

Solar Tree Installation in Campus

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Abstract – The Solar Tree is an innovative structure designed to harness solar energy efficiently while occupying minimal ground space. It represents a modern solution to the increasing global energy demand and the limitations of conventional solar panel installations that require large land areas. The solar tree structure mimics the form of a natural tree, where each branch supports a solar photovoltaic (PV) panel that functions as a “leaf” to capture sunlight and convert it into electrical energy. This concept integrates technology with nature, promoting sustainable and eco-friendly power generation. In this project, a solar tree is designed and installed within the campus to demonstrate the practical application of renewable energy. The system consists of three 12 V, 20 W solar panels connected in parallel to maintain the desired voltage while increasing the current output. The generated power is regulated through a 12 V, which charges a 12 V, 6 Ah battery. The stored energy is then utilized to operate 2x 36W Flood lighting and other low-power devices, especially during nighttime. This project aims to create awareness about renewable energy among students and encourage the adoption of green technologies. It also supports India’s mission toward clean and sustainable energy development by showcasing an efficient, space-saving solar solution that combines engineering innovation, environmental responsibility, and aesthetic appeal.

Key Words: *solar tree, Solar Panels, Battery, MCB*

1. INTRODUCTION

In the present era of rapid industrialization and urbanization, the demand for electrical energy is increasing at an alarming rate. Conventional energy sources such as coal, oil, and natural gas are not only depleting rapidly but also causing severe environmental problems like global warming, air pollution, and ecological imbalance. Therefore, there is an urgent need to shift towards clean and renewable sources of energy. Among various renewable options, solar energy is the most promising, abundant, and inexhaustible source available to mankind. India, being a tropical country, receives an average solar radiation of about 4–7 kWh/m² per day for nearly 300 sunny days annually, which makes it highly suitable for solar energy utilization. However, one of the major limitations of conventional solar installations is their requirement of large land area.

In densely populated or space-limited areas such as educational campuses, residential complexes, or urban localities, becomes difficult to allocate wide open spaces for mounting solar panels. To overcome this limitation, the concept of a Solar Tree has been introduced. A solar tree is an innovative and compact design where multiple solar panels are mounted on a single vertical structure, resembling the branches and leaves of a natural tree. This arrangement allows maximum utilization of vertical space and minimizes the shadow effect between panels, thus improving overall system efficiency. The solar tree not only generates clean energy but also adds an aesthetic and educational value to its surroundings. It symbolizes the integration of technology with nature — just as a real tree converts sunlight into food through photosynthesis, a solar tree converts sunlight into usable electrical energy. In this project, a solar tree has been designed and installed in the campus to demonstrate the practical application of solar energy in a small-scale, space-saving form. The system uses three 12V, 20W solar panels connected in parallel to maintain a constant voltage and increase current capacity, charging a 12V, 36Ah battery through a solar charge controller. The stored energy is used to power LED lights or other small electrical loads, especially during evening hours. This project serves multiple objectives promoting renewable energy awareness, demonstrating sustainable engineering practices, and contributing to energy conservation. It provides students with practical exposure to solar photovoltaic systems, battery management, and load integration.

2. OBJECTIVES

The development and implementation of Solar Trees are driven by a set of clear objectives, aiming to revolutionize how we generate and utilize green energy, especially in contexts where traditional solar solutions face constraints. These objectives encompass technological, environmental, economic, and societal aspects:

1. **Maximize Energy Generation in Limited Space:** To develop solar tree designs that efficiently capture solar energy in a compact, vertical footprint, significantly reducing land requirements compared to conventional ground-mounted solar farms. This is particularly crucial for urban areas and densely populated regions like Chandrapur, Maharashtra.

2. Enhance Aesthetic Integration: To create visually appealing and architecturally harmonious solar structures that seamlessly blend into various environments, including public parks, urban landscapes, commercial spaces, and residential areas, overcoming the visual impact often associated with large solar arrays.

3. Promote Renewable Energy Awareness and Adoption: To serve as visible symbols of sustainable technology, raising public awareness about renewable energy and encouraging its wider adoption through interactive designs and educational features.

4. Increase Energy Efficiency through Biomimicry: To leverage biomimetic principles, such as spiraling phyllotaxy (arrangement of leaves on a stem), to optimize panel orientation and minimize self-shading, thereby maximizing sunlight absorption throughout the day and increasing overall energy yield.

5. Enable Multi-Functional Capabilities: To integrate additional functionalities beyond pure energy generation, such as LED lighting for public spaces, Wi-Fi hotspots, EV charging stations, seating areas, and even rainwater harvesting or vertical gardens, transforming them into valuable urban amenities.

3. SOLAR TREE

A solar tree is a decorative means of producing solar energy and also electricity. It uses multiple no of solar panels which forms the shape of a tree. The panels are arranged in a tree fashion in a tall tower/pole.

TREE stands for

T= TREE GENERATING

R=RENEWABLE

E=ENERGY and

E=ELECTRICITY

This is like a tree in structure and the panels are like leaves of the tree which produces energy. As we know trees are present in nature and they can produce their own food material by the process called PHOTOSYNTHESIS. It is the process by which the green plant collects energy from sun and the water present in soil at the day time and can produces their own food material. By this process they are indirectly providing food to the human society because we are depending on the green plants for our food directly or indirectly. Here we are considering the example for understanding about the solar tree. This is a tree in which the stems connected acts as the branches of the tree and the solar panels are like the leaves. Green leaves are producing food materials for human beings likewise this leaves are producing energy forthe society. So it is very appropriate to called it as a tree. It is a technique used in designing of solar tree. it provides the way to help the lower panels from the shadow.



Fig 1. Natural tree and Solar tree

4. HOW SOLAR CELL WORKS

A solar cell (photovoltaic cell or photoelectric cell) is a solid state electrical device that converts the energy of light directly into electricity by the photovoltaic effect. The energy of light is transmitted by photons-small packets or quantum of light. Electrical energy is stored in electromagnetic fields, which in turn can make a current of electrons flow. Assemblies of solar cells are used to make solar modules which are used to capture energy from sunlight. When multiple modules are assembled together (such as prior to installation on a pole-mounted tracker system), the resulting integrated group of modules all oriented in one plane is referred as a solar panel. The electrical energy generated from solar modules, is an example of solar energy. Photovoltaic is the field of technology and research related to the practical application of photovoltaic cells in producing electricity from light, though it is often used specifically to refer to the generation of electricity from sunlight. Cells are described as photovoltaic cells when the light source is not necessarily sunlight. These are used for detecting light or other electromagnetic radiation near the visible range, for example infrared detectors, or measurement of light intensity

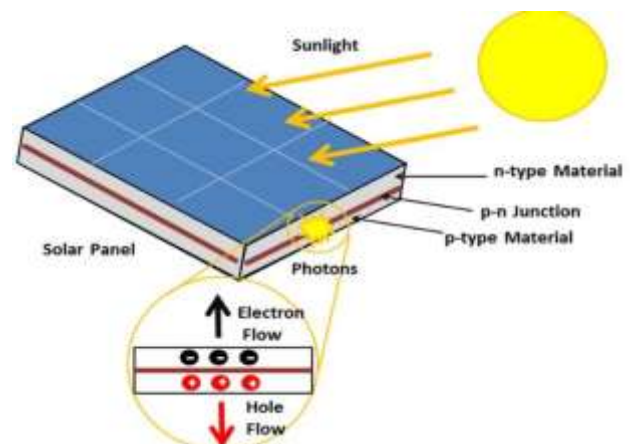


Fig 2 Structure of solar cells.

5. BLOCK DIAGRAM

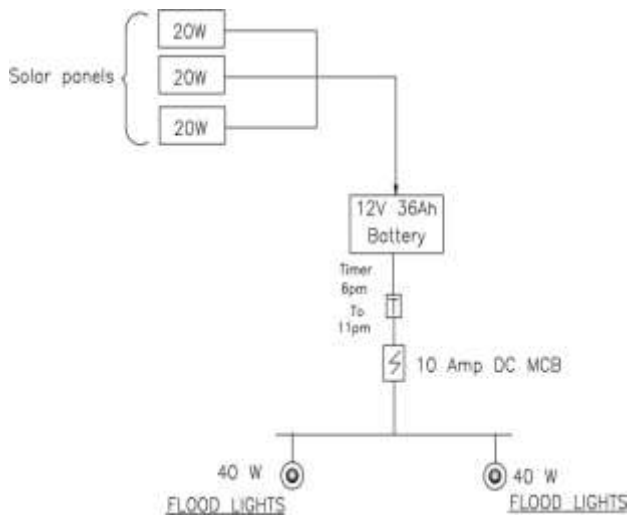


Fig 3 Block Diagram

6. CONSTRUCTION & WORKING

The solar tree consists of some important parts in its design

They are as follows:

1. Solar panels
2. Long tower
3. LED's
4. Batteries
5. Stems for connecting panels

Solar Tree is designed to function both autonomously and in synchronization with the public grid. Electric grid, it uses the energy generated by the solar panels during the day to recharge the batteries. At dusk, which is recognized by automatically monitoring the solar panel output, the LED sources are activated and remain lit until dawn (or as long as the batteries remain charged). Solar Tree is capable of functioning for three consecutive days of cloudy or overcast weather. When wired for coordinated functioning with the public lighting grid, it uses the energy generated by the solar panels to recharge the batteries and activate/deactivate the LED sources in synchrony with the grid, to which eventual surpluses of stored current can be relinquished. Major problems of Power system are the storage of Electric energy. Output fluctuations of solar cell are eliminated by the day and night cycle or weather shifts. Solar tree panels can charge batteries during the day time. Solar trees automatically switch on its LED. The internal control can also regulate the amount of light produced. A sensor is used to measure the amount of light in atmosphere and triggers the solar lamps to switch ON automatically at sunset and OFF at sunset A light-emitting diode (LED) is a semiconductor lightsource. LEDs are used as indicator lamps in many devices and are increasingly used for other lighting.

Appearing as practical electronic components in 1962, early LEDs emitted lowintensityred light, but modern versions are available across the visible, ultraviolet, and infrared wavelengths, with very high brightness. When a light-emitting diode is forward-biased (switched-on), electrons are able to recombine with electron holes within the device, releasing energy in the form of photons. This effect is called electroluminescence and the color of the light (corresponding to the energy of the photon) is determined by the energy gap of the semiconductor. An LED is often small in area (less than 1 mm²), and integrated optical components may be used to shape its radiation pattern. In this system the solar tree panels batteries charged during the day time. At dusk the solar tree automatically switches on the LED's. The internal control can also regulate the amount of light produced depending on how much charge is left in batteries. And moreover, the energy stored in the batteries can be used to store energy so that we can use it at night and in cloudy day when no sunlight is there.

7. COMPONENTS

A solar tree is made up of several important electrical, electronic, and structural components that work together to generate and manage solar energy efficiently. Below are the main components and their functions:

7.1 Solar Panels (Photovoltaic Modules)

- These are the main components that convert sunlight into electrical energy using the photovoltaic effect.
- Generally made of monocrystalline or polycrystalline silicon.
- Each panel typically has a rating (e.g., 12V, 20W or 50W) and is mounted at an angle to receive maximum sunlight throughout the day.
- In a solar tree, panels are arranged on branches to resemble leaves of a tree.

7.2 Mounting Structure (Pole or Frame)

- The supporting framework that holds the solar panels in position.
- Usually made of mild steel or galvanized iron for strength and weather resistance.
- Designed like a tree trunk with branches to mount panels at different levels and directions for better sun tracking and reduced shading.
- The structure must withstand wind load, vibrations, and rain.

7.3 Battery

- Stores the electrical energy generated by solar panels for use during night or cloudy weather.
- Commonly used: 12V lead-acid or lithium-ion batteries.
- The capacity (in Ah) depends on the required load and backup time. Example: A 12V, 26Ah battery can power small lights and fans for several hours.

7.4 MCB (Miniature Circuit Breaker) and TIMER

- Protects the system from overcurrent and short circuits.

- MCBs ensure safety during maintenance or fault conditions.

- Proper rating selection (e.g., 6A or 10A for small systems) is essential for reliable operation.

- A Timer is an important control component used in a solar tree system to automatically manage the operation of electrical loads such as LED streetlights or garden lights. It helps in saving energy and improving system efficiency by turning the lights ON and OFF at specific times, without the need for manual operation. (E.g. lights will get automatically on at 6pm in the evening and will get off by 11pm.)

7.5 Wires and Cables

- Used to connect the solar panels, charge controller, battery, and inverter.

- Must be UV-resistant and weatherproof to withstand outdoor conditions.

- Proper wire gauge is important to reduce voltage drop and power loss.

7.6 Earthing and Lightning Protection

- Ensures safety of the system and protects against lightning strikes and electrical faults.

- The metal structure and system components are properly earthed using copper plates or rods.

7.7 Load (Output Devices)

- The electrical equipment powered by the solar tree — such as LED Flood lights.

- Energy-efficient LEDs are preferred to reduce power consumption.

8. ADVANTAGE

Efficient Use of Land:

The biggest advantage of a solar tree is that it requires very little ground space compared to conventional solar panel installations. Because the panels are arranged vertically on branches, they occupy only a few square feet of land. This makes solar trees ideal for urban areas, campuses, gardens, and public parks where land is scarce.

Higher Power Generation per Unit Area:

Solar trees can generate more energy per square meter of land than flat-mounted panels. The panels are placed at different heights and angles, minimizing shadowing and allowing each panel to receive maximum sunlight throughout the day.

Aesthetic and Eco-friendly Design:

The solar tree has a beautiful, tree-like structure that adds to the aesthetics of public places. It symbolizes the harmony between technology and nature, promoting awareness about renewable energy and environmental conservation.

Reduced Dust Accumulation:

Since panels are mounted at a height, they accumulate less dust and debris than ground-mounted panels. This helps maintain better efficiency and reduces the frequency of cleaning. Additional Functional Uses

9. CONCLUSION

The installation of a solar tree in a college campus represents an innovative approach to promoting renewable energy awareness and sustainable development. A solar tree efficiently utilizes vertical space, allowing multiple solar panels to be mounted in a compact area while generating clean and renewable electricity. This makes it ideal for educational institutions where open land is limited. The energy produced can be used for lighting pathways, powering laboratories, and charging electronic devices, thereby reducing dependence on conventional electricity and lowering carbon emissions. Moreover, solar trees serve as live demonstration models for students, helping them understand the working of solar photovoltaic systems and encouraging research in green technologies. Despite challenges such as initial installation cost, maintenance difficulties, and design considerations, the long-term environmental and economic benefits make solar tree projects highly valuable. They contribute to the green campus initiative and support India's mission toward sustainable and eco-friendly energy solutions. In conclusion, the solar tree is not just a symbol of technological progress but also a practical solution for clean energy generation and environmental conservation in educational institutions. Its implementation inspires future generations to adopt renewable energy for a brighter and greener future.

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