

# Design and Development of a 500-W-Class Solar Tree for Methodist College of Engineering and Technology

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## Abstract

Interest in tiny photovoltaic buildings has grown in response to the rising need for decentralised clean-energy systems on college campuses. These structures integrate aesthetics, generate energy, and make optimal use of land. The 500-W-class solar tree at Methodist College of Engineering and Technology (MCET) in Hyderabad was designed, developed, and evaluated at the prototype level in this article. In order to minimise the system's impact on the ground while maximising solar exposure, the designers came up with a tree-inspired vertical structure that would house several photovoltaic modules. An array of solar cells, a charge controller, a 24-volt battery bank, an inverter, and an interface for campus-scale utility loads are all part of the prototype. The fourteen 40-W modules are placed in a 2-series, 7-parallel arrangement, which produces a nominal array output of 559.44 W, according to the project design data. Structural design, electrical configuration, irradiance component working principles, and prototype implementation are all part of the endeavour. Due to their dual purpose of preserving useable ground surface and providing educational opportunities, solar trees are shown in the research to be an ideal solution for institutional settings with limited space.

**Keywords:** solar tree, photovoltaic system, campus renewable energy, battery storage, urban photovoltaics, space-efficient solar design.

## I. INTRODUCTION

In order to lessen their reliance on the grid, increase their sustainability, and give students hands-on experience with green technology, more and more schools are installing distributed renewable-energy systems. Traditional ground-mounted or flat-panel photovoltaic (PV) systems provide good results, but they may be difficult to accommodate on urban campus locations due to the lack of horizontal space they need. As an alternative, solar trees may produce power with a far less impact on the ground by making use of vertical space and arranging modules in a branch-like fashion.

"Design and Development of a 500W Solar Tree for MCET Campus Renewable Energy Generation" is the title of the MCET student project that is being presented in this paper in an IEEE-style. An upright

solar-tree arrangement meant to facilitate renewable-energy production with battery backup was detailed in the first project report. You may put together a formal engineering presentation with the help of the source material, which details a PV array, battery system, charge controller, inverter, structural design, and implementation images. Consequently, rather than focusing on long-term field performance, this research is framed as a study of design and development prototypes.

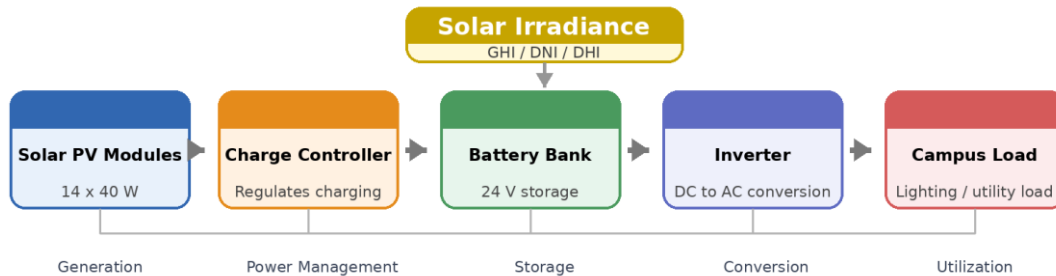


Fig. 1. System architecture and energy flow of the proposed solar-tree prototype.

## II. TECHNICAL BACKGROUND AND RELATED WORK

Semiconductor cells in a photovoltaic system absorb light and discharge charge carriers, resulting in direct current (DC), which is used to generate power. Charge controllers, batteries, and inverters are some of the auxiliary devices that condition, store, or convert the produced DC to AC. Global horizontal irradiance (GHI), direct normal irradiance (DNI), and diffuse horizontal irradiance (DHI) are typical ways that solar resource evaluation is stated for PV design.

New research on solar trees highlights three benefits: less land use, better angle exposure from branch-like positioning, and less visual intrusiveness in public settings compared to traditional solar fields. Because of these qualities, solar trees are ideal for micro-generation applications in cities, parks, and university campuses.

## III. SYSTEM DESCRIPTION AND METHODOLOGY

### A. System Architecture

Following the energy route PV array → charge controller → battery bank → inverter → load is the path that the constructed solar tree takes. With the help of a charge controller, which controls charging, a battery bank to store extra energy throughout the day, and an inverter to provide AC power to the linked campus load, the solar array primarily harvests energy.

The original idea was for a standalone device that runs on 24-volt batteries and is intended for use on school campuses. Daytime energy utilisation and battery-supported supply during low-irradiance times are both made possible by this approach.

### B. Solar Irradiance Model

Panel tilt and orientation analysis is based on DNI, GHI, and DHI, according to the source report. The following is the conventional irradiance balance for a horizontal surface, which relates these values; here,  $\theta_z$  is the sun zenith angle.

$$GHI = DNI \cos(\theta_z) + DHI \quad (1)$$

$$DNI = (GHI - DHI) / \cos(\theta_z) \quad (2)$$

C. Structural and Electrical Design

To keep the PV modules above the ground, the design calls for a vertical support that mounts to the flange and has raised branches. With an overall height of around 3 meters, a branch height of 2.1 meters, and a branch length of 2.4 meters, the structure may be deployed in institutions with ease while still leaving enough room for accessible ground area below the array, according to the source document.

Fourteen 40-watt photovoltaic modules provide the backbone of the electricity system. There is a maximum power current of 2.22 A and a maximum power voltage of 18 V for each module. A nominal 36-volt array, which may be used to charge a 24-volt battery system with the right controller, is formed by connecting two modules in series per string and seven strings in parallel.

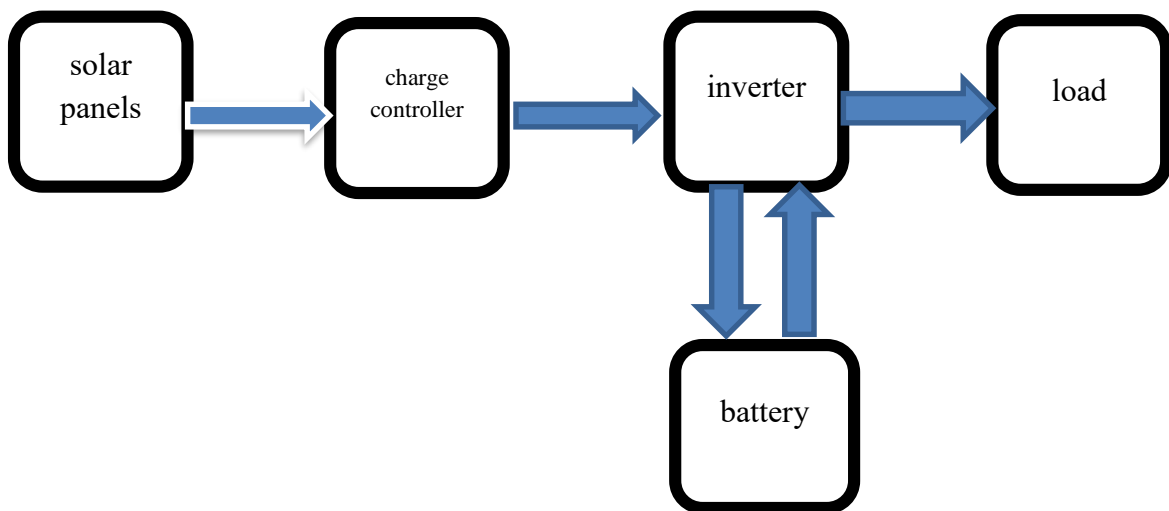


Fig. 2: Block diagram of solar tree

TABLE I: Key Design Parameters of the Proposed Solar Tree

Parameter	Value
Prototype class	500-W-class solar tree
Total number of panels	14
Panel rating	40 W each
Module $V_{mp}$	18.0 V
Module $I_{mp}$	2.22 A
Array configuration	2S × 7P
Nominal array output	559.44 W
Battery system	24-V battery bank
Overall structure height	3.0 m

Branch height / length	2.1 m / 2.4 m
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D. Array Calculation

The nominal electrical output of the PV array is obtained from the rated voltage and current of the series-parallel configuration. For one series string consisting of two 40-W modules:

$$V_{string} = 2 \times 18 = 36 \text{ V} \tag{3}$$

$$I_{string} = 2.22 \text{ A} \tag{4}$$

For seven such strings connected in parallel, the total current becomes:

$$I_{array} = 7 \times 2.22 = 15.54 \text{ A} \tag{5}$$

$$P_{array} = 36 \times 15.54 = 559.44 \text{ W} \tag{6}$$

Design and Implementation of Solar Tree Systems

3. Land Availability

- Though a solar tree takes up less land than traditional solar panels, ensure
- Stable ground or firm structure for installation

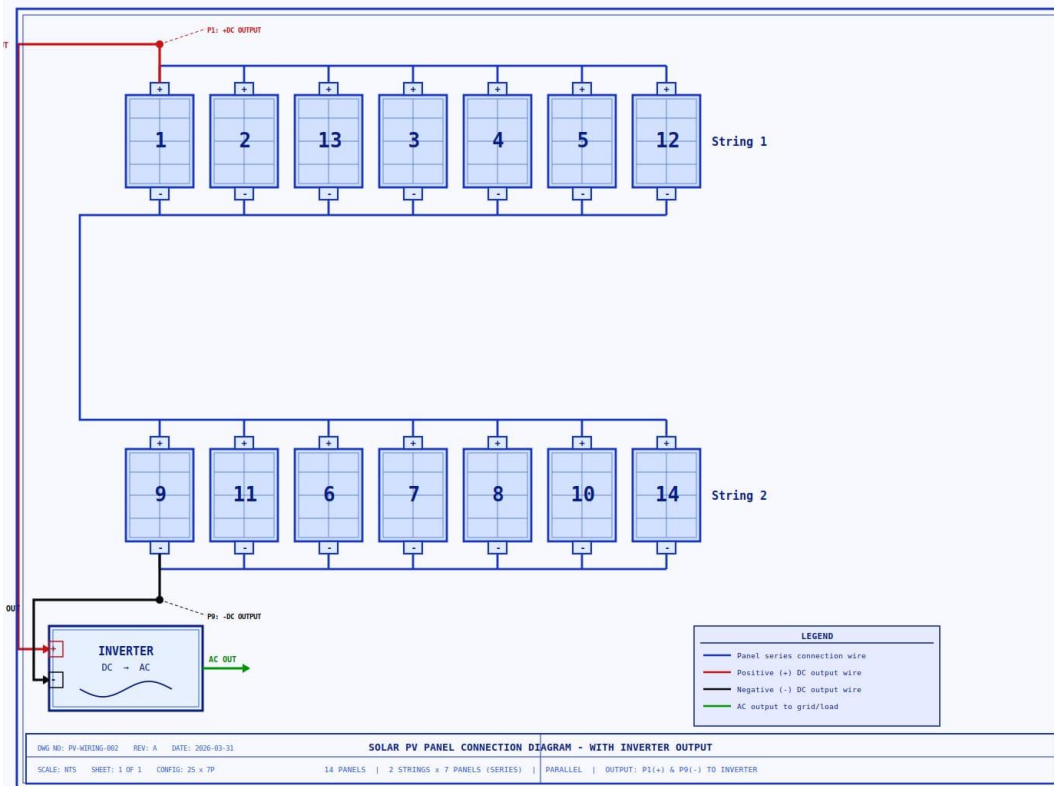


Fig.3: connection of panels

E. System Architecture and Energy Flow

This is a schematic of a solar power system that would operate independently on the MCET campus. This is the main energy harvester: a 500W solar PV module. The solar panels that make up the tree's "leaves" use the photovoltaic effect to transform sunlight into DC power. The system controller receives power from the 500W-capable modules, which are specially designed for this purpose.

The solar charge controller controls the current and voltage that flow from the photovoltaic modules; it is like the "brain" of the system. Its principal function is to prevent the 24V battery bank from being overcharged while charging. Storage of energy is essential for a campus utility in a battery bank, namely at 24 volts. Any energy that is not used throughout the day is stored in the 24V battery bank. Because of this, the solar tree can reliably power electronics like mobile chargers and LED lights at all hours of the day and night, even when the sun isn't directly above.

The inverter transforms direct current (DC) from the battery into alternating current (AC), which is needed by the majority of campus appliances and the local power grid. Powering conventional AC loads, such as laptops or bigger campus machinery, requires this part.

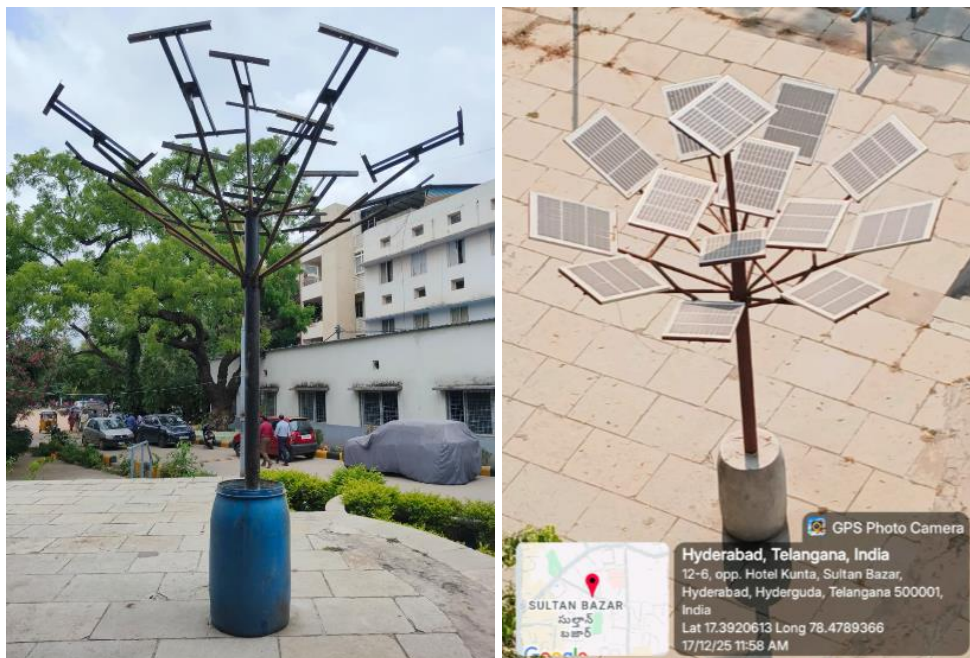


Fig.4: construction of solar tree

## 5.2 Electrical Design and Component Selection

In order to generate, store, and use energy efficiently, the electrical design of a solar tree has a number of components that must be carefully chosen and integrated. Important factors and parts related to electricity include:

**Solar Panels:** The output you're hoping to achieve dictates the kind and size of solar panels you'll need. Power output per panel may vary from 50 W to 350 W, and there are monocrystalline and polycrystalline panels to choose from. Four 250 watt solar panels could power an on-grid solar tree with one kilowatt of power, while thirty-six 350 watt panels may power a 500 watt system.

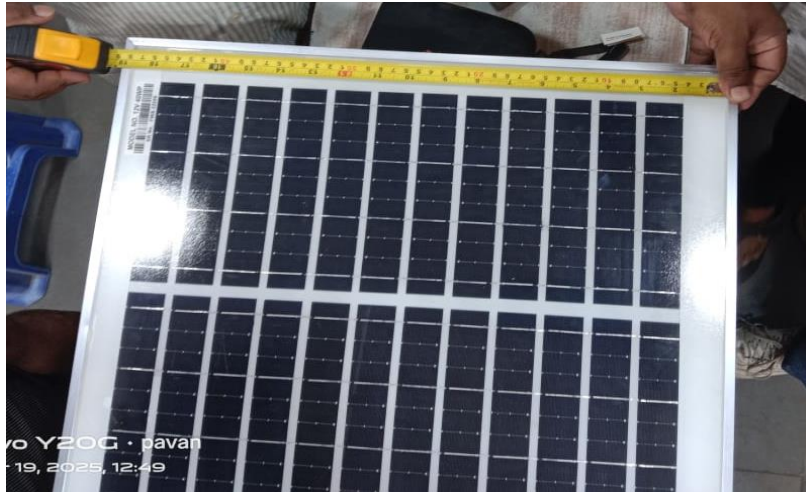


Fig.5: photo of solar panel

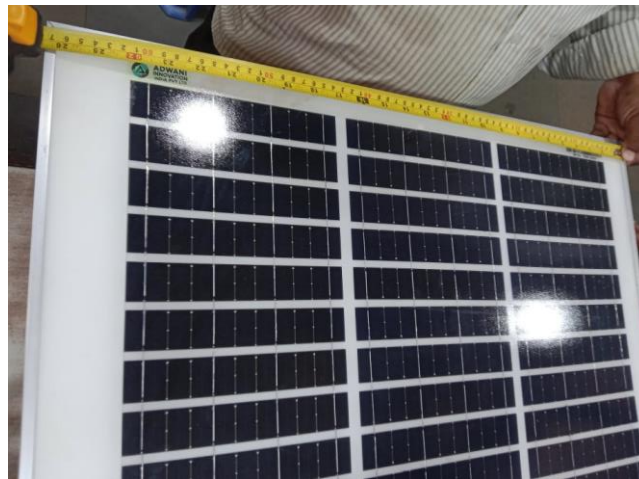


Fig.6: photo of solar panel

Table II: Solar Panel Specifications

Parameter	Specification
Maximum Power	40 Wp
Voltage at Maximum Power	18.0 V
Current at Maximum Power	2.22 A
Open Circuit Voltage	22.05 V
Short Circuit Current	2.08 A

The use of light-emitting diode bulbs has led to the proliferation of solar trees. Typically, they have several power ratings (e.g., 20 Watts per light) and are all-in-one devices that include a solar panel, battery, and light. Ten of these LED lights, adding up to a total of 200 Watts, may be found in a standard solar tree. It is common practice to hide the LED lights within GI sheet forms fashioned like leaves.

The inverters used in a system are chosen with consideration for whether it is connected to the grid or not. Solar on-grid inverters (e.g., 1KW, 10KW, 12KW) are used in on-grid systems, while off-grid MPPT drivers are used in off-grid systems. Solar panels produce direct current (DC), and these inverters transform it into alternating current (AC) for use in appliances or to feed into the power grid.

Batteries: Energy storage is crucial for solar trees that are off-grid or that need backup power. Typical backup battery capacity range from 12 to 18 hours, and they are made of Lithium Iron Phosphate (LiFePO4) or Lithium-Ion. Many integrated LED light sets include these batteries. The structure's electrical wiring should be hidden for both practical and aesthetic reasons.



Figure 5.2.5: Lead-Acid Battery 12V,80Ah

#### IV. RESULTS AND DISCUSSION

The prototype documentation primarily provides the nominal electrical rating of the array as a quantitative result. Despite the 500-W solar tree being mentioned in the project title, the 14-panel arrangement that has been reported delivers 559.44 W at rated circumstances. Hence, a 500-W-class prototype is the most appropriate way to characterise the implementation.

There are three concrete advantages of using the solar tree in campus layout. Firstly, in contrast to a flat ground-mounted array, it keeps more of the available ground space. Secondly, being vertically orientated, it is an excellent choice for public and educational areas that need sustainability infrastructure to be both compact and easily visible. Thirdly, the system is built with battery storage and inverter output, so it can handle low to moderate campus utilities like lighting, awareness displays, and mobile charging.

Nonetheless, this is not a long-term field performance review; rather, it is a study of design and development. Though it contains inverter readings and images of the installation, the source report is lacking in a continuous dataset that measures irradiance, daily energy production, seasonal change, or efficiency in response to dynamic environmental factors. Thus, data recording, comparison testing, and analysis of controller-level performance should be prioritised in future validation. TABLE III: Summary of Prototype Outcomes and Engineering Interpretation

Metric	Result	Interpretation
Nominal peak output	559.44 W	Confirms 500-W-class operation
Array voltage	36 V	Suitable for regulated charging of a 24-V bank

Ground footprint	Low	Supports campus deployment in space-constrained areas
Battery-backed operation	Yes	Enables limited continuity of supply beyond daylight hours

## V. CONCLUSION

This report detailed the process of creating a 500-W solar tree on the MCET campus to generate sustainable energy. The project report states that the prototype incorporates a 48-volt battery bank, an inverter-based load interface, a charge controller, fourteen 40-watt solar modules, and a vertical PV structure. According to the electrical study, the system is theoretically compatible with a 500-W-class classification because the chosen 2S7P configuration produces a nominal output of 559.44 W.

The research shows that solar trees are a viable alternative for campuses that prioritise renewable energy, compact land use, and visible sustainability infrastructure. By connecting clean-energy production with student involvement and future smart-campus prospects, the prototype is particularly helpful as a teaching and demonstration platform.

## FUTURE WORK

Instrumented field validation need to be the center of future endeavours. The next step is to monitor the irradiance, temperature of the modules, battery charge, efficiency of the inverter, and daily energy production in real time. Installing a fixed-tilt reference array on the same campus as the solar-tree prototype and comparing its ratings would be helpful as well.

Potential future enhancements include bifacial modules, optimised MPPT, enhanced structural maintenance, and monitoring via the Internet of Things. Further research using more comprehensive information might evaluate the solar-tree concept's economic payback and lifespan performance in institutional contexts.

## REFERENCES

1. U.S. Department of Energy, "Solar Photovoltaic System Design Basics."
2. U.S. Department of Energy, "PV Cells 101: A Primer on the Solar Photovoltaic Cell," 2019.
3. M. Almadhhachi, I. Seres, and I. Farkas, "Significance of solar trees: Configuration, operation, types and technology commercialization," *Energy Reports*, vol. 8, pp. 6729-6743, 2022.
4. M. Almadhhachi, I. Seres, and I. Farkas, "Sunflower solar tree vs. flat PV module: A comprehensive analysis of performance, efficiency, and land savings in urban solar integration," *Results in Engineering*, vol. 21, 2024.
5. National Renewable Energy Laboratory, "National Solar Radiation Database (NSRDB)."
6. "Design and Development of a 500W Solar Tree for MCET Campus Renewable Energy Generation," student project report, Methodist College of Engineering and Technology, Apr. 2026.