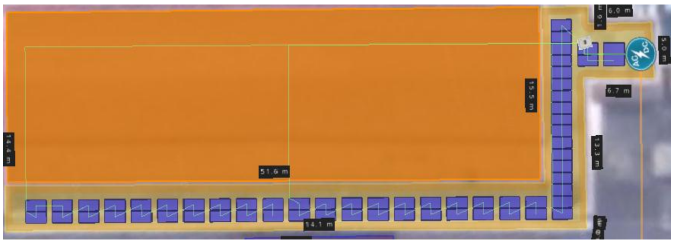

Fig-8: Design Simulation roof -C1

10.4. Roof top building – C opposite to CL 302, Mech Engg Dept.

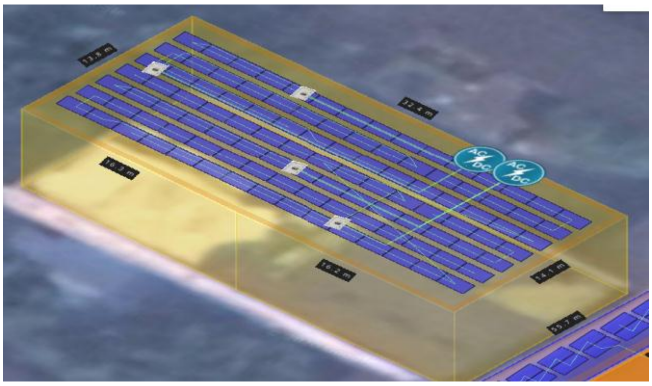

Fig-9: Design Simulation roof -C2.

10.5. Rooftop building – A third floor, Civil Dept.

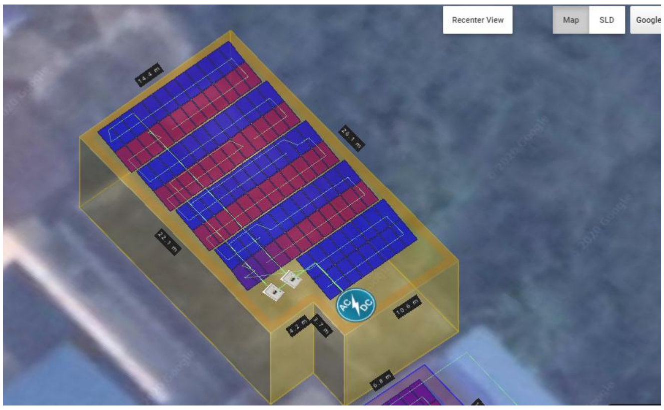

Fig-10: Design Simulation roof -A.

10.6. Rooftop building – A rooftop Electrical Dept.

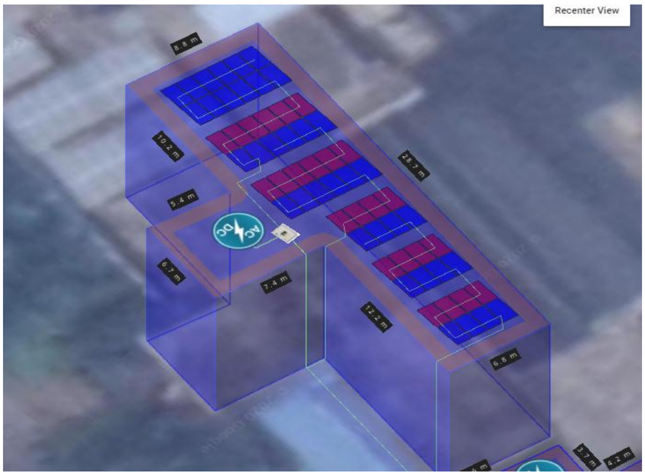

Fig-11: Design Simulation roof -A1.

11. INPUT DATA FOR SIMULATION.

Table-5: Input Data

Data	Parameters.
Number of modules.	474 Nos
Frame size.	2 Up & 1 Dn
Orientation.	Portrait and horizontal.
Row spacing.	0.5 M
Module spacing.	0.05 M
Setback from edges.	1-2 M
Alignment.	Central position.
Azimuth angle.	192.6 degree towards south
Tilt angle module.	10°
Keep out entrance.	0 M
Inverter used.	Fronius Eco 25
Count of inverter.	7 Nos
Combiner boxes.	11 Nos
Home runs string	12 AWG copper 0.2% 758.4 M-sq
Combiner string range.	16-20 Modules.
Solar radiation.	600-700 W/M sq.
Stringing.	Along racking.
Module.	Vikram Solar Eldora 72.

12. RESULT OF SIMULATION.

Table-6: Result obtained from the software simulation.

Data	Parameters.
Total generation capacity.	165.2 KWp.
Ground coverage ration.	0.85 %
Annual production.	243.7 MWh
Plant performance ratio.	77.3 %

12.1. Annual energy estimation of generation.

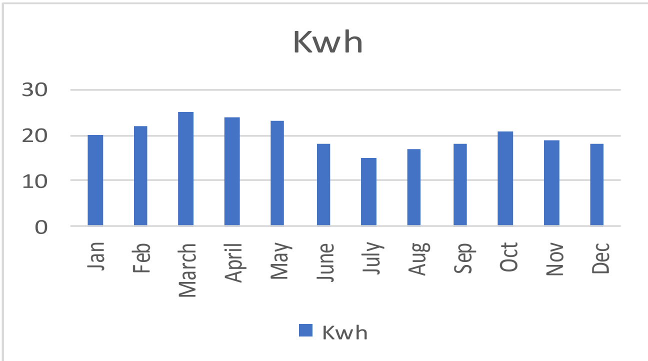

Fig-12: Annual Power Generation

12.2. Sources of system losses.

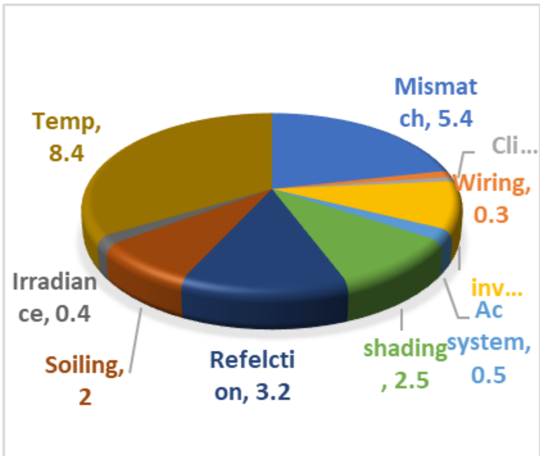

Fig-13: System Losses.

13. PV PLANT COST ESTIMATION.

Table-7: Cost Estimation

Plant Equipment cost	Inverter cost - 2,18,000 INR/Each. Total inverter cost – 15,26,000 INR. Module cost -7000/ module Tot module cost – 33,18,000 INR. Combiner cost – 4000 INR /each Total Combined cost – 44,000 INR. Total string cost – 5,00,000 INR
Total PV Plant Cost	53,88,000 INR

14. CONLUSION.

Making use of Helioscope simulation software, design, and energy estimation of 165KWp solar PV plant was initiated for location of VJTI Campus located at latitude 19° and longitude 72°. Through practical assessment it was found that the solar irradiation for the proposed site was 700Watt/sq-m, which is considered as most efficient radiation to obtain maximum peak generation of electricity from PV module. The plant, performance efficiency ratio of 77.3% was achieved with estimated annual power generation of 273MW. Through analytical calculation the total PV plant initial cost amount is estimated to be 53,88,000 INR.

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