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Assessment of Solar Energy Potential on Rooftops using GIS for Installation of Solar Panels: A Case Study

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Abstract

The objective of this study is to assess the potential of solar energy in a typical building using Geographic Information System (GIS). It also presents the detailed steps required to install solar panels on rooftops of building after assessment. The three step methodology has been adopted. In the first step, solar energy harvesting potential is determined followed by the calculation of electric energy demand in the area. Secondly, the capacity of solar panels and machines are worked out and installation details are calculated. This is followed by the final step of cost-benefit estimation. For a rooftop area of around 6840 m^2 and weekly AC/DC machine demand of 50 kWh, it was proposed to install 279 solar panel modules. The total capacity of solar power was worked out to be 69.75 KWp with specified production of 1571 KWp/KWh/year. The use of GIS brought down the time and effort and dependability on blue prints of building plan for calculating the study area. Solar power has the flexibility that it can be used anywhere and everywhere. Though the initial set up of solar power generation is costly, it is a viable solution for sustainable operation of the building.

Keywords: Geographic Information System, Solar Energy Potential, Solar Panels

1. Introduction

Consumption of non-renewable resources on large scale in order to meet the increasing demand of human race is creating a stress on the available resources. Moreover, this is polluting the environment thus making it unsustainable. In order to reduce this stress, the use of natural and renewable sources of energy is being advocated for environmental friendly solutions. The energy retrofitting of buildings is in demand for promoting green and clean technology[1,2].

Energy conscious buildings involves the use of eco-friendly and less energy intensive materials, incorporation of passive solar techniques (including day lighting features) and integration of renewable energy technologies[3,4]. It also includes

conservation of water and waste water recycling, rainfall harvesting and the use of energy-efficient appliances in buildings. With the increase in standards of living, the consumption of energy in buildings is progressively rising. The explosion in building sector is going to create further demands, resulting in greater pressure on the energy supply situation. In this context, the conservation of energy in buildings through appropriate construction, operation and maintenance practices assume prime importance. In order to meet this increase in demand of energy, many countries having limited land resources and rising demands are already on the lookout for alternative sources and innovative methods of energy conservation.

The National Institute of Solar Energy in India has reported the solar power potential of country as 750 GW[5]. However, the current solar power installed in India is less than 0.5% of the estimated potential. There is a massive opportunity to tap the solar power. Geographical information system (GIS) can be used to estimate the potential of tapping solar energy in a building or at a larger scale.

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This paper presents the detailed steps required to install solar panels on rooftops of buildings by assessing the potential of solar energy using

Geographic Information System (GIS). The calculation includes the computation of area of rooftop using GIS, estimate for weekly AC/DC heaps of the machines as per the requirement in the study area, installation of solar panels and estimation of the cost involved.

2. Study Area and Data Used

The study has been carried out for a school building in NOIDA, India. The school is located in a wide-spread green open space of 60 acres and receives good amount of sun light during the day. The rooftop is relatively empty with major construction in the form of water tanks. This makes the rooftop as ideal place for solar panel installation.

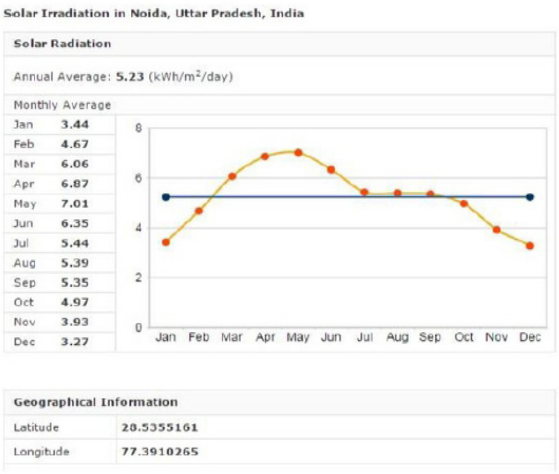

Figure 1. Graph showing solar radiation over NOIDA, Uttar Pradesh.

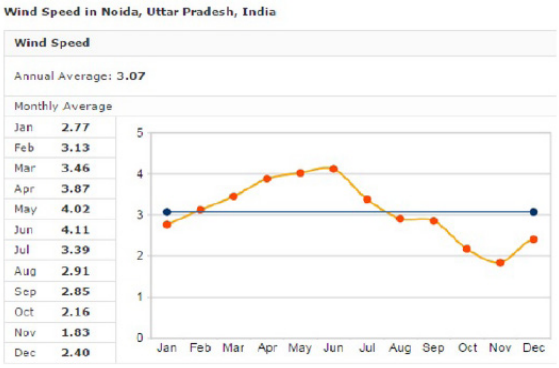

Figure 2. Graph showing the variation of wind speed over NOIDA, Uttar Pradesh.

The average solar radiation per year and rainfall received by NOIDA is 5.23KW/m²/day[6] and 792.4mm respectively[7]. Figure 1 and 2 depicts the solar radiation and average wind speed over NOIDA.

3. Methodology

Figure 3 depicts the steps carried out for the study. After earmarking the study area, the data of existing electricity consumption was carried out for benchmarking the project. The available rooftop area was calculated using GIS as a tool[8]. With the input of electricity consumption, the weekly AC/DC loads of appliances were calculated. The proposal for setting up of solar power plant was then detailed out. Finally, the cost of setting of rooftop solar panel was calculated.

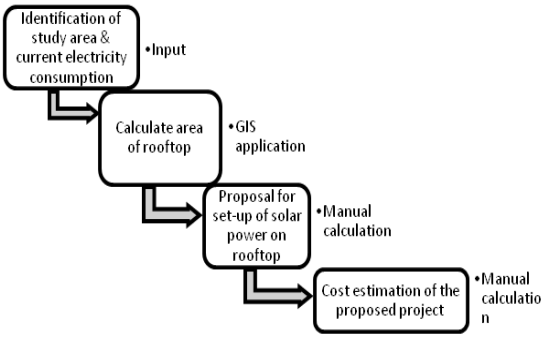

Figure 3. Study methodology.

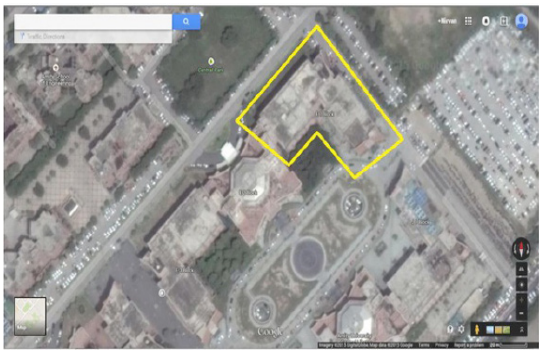

Figure 4. Satellite image of engineering block.

3.1 Calculation of Area over the Roof

The satellite image of the school (Figure 4.) was extracted from the Google Earth and digitized. The image was then

Table 1. Weekly AC/DC loads of appliances

Dc Loads	Quantity	Watts	Hours Of Operation	Days/ Week	Weekly Demand
Lights	8	40	8	5	12800
P.L. Lights	2	11	2	5	222
Computer	4	200	4	5	8000
Projector	1	300	3	5	4500
Microwave	1	800	2	5	8000
Refrigerator	1	300	3	7	16800
				Weekly AC Loads	50320

exported as shape file. The shape file was then imported in GIS software for analyzing and finding the area of the rooftop where the solar panels could be installed.

3.2 Present Energy Consumption

The estimate for weekly AC/DC heaps of the machines of the school building is tabulated in Table 1.

3.3 Proposed Set-Up of Solar Power Project

The sun based board made of polycrystalline is used based on specification parameters namely assembling, wattage, size, outline material and productivity. The configuration can be concluded after computation of wind burdens, stress investigation and tipping examination. Photovoltaic solar power plant is proposed at aspect of 28.5 degrees North and 77.3 degrees East. Main parts of plant with capacity of 1001 KW are solar panel mounts and anchoring system. The design of mount, trusses and laying of solar panels is carried out in step by step manner. The capacity of solar panel is 240 Watt and weight of each solar panel is 16 kg/m^{29}. The surface is cleaned for laying the foundation of panels based

on weights of panel and truss loads. The concrete block foundations are laid at the base of the footing of the truss. Solar panels are then fixed to the trusses brackets. Inverters are connected to main supply and are fitted to panels for energy transfer and storage. At the end, inspection of connections and integrations of power supply to the grid is carried out. The benchmark energy generated from a 1 MW solar plant is 1.5 million units. The energy generation in solar power depends on number of sunny days in a year, day temperature, air mass.

3.4 Cost Estimation

Solar power plants on roof can be divided into Battery based or Non-battery based systems. The benchmark cost set by MNRE is Rs. 90-100 per KW for battery systems and Rs. 170-210 per KW for non battery systems.

The total project cost for school for 1 MW solar power is tabulated in Table 2.

Table 2. Solar power benchmark cost

S.No.	Particulars	Capital cost norm for Solar PV project (Rs. Lakh/MW)	Total cost (%)
1	PV Modules	365.8	52.9
2	Mounting Structures	50	7.23
3	Land Cost	25	3.6
4	Additional Module Cost	11.29	1.63
5	Civil and General works	60	8.7
6	Power Conditioning Unit	50	7.23
7	Evacuation cost up to Interconnection Points (cables and transformers)	60	8.7
8	Preliminary (IDC, contingency)	69	9.98
	Total Capital Cost	691	100

4. Results

The area of the rooftop for installation of solar panels was found to be 6840 m^2 (approx.). The calculation of area was done with the help of GIS. The area was used for the installation of solar panels on school block. As per the demand, 279 solar panel modules were required. The total capacity of solar power is 69.75 KWp and specified production of 1571 KWp/KWh/year.

5. Conclusion

In this paper, the installation of solar panels on rooftops is proposed to reduce the energy consumption from the non renewable sources. Use of GIS brought down the time and effort and dependability on blue prints of building plan for calculating the study area. Solar power has the flexibility that it can be used anywhere and everywhere. The work was carried out in a school building with an aim to cater to the electricity demand through the solar power. It was concluded that the initial set up of solar power generation is costly but it is a viable solution for sustainable operation of the building.

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