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Greening Academia: A Proposal for Implementation of Solar Power Plant in Academia

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Abstract: The rising demand for clean energy solutions has spurred the exploration of solar power integration in various sectors. This study investigates the feasibility of replacing the grid-based power source for the Academic block in Y.S.R. Engineering College of YVU, Proddatur, Andhra Pradesh with a solar photovoltaic (PV) system. A comprehensive analysis was conducted, encompassing power load calculations, solar panel requirements based on available space, economic evaluation of the system, and greenhouse gas emission reduction estimation. The results indicate that the proposed solar PV system can meet the college building's energy needs. The economic analysis reveals a positive result like a favorable payback period, and cost savings within a reasonable timeframe. It also demonstrates the project's financial viability. This study suggests that solar power presents a compelling solution for the college, promoting energy independence, cost-effectiveness, and environmental sustainability.

Keywords —Academia, Solar Power Plant, Solar Energy, Carbon Emission Savings, Power Load, Greenhouse gas emissions.

I. INTRODUCTION

Today, every country draws its energy needs from a variety of sources such as conventional and non-conventional energy. The commercial sources include the fossil fuels (coal, oil and natural gas), hydroelectric power and nuclear power, while the non-commercial sources include wood, animal waste and agricultural wastes.

Non-conventional energy sources, also known as renewable energy sources, are those that are naturally replenished and have a significantly lower environmental impact compared to conventional fossil fuels like coal, oil, and natural gas. These energy sources play a crucial role in mitigating climate change, reducing greenhouse gas emissions, and ensuring energy security

A solar cell, also known as a photovoltaic cell (PV cell), is an electrical device that directly converts light energy into electrical energy using the photovoltaic effect.

II. LITERATURE REVIEW

Smith, J., and Johnson, A., [1] studied a detailed examination of solar photovoltaic (PV) systems within educational institutions. Through a series of case studies, various aspects including initial investment costs, operational savings, and the long-term financial sustainability associated with the implementation of these systems have been analyzed.

Brown and Garcia [2], Almasri et.al., [3] conducted a comparative analysis of solar integration projects in multiple higher education institutions. Their study gives a financial viability of such projects by evaluating key economic metrics including return on investment (ROI), payback period, and net present value.

Martinez et al. [4] review of solar energy systems in college academic buildings emphasizes the considerable environmental and economic advantages linked with the adoption of solar energy within educational institutions. Specifically, it underscores the substantial reduction in carbon emissions and operational cost savings achieved through solar integration, shedding light on the potential economic benefits for colleges embracing renewable energy technologies.

The study of Maryam et.al., [5] aims to understand energy use characteristics of different types of buildings in higher education campuses and to establish an energy benchmark system [6]. By leveraging these insights, colleges and similar educational entities can navigate the complexities associated with implementing solar energy projects effectively, thus facilitating sustainable energy integration within academic environments.

This literature survey provides a snapshot of relevant studies and research areas related to the economic analysis of solar integration in college academic blocks. It encompasses various aspects such as financial viability, environmental benefits, barriers to adoption, and social impacts, and perspectives for this project.

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III. ACADEMIC COMPLEX DETAILS

The academic complex is a four storied building consisting of the following spaces and the rooftop area available is 850 m².

The spaces and their details are:

1. **Classroom (Type 1):**
   - Number: 8
   - Operating Hours: 9:30 AM to 4:30 PM (6 days a week)
   - Appliances used:
     - Fans: 6 x 55 Watt
     - Ceiling Lights (Type 1): 8 x 30 Watt
     - Projector: 1 x 150 Watt
2. **Classroom (Type 2):**
   - Number: 6
   - Operating Hours: 9:30 AM to 4:30 PM (6 days a week)
   - Appliances:
     - Fans: 6 x 55 Watt
     - Ceiling Lights (Type 1): 8 x 30 Watt
3. **Classroom (Type 3):**
   - Number: 7
   - Operating Hours: 9:30 AM to 4:30 PM (6 days a week)
   - Appliances:
     - Fans: 6
     - Ceiling Lights (Type 1): 6
4. **Seminar Hall:**
   - Number: 1
   - Operating Hours: 6 hours every week
   - Appliances:
     - Fans: 8
     - Ceiling Lights (Type 1): 6
     - Projector: 1
     - A.C (2 ton): 4 x 1820 Watt
     - A.C (1.5 ton): 1 x 1560 Watt
5. **Office:**
   - Number: 3
   - Operating Hours: 9:30 AM to 4:30 PM (6 days a week)
   - Appliances:
     - Fans: 6
     - Ceiling Lights (Type 1): 6
     - Computers: 3 x 300 Watt
     - Printer: 1 x 150 Watt
     - A.C (2 ton): 1
6. **Library:**
   - Number: 1
   - Operating Hours: 7:00 AM to 7:00 PM (6 days a week)
   - Appliances:
     - Fans: 8
     - Ceiling Lights (Type 1): 12
     - Computers: 6
     - Printer: 1
7. **Laboratories:**
   - *Type 1:*
     - Number: 1
     - Operating Hours: 9 hours per week
     - Appliances:
       - Fans: 8
       - Ceiling Lights (Type 1): 6
       - Computers: 1
       - Laboratory Equipment type 1: 1 x 1000 Watt
   - *Type 2:*
     - Number: 1
     - Operating Hours: 30 hours per week
     - Appliances:
       - Fans: 8
       - Ceiling Lights (Type 1): 6
       - Computers: 2
       - Laboratory Equipment type 2: 2 x 1500 Watt
   - *Type 3:*
     - Number: 2
     - Operating Hours: 30 hours per week
     - Appliances:
       - Fans: 8
       - Ceiling Lights (Type 1): 6
8. **Lobby:**
   - Number: 4
   - Operating Hours: 9:30 AM to 4:30 PM (6 days a week)
   - Appliances:
     - Water Cooler: 1 x 190 Watt
     - Ceiling Lights (Type 2): 1
9. **Corridors:**
   - Number: 4
   - Operating Hours: 24/7
   - Appliances:
     - Ceiling Lights (Type 1): 4
     - Ceiling Lights (Type 2): 7
10. **Restrooms:**
    - Number: 16
    - Operating Hours: 9:30 AM to 4:30 PM (6 days

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a week)

- Appliances:
  - Ceiling Lights (Type 2): 4
  - Exhaust Fans: 2 x 25 Watt

11. **Stairwells:**

- Number: 8
- Operating Hours: 24/7
- Appliances:
  - Tube lights: 2 x 20 Watt

12. **Building Entrance:**

- Number: 1
- Operating Hours: 24/7
- Appliances:
  - Tube lights: 2
  - Flood light: 2 x 50 Watt

13. **CCTV Setup** (server included):

- Number: 1 (for entire building)
- Operating Hours: 24/7
- CCTV Set up: 1 x 350 Watt.

IV. Load Calculations

In a working day of 8 hours, the energy Consumption = 301869 Wh ≈ 302 kWh

The energy consumption for each type of room/space on a non-working day:

1. **Corridors:**

- Ceiling Lights (Type 1): 4 * 30 Watts = 120 Watts
- Ceiling Lights (Type 2): 7 * 12 Watts = 84 Watts
- Total: 120 + 84 = 204 Watts

Energy consumption = 204 watts * 24 hours *4(spaces) = 16416Wh

2. **Stairwells**:

- Tube lights: 2 * 20 Watts = 40 Watts

Energy consumption = 40 Watts * 24 hours *8(spaces) = 7680Wh

3. **Building Entrance**:

- Tube lights: 2 * 20 Watts = 40 Watts
- Flood light: 2 * 50 Watts = 100 Watts
- Total: 40 + 100 = 140 Watts

Energy consumption = (40 Watts + 100 Watts) * 24 hours = 3360Wh

4. **CCTV Setup** (server included):

- CCTV Setup: 350 Watts

Energy consumption = 350 Watts * 24 hours = 8400Wh

Total energy Consumption on a non-working day = 35856Wh ≈ 36 kWh.

Power load for one month:

Considering, a month contains 26 working days and 4 non-working days

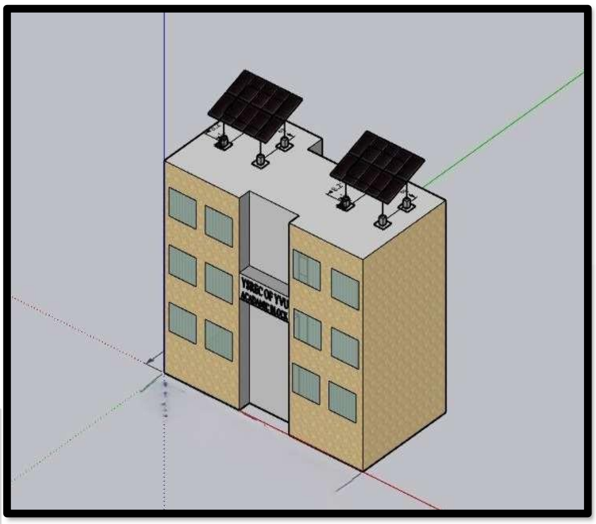

Fig. 1. Schematic of Academic Building and rooftop Solar Panel set up

Total Energy Consumption for 26 working days = 7848594 Wh≈ 7848.594 kWh

Total Power Load for 4 Non-Working Days = 143424 Wh ≈ 143.424 kWh

Total Power Load for the Month = 7992.018 kWh

Rounding off the power load for a month ≈ 8000 kWh

So, the total power load for the entire month, considering both working and non-working days, is approximately 8000 kWh.

V. Design of Rooftop Solar Power Plant

We consider the following essential components while setting up the Solar power plant. The schematic of the Academic building and rooftop solar panel setup is shown in the Fig.1. The components needed to install the power plant is shown below and schematic is shown in the Fig.2.

- Solar panel
- Solar inverter
- Cables
- MCB and Other accessories
- Structure
- Earthing
- Installation
- Transportation and handling.

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Rooftop solar power Essentials

The list of components required for setting up a solar power plant on a rooftop:

1. Solar Panels

Solar panels, also known as photovoltaic (PV) panels, are the primary components of a solar power system. They convert sunlight into electricity through the photovoltaic effect, where photons from sunlight knock electrons free from atoms, generating an electric current.

There are several types of solar panels, each with its own advantages and characteristics:

1.1 Monocrystalline Solar Panels: Made from single-crystal silicon, monocrystalline panels are known for their high efficiency and sleek appearance. They have a uniform dark colour and are space-efficient, making them ideal for installations with limited space.

1.2 Polycrystalline Solar Panels: Polycrystalline panels are made from multiple silicon fragments melted together. While slightly less efficient than monocrystalline panels, they are more cost-effective to produce and offer good performance in a variety of conditions.

1.3 Thin-Film Solar Panels: Thin-film panels are made by depositing thin layers of semiconductor materials onto a substrate, such as glass, metal, or plastic. They are lightweight, flexible, and often used in applications where traditional rigid panels are not suitable, such as on curved surfaces or portable solar chargers. However, they typically have lower efficiency compared to crystalline silicon panels.

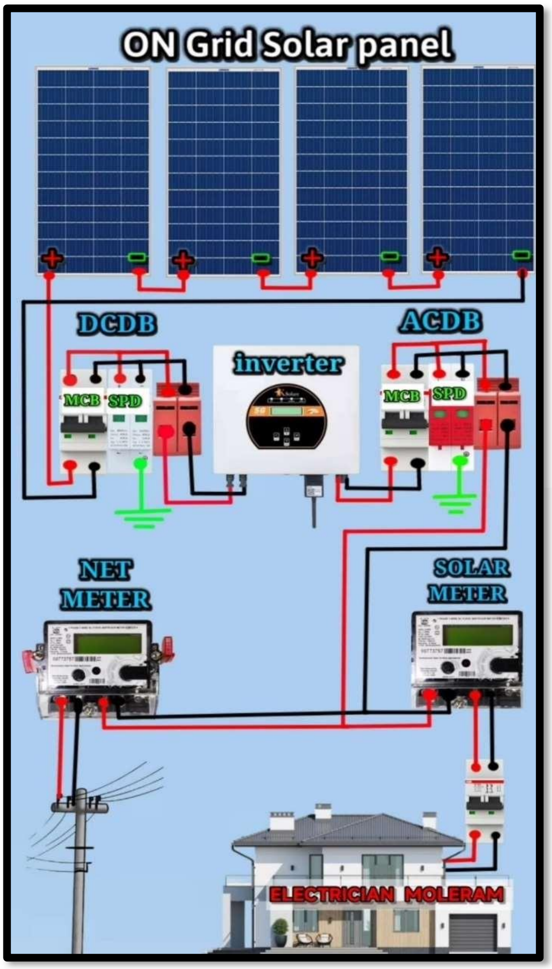

Fig.2.Ongrid Solar Panel

1.4 Bifacial Solar Panels: Bifacial panels can generate electricity from both the front and back sides, capturing sunlight reflected off surfaces such as the ground or nearby buildings. They can provide higher energy yields, especially in locations with high albedo (reflectivity), but may require specialized mounting systems to take full advantage of their dual-sided design.

Each type of solar panel has its own set of characteristics, costs, and applications. The choice of panel type depends on factors such as available space, budget, efficiency requirements, and installation conditions.

2 Mounting Structure

The mounting structure is a critical component of a rooftop solar power system. It serves as the framework that supports and secures the solar panels in place on the rooftop. The mounting structure plays several key roles.

2.1 Support and Stability: The mounting structure must be strong and stable enough to support the weight of the solar panels and withstand various environmental factors, including wind, snow, and seismic loads.

2.2 Optimal Orientation: Proper orientation and tilt angle of the solar panels are essential for maximizing sunlight exposure and energy production. The mounting structure allows for adjusting the tilt angle and orientation of the panels to optimize their performance based on factors such as geographic location, time

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of year, and shading.

2.3 Roof Compatibility: The mounting structure must be compatible with the rooftop's material and design.

2.4 Ventilation and Cooling: Adequate airflow around the solar panels is essential for maintaining their efficiency and longevity.

2.5 Ease of Installation and Maintenance: The mounting structure should be designed for ease of installation and maintenance, with components that are straightforward to assemble, adjust, and access.

2.6 Durability and Weather Resistance: The mounting structure should be made from durable materials that can withstand exposure to sunlight, moisture, temperature fluctuations, and other environmental factors over the system's lifespan.

3 *Inverter*

The inverter is a vital component of a solar power system, responsible for converting the direct current (DC) electricity generated by the solar panels into alternating current (AC) electricity that can be used to power household appliances, electronics, and other devices. Here are some key aspects of inverters:

DC to AC Conversion: Solar panels produce electricity in the form of direct current (DC), but most household appliances and the electrical grid operate on alternating current (AC). The inverter converts the DC electricity from the solar panels into AC electricity, making it compatible with the electrical grid and usable in homes and businesses.

4 *Electrical Wiring and Components*

Electrical wiring and components are crucial aspects of a solar power system, responsible for safely and efficiently connecting various elements of the system, including solar panels, inverters, batteries (if applicable), and the building's electrical system.

Considering an additional 15% power load for rendering power load calculation for designing solar panel grid the total power load is approximately 9200 kWh per month.

According to data given by the Solar on grid Power Systems Service provider, the space required for installation of a rooftop solar power system is 7000 sqft shadow free area. Power generated by 1kW solar panel per day is 4 kWh. Hence, a 80kW Solar power plant is enough for our Power load of the college academic block. For installing solar panels with power rating of 80kW it requires 7000 ft² shadow free area

VI. Budget Estimation of Plant and Breakeven Analysis

Power bill for one month of a building would be Rs. 72,000 for 8000 kWh at the rate of Rs. 9 per kWh. (8000 kWh * Rs 9/kWh). If we go for rooftop solar power plant, budget estimation is as follows.

Budget estimation for Rooftop solar power system:

According to data given by the Solar grid Power Systems Service provider.

The cost of each equipment and components while setting up the Solar power plant is like

Solar panel	₹27-₹29/Watt
Solar inverter	₹7-₹9/Watt
Cables, MCBs and Accessories:	₹6-₹7/Watt
Structure, earthing, etc	₹9-₹10/ Watt
Installation	₹2-₹3/ Watt
Transportation and handling	₹1.5/-₹2/ Watt
Tax is applicable (G.S.T)	18%

Considering average costs, total costs for 80,000 Watt are:

Total cost of solar panels = 80,000 Watts × ₹28/Watt
Total cost of solar panels = ₹2,240,000

Cost of solar inverter = ₹640,000

Cost of cables, MCBs, Accessories = ₹520,000

Cost of structure, earthing, etc = ₹760,000

Cost of installation = ₹200,000

Cost of transportation and handling = ₹140,000

Total cost including taxes = ₹4,500,000 + ₹810,000

Total cost including taxes = ₹5,310,000

The estimated total cost for installing an 80kW solar panel system, including taxes, based on the provided data, is approximately ₹5,310,000.

Since the plant warranty is 12 years and the payback period will be 5.65 years the remaining period of 6.35 years, we can save the money and also generate some revenue out of the plant.

Carbon Emission Savings:

In an environmental perspective, we can save carbon emissions from this solar power plant up to 59.85 tonnes per year.

The total emission savings over each period are determined:

- Emission savings (1 year) = 108,000 kWh * 552 gCO_2e/kWh = 59,856,000 gCO_2e= 59.85 tonnes
- Emission savings (10 years) = 1,080,000 kWh * 552 gCO_2e/kWh = 598,560,000 gCO_2e = 598.56 tonnes
- Emission savings (25 years) = 2,700,000 kWh * 552 gCO_2e/kWh = 1,486,800,000 gCO_2e = 1,486.8 tonnes of CO_2 equivalent

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VII. Conclusion

The proposal for implementing a solar power plant in Y.S.R. Engineering College of YVU Academic Complex represents a significant opportunity to embrace sustainable energy solutions and promote environmental responsibility. Through a comprehensive analysis of energy resources, solar cell technologies, and load calculations for the college academic complex, it has become clear that integrating solar energy is both feasible and advantageous.

By detailing the installation requirements and costs, as well as conducting breakeven analyses between conventional methods and solar rooftop installation, it has demonstrated the economic viability and long-term benefits of transitioning to solar power. The Emission Savings Analysis Report further highlights the positive impact on reducing carbon emissions and mitigating environmental harm.

By considering plant warranty of 12 years, the payback period will be 5.65 years and the remaining period of 6.35 years, we can save the money and also generate some revenue out of the plant.

This proposal, not only addresses the energy needs of the college but also sets a precedent for sustainable practices within educational institutions. By harnessing renewable energy sources like solar power, not only reduces the carbon footprints but also contribute to a cleaner and healthier environment for current and future generations.

By embracing this proposal, we can lead by example and inspire others to follow suit in adopting renewable energy solutions to educational institutions.

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