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Building Integrated Photovoltaic Electricity Generating Potential

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Abstract—*The Global energy scenario has undergone a drastic change in the last two decades. The cost of fossil fuels has been destabilized for the gain of empowered economies. Developed countries had already shifted their attention to the research and development of renewable sources of energy especially solar energy. India is endowed with vast solar energy potential. About 5000 trillion Kwh/year energy is incident over India's land area with most parts receiving 4-7 Kwh/sq.m/day. This huge scalability for solar in India can effectively be harnessed by converting solar radiation into electricity i.e. Solar Photovoltaic. The constrain on scalability is the availability of space. This poses the threat to in-situ electricity generation in the high rise concentrated congested cities like Mumbai.*

Researchers have come up new concept of 'Building Integrated Photovoltaic (BiPV)' to counteract this threat. BiPV are photovoltaic panels used to replace conventional building materials (such as glass facades, aluminum panels/ cladding, structural glazing and so on) in parts of the building envelope. Such buildings can use BiPV as a alternate source of energy but also feed electricity to grid.

Mumbai, the economic capital of India is one of the few rapidly and vertically expanding cities in the world. The commercial hub of India, Mumbai is becoming a center for high rise structures.

The primary goal of the study is to evaluate the BiPV potential using software PVSyst.

1. INTRODUCTION

Photovoltaic systems convert light energy directly into electricity providing an interesting bundle of abundant energy source and at the same time environmental preservation, for the good of humanity and our planet[1]. Buildings are major consumers of energy insofar as their construction, operation and maintenance are concerned.

Though this is not very well quantified in India, yet there is ample scope for energy savings[2]. The indoor environments are becoming increasingly important for human comfort and from health point of view. It is estimated that almost 50% of the global energy demand is due to buildings. Thus, the energy conscious architecture has evolved to address these issues[4]. It involves the use of eco-friendly and less energy intensive building materials, incorporation of passive solar principles in building design and operation including daylighting features, integration of renewable energy technologies, conservation of water, waste water recycling, rainfall harvesting and use of energy-efficient appliances in buildings.

India's strategic geographical location enables it to tap the vast potential for solar power generation, with about 300 clear sunny days in a year. By 2050, about 69 percent of the electricity produced in India will come from renewable like solar energy[3]

2. SOLAR RADIATION DATA

Planning of PV power plant requires reliable solar data the solar resource of a location is usually defined by the values of the global horizontal irradiation (GHI) is the total solar energy received on the unit area of horizontal surface. It include energy from the sun that is received by the direct beam and from all directions of the sky the yearly sum of GHI is of particular relevance for PV power plants.

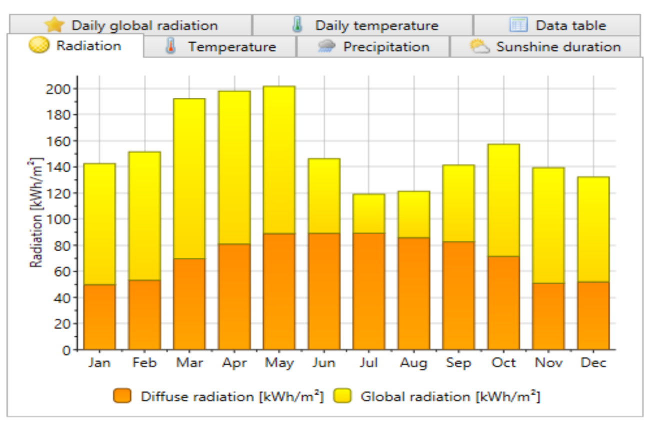

Fig. 1: Monthly Diffuse and Direct Solar Radiation in Mumbai

Global Solar Radiation data of Mumbai city for the past 20 years been obtained from Indian Meteorological Department Pune. Irradiation values are given for a period of a day, a month and year. a high long term avg. annual GHI is evaluated. Average monthly values are important when accessing the energy generated in each month. In terms of irradiation the solar resource is intermittent. In any given year the total annual GHI varies from a long term average due to climatic fluctuations. Fig. 1 shows how the monthly solar irradiation varies over a year at Mumbai.

Geographical location of Mumbai is 19.0759837 latitude and 72.8776559 longitude The annual average solar irradiation in Mumbai is 5.90 kWh/m^2/day. which is ideal for photovoltaic electricity generation.

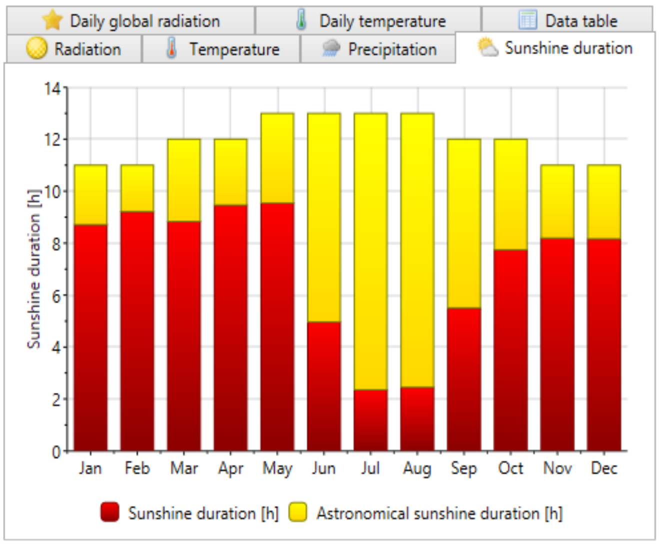

Fig. 2: Sunshine hours in Mumbai

Fig. 2 shows annual bright sunshine hours in Mumbai. Graph shows Mumbai has average 8 hours of bright hours. It satisfies global scenario of ideal requirements of PV energy generation.

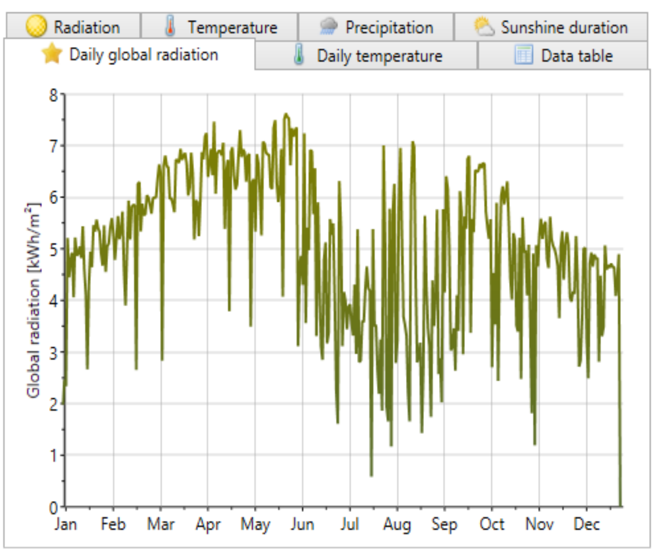

Fig. 3: Daily Global Radiation in Mumbai.

3. COST ANALYSIS

Table 1: Glass Panel Break up cost

Standard Size Of Panel : 1090 mm (Width) X 3503 mm (Height					
Area of Standard Panel : 3.82 Sq. Mtr					
Short Description	**W (mm)**	**H (mm)**	**A (Sqm)**	**Rate**	**Amount**
Aluminum System	1090	3503	3.82	4231	16155.1
Vision DGU Glass Type 1	1062	2072	2.20	2501	5503.36
Vision DGU Glass Type 2	1062	735	0.78	2367	1847.61
Openable	0	0	0.00	8398	0.00
Vision SGU Glass Type 3	1062	612	0.65	1048	681.14
Vision DGU Glass Type 4	0	0	0.00	2367	0.00
Gi Tray Spandral Insulation	1062	612	0.65	1252	813.73
COST OF ONE STANDARD PANEL					25000/-

Table 2: Solar Panel Break up cost

Sr. No.	Material BOM	Qty	
1	HIT 240 Wp solar module	1 nos	17280
2	MC4 Connector	1 pair	150
3	DC cable	30M	1800
4	solar mounting structure	15Kg	2000
5	structure fastners	1 set	100
		Sub Total	21330
		Installation @ 2% to 5%	1066
		Total	22396/-

Table 1 shows per glass panel cost as Rs. 25000/-. whereas table 2 shows installation cost of one 240 watt solar panel as Rs 22396/- (excluding inverter cost).

1 kWp of solar system normally requires 0.8 kWp inverter which cost around Rs 25000/-. Including inverter cost, per solar panel cost increases to Rs 47396/-

Standard assumptions shows that 1 kWp solar system generates 1700 units. In case of building integrated photovoltaic, modules are installed at 90^0 inclination. whereas roof top modules can be installed south facing with respective latitude. That's why roof top system is always energy convenient than building integrated.

Building integrated has constraint of module orientation. 90^0 module orientation 1 kWp BiPV system generates 1000 units against 1700 units of roof top system. Literature review shows that 1 unit of electricity generally costs Rs 7. So BiPV system produce Rs. 7000 electricity per annum.

Initial investment in BiPV may be high but considering the fact that system reduces the conventional grid electricity load and can also contributes to local grid developers and architects paradigm is shifting towards BiPV. Energy payback time of BiPV system is 8 to 9 years, after that initial investment becomes zero and BiPV system can be a profitable venture after Energy payback time.

4. PVSYST SIMULATION

Given future scenarios, renewable energy sources, in particular photovoltaic technology, will develop quickly. This has to be done in a sustainable way using the best technical economical solutions.

It is essential to develop PV technology in an optimal and reliable way. Pursuing this objective, the PVsyst software is a tool that allows to accurately analyze different configurations and to evaluate the results and identify the best solution.

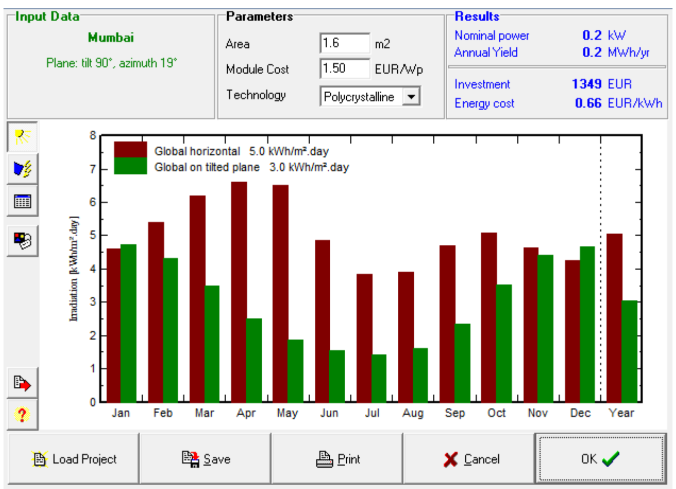

Fig. 4: Simulation output for a solar panel.

PVsyst simulation has been run for one panasonic 230 Wp 36 V HIT module no. VBHN230SE51 solar panel. Data feed to simulation is area exposed to sunlight as 1.6 m^2 with 90^0 orientation and azimuth 19^0. After running preliminary simulation results shows that as annual yield from one solar panel is 0.2 MW per year against the investment of Rs. 91313/- and energy cost as Rs. 45 per kWh.

5. CONCLUSION

Solar energy resource is rich in mumbai a good policy and planning from government can help local industry to use BiPV for electricity production. the electricity from BiPV system can contribute to one third of the total electricity supply if most of the buildings are integrated with PV modules for electricity generation. The price of BiPV electricity is quite higher than conventional. In coming future most government policies are favoring renewable energy production is likely to reduce solar module cost which can lower BiPV electricity cost in future.

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