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A narrative review of Solar photovoltaic tree applications with various design elements, performance, and limitations

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Abstract — Increasing demand for traditional energy sources like coal, natural gas, and oil has compelled scientists to create renewable or alternative energy sources. Due to the ever-increasing need for power and rising expectations, renewable energy sources like fuel cells, wind, and solar have attracted a lot of interest. The conversion of sunlight into electricity using photovoltaic technology is the most common and advanced technology, including many systems for using solar energy. It takes more land in an open area to place solar panels to produce the most solar energy, and as we all know, the land is already in short supply in most nations. The maximum solar surface can be created with the least amount of space by building a holding system for PV modules with a vertical pole on the ground and keeping the PV cells in a structure resembling the branches and leaves of a natural tree. As a result, the system is referred to as a solar PV tree. In comparison to flat solar PV, solar photovoltaic tree structures have varied heights and creative designs, which boost efficiency by roughly 10 to 15%. Solar PV trees are man-made solar structures that resemble real trees. Unique solar tree designs were developed to offer particular support to varied urban and natural surroundings. This essay offers a thorough analysis of the various solar photovoltaic tree designs and implementations now in use worldwide. This article also examined the energy, financial, and environmental performance of solar photovoltaic trees.

Key Words — **Solar reviews; Photovoltaics; Solar trees; land footprint; Solar reviews; PV systems that save the land**

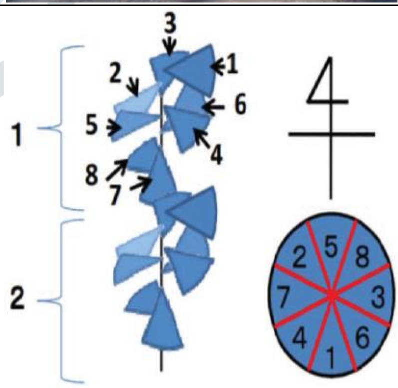
I. INTRODUCTION

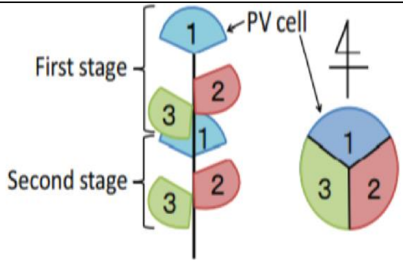
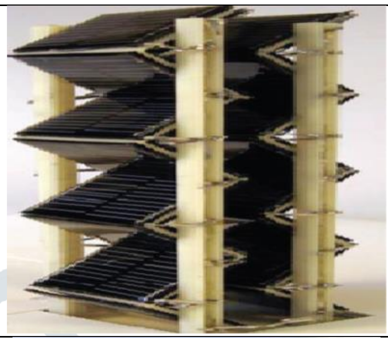
Because of the rising energy demand, it is necessary to upgrade both renewable and nonrenewable technologies to generate more energy. The technological trend in favor of renewable energy sources validates their popularity and significance. Due to its ease of use and supremacy in the renewable energy sector, solar energy has a tremendous amount of potential. For a sustainable and eco-friendly future, the government encourages everyone to push the best and most effective inventions to cut carbon emissions. Solar energy also helps to reduce transmission of infectious diseases by improving immunity of an individuals (Shah et. al., 2021, Shah et. al., 2020, Shah et. al., 2021). The sun's light and heat made up solar energy. Solar energy is used in numerous cutting-edge technologies, including artificial photosynthesis, solar fuel, solar thermal, and solar heating. This can also play a vital role in assistive technology such as prosthetic arms which is very well described by (Pawar & Mungla, 2022) and (Pawar & Bhatt, 2019)The most popular way to use solar power is through photovoltaic (PV) technology. PV (photovoltaic) panels aid in capturing solar energy. Solar irradiance can be used by PV panels that are exposed to the sun as a crucial stand-in for energy sources from which electrical energy can be produced. It is vital to position the solar panels such that the sun's rays are concentrated on their surface to get the most energy from the sun. PV panels are raised in the solar power generation system so that their surfaces get the maximum amount of daylight illumination due to their angled placement. It needs a suitable framework to hold the solar above the area where it landed in an open area.

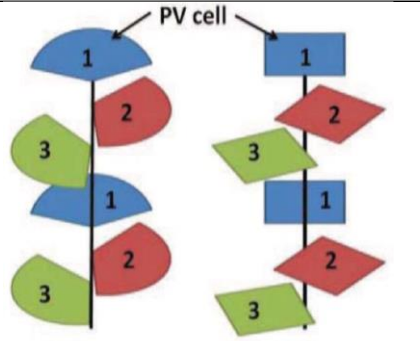
Panels to increase power production Rooftop solar PV structures are created as a result, however, they need a lot of land surface area to house the panels and produce energy. Problems with land requirements, capture efficiency, and public perception exist for solar PV technology (because of a lack of congenial esthetics). Sun-tracking PV systems can be constructed; however, their high cost and upkeep significantly raise the cost of energy generation overall. The concept of a solar tree can elegantly and effectively address these problems. Like a real tree, a solar tree produces power and solar energy for decorative purposes. Connected stems serve as the tree's branches and solar panels serve as the leaves of the solar tree. "TREE stands for T = Tree generating R = Renewable E = Energy and E = Electricity" in the Solar Tree. The main benefit of the solar tree is that it uses 1% less space than a traditional solar PV system because it uses a holding mechanism for the PV modules that are supported by a vertical pole that is placed on the ground and arranges the PV cells to resemble the branches and leaves of a natural tree. By generating a maximum solar surface, it is feasible to utilize the least amount of land for the greatest absorption of solar electricity. Streetlights, handheld electrical devices, cell phones, and laptops may all be charged by the solar tree. In terms of originality, creativity, and an effort to use solar energy, the concept of a solar tree is distinctive. The photovoltaic modules are put together into a three-dimensional structure to increase the total solar surface area and effectively convert solar energy into energy when the sun's irradiance is low.

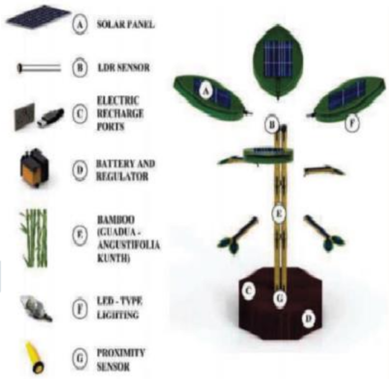
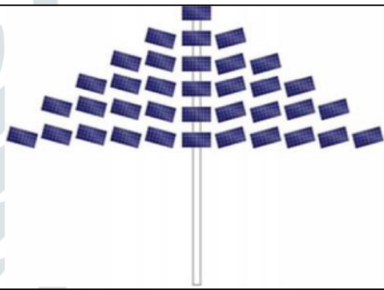
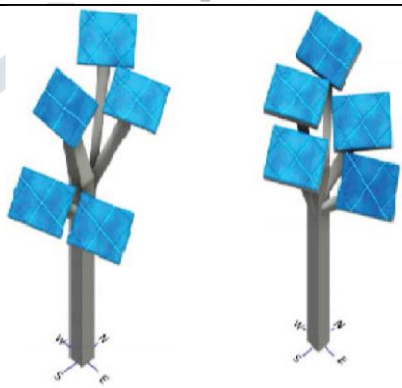
There are 5 sections in this article. The solar PV state-of-the-art is presented in Section 2, which is divided into two sections: I The fundamental structure and elements Available in solar PV tree designs are (ii). In part 3, we covered the energy, economic, and environmental performance of solar PV trees. The application, difficulties, and future potential of solar PV trees are covered in Section 4. We concluded in the last part about solar PV trees.

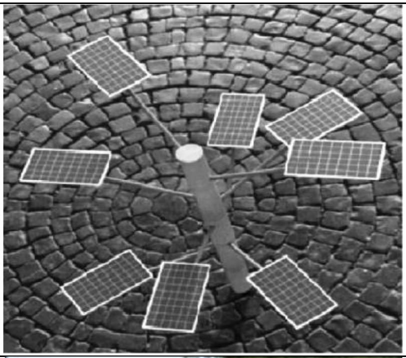
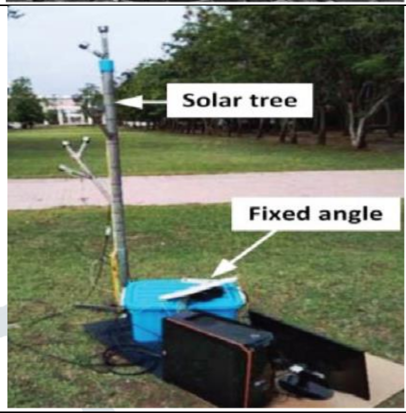
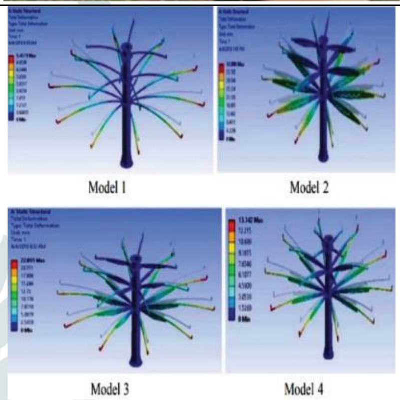
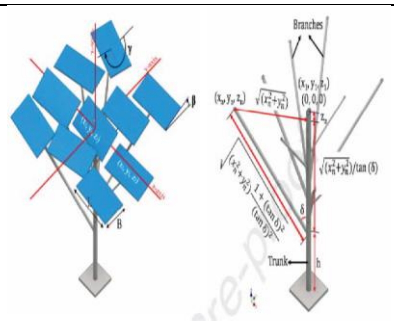
II. STATE OF THE ART ON SOLAR PV TREES

Author	**Description**	**Model**
Lovegrove (2007)	An organic-looking solar device with numerous curved branches and a ring-shaped cluster of photovoltaic cells was created by the researcher. This solar tree idea was based on the sinuous tree and was made of 5.5-meter high steel pipes that supported a light bubble that had 38-watt capacity solar cells that were wired to a 12 V hidden battery system and had 1-watt Leds put on the bubble edge to provide color. This solar tree was created by a researcher to automatically switch on the mounted LED light at dusk while also charging the batteries. Key characteristics include the solar structure's organic appearance and the collection's round shape.	
Milisavljevic(2010)	A solar tree designed exclusively to charge mobile devices was created and erected in the central park of Obrenovac, Serbia, by the company's founder. The solar tree's primary parts were (a) solar panels (b) capable of sustaining operation for 14 days (c) 16 cords for a variety of mobile devices (d) little physics that maintained a balance between energy produced and consumed. A second free mobile solar charger was set up in Zvezdara, Belgrade, Serbia, a year later. Novi Sad, Serbia, set a third Arbutus unedo in the same month. The strawberry tree was the first public mobile charger in history. (0000 Milisavljevic)	
Yuji and Yachi (2010)	presented a research paper named "A Novel Photovoltaic Module Assembled Three-dimensional" to maximize the amount of power that could be generated from solar panels for a given area to make the most efficient use of solar energy. According to the researchers, the solar PV three-dimensional construction produced more electrical energy under low solar irradiation conditions than the flat-mounted solar PV module structure. In 2010 (Yuji and Yachi), The following are the essential characteristics: Solar PV tree structure based on phyllotaxy pattern using Fibonacci sequence, MPPT controlling azimuth angles of solar cells. Fibonacci sequence-based phyllotaxy pattern is the basis of the solar PV tree structure, while MPPT regulates the azimuth angles of the solar cells.	
Dwyer (2011)	He investigated how natural trees could track the sun's movement in the sky and capture the majority of the sunlight in dark forests by using the Fibonacci sequence. To test whether the Fibonacci pattern of an oak tree helped branches and leaves accumulate the most sunlight, he created a test model employing the pattern.	
	Key Features: adhere to the Fibonacci series	

Suto and Yachi (2011)	Utilizing a Fibonacci number (FPM), the authors created a three-dimensional PV module simulation model that included shadow effect analysis to maximize solar energy. Each PV module's shadow effect was examined by the authors. The output of the simulation model demonstrated that the two-stage FPM simulation model has greater power than a typical module. The outcomes also demonstrated that the power generated by single-stage FPM was less than the power generated by two-stage FPM when the shadow effect on each PV cell is taken into account. (2011) Suto and Yachi Key design Features: 1/3 phyllotaxy pattern-based two-stage FPM.	
Bernardi et al. (2012)	studied and had its three-dimensional solar energy collection problem computationally solved. In comparison to standard PV panels, the 3DPV construction produced high energy density (energy per base area, kWh/m2) by a ratio of 2 to 20. At all latitudes, the 3DPV construction can be used to generate electricity. According to the authors, harvesting solar energy in three dimensions improved a new route for the Terawatt generation range. (2012) Bernardi et al. Important design elements include a 3DPV with a reflector and absorber combo.	
Suzumoto and Yachi (2013)	studied and computationally resolved the three-dimensional solar energy collection problem. In comparison to traditional PV panels, the 3DPV construction produced high energy density (kWh/m2; energy per base area). Power generation using the 3DPV structure is possible at all latitudes. The authors proposed a new way for the Terawatt generating range by harvesting solar energy in three dimensions. Bernardi et al. (2012) Important design elements: (3DPV) with a mix of reflectors and absorbers. Key Features: FPM structure is based on three dimensions in two stages.	
Maity (2013)	Created a silicon-crystalline PV (SPV) power tree. The researcher put a 50–70-foot metal pole in a 2x2 basement. This metal pillar supports all SPV panels like a tree. This solar power tree used only 4 to 5 square feet of surface ground, 1% of the acreage needed for standard solar construction. SPV panels followed phyllotaxy. To avoid wind pressure, the SPV panels were bendable. The researcher put 26 solar PV panels on that metal pole. This solar power tree produced 1000Wh at peak hours. (2013). Key design Features: solid silicon-crystalline photovoltaic (SPV) cell, spiraling Phyllotaxy pattern.	
Avdic et al. (2013a)	Researchers proposed a new solar tree design. Researchers installed solar trees in Sarajevo's urban area. Researchers proposed three urban solar tree designs. Two solar tree designs were presented. Solar tree electricity charges devices and LCDs. (ii) Solar trees power streetlights. (2013) Key design Features: 3-axis symmetric, lower panel density	
Avdic et al. (2013b)	Again suggested building a solar tree in Sarajevo, Bosnia, and Herzegovina, considering social, technological, and economic factors. Based on annual sunshine days/hours, the researchers highlighted the solar tree's pros and cons for that location. The	

	project's major objective was to achieve street illumination, laptop and mobile device charging, solar tree battery and durability, and economic viability. (2013)	
Mukaiyama and Yachi (2014)	Showed that a three-dimensional Fibonacci numbers PV module (FPMpower)'s relies on solar cell form and size. Square cells generate more electricity than sector cells, according to the authors. Simulations of a 1/3 phyllotaxy pattern-based two-stage FPM with varied PV cell designs and sizes assist, the researchers said. A multi-stage FPM shadow reduced the power output of the first cell in the second stage by 64% for sector cells and 30% for square cells. FPM power increased with stage count. (2014). Key design Features: square-cell multistage FPM.	
Nishiwaki and Yachi (2014)	Researchers suggested a three-dimensional FPM leaf layout to maximize solar energy. The researchers examined how shadow affected surrounding FPMs for power generation and suggested forest correction. The researchers set up the experiment on the Tokyo University of Science Research Building roof. They deployed many FPMs and compared outcomes with a solo FPM. The researchers placed a fake FPM near the functioning FPM for comparison. Researchers placed the fake FPM eight times. Solar modules were always 55 cm apart. A nearby FPM facing south had more shadow impact and generated less power. (2014). Key design Features: three-dimensional FPM.	
Dimitrokali et al. (2015)	3D PVTree helped researchers study architectures and prototype models (concepts, drawing, and modeling). The major goal was to learn about PV tree opinions, thoughts, and 3D model progress. (2015)	
Takahashi et al. (2016)	Researchers designed a power-producing forest using Fibonacci sequence PV modules. The power generation forest research examined how shadow affects three-dimensional Fibonacci numbers PV module power generation (FPMs). 1/3 phyllotaxy pattern-based two-stage FPMs were used in their model. The researchers also found that changing FPM layout patterns affected electricity generation. Honeycomb structure-based FPMs provided the most electricity year-round. (2017) Features 3D FPM construction, square, diamond, and honeycomb.	
Mafimidiwo and Saha (2016)	Designed a three-dimensional solar tree system to maximize power output. Researchers examined computing methods and employed Height per unit volume against the fixed surface solar structure. The three-dimensional PV solar tree construction generated much more energy than the fixed-angle two-dimensional structure. The researchers established a linear relationship between 3DPV volume creation and planar area generation. 3DPV power over the flat structure rose by 16%. Height improves solar power output. However, when more than one tree is employed, the likelihood to encounter uneven solar panel lighting due to competing solar cell shades may provide different outcomes. (2016)	

Berny et al. (2016)	Showed a massive solar tree with completely solution-coated, flexible organic, and semitransparent PV modules. The researchers exhibited the solar tree's technology at Expo Milano's German pavilion. Researchers assimilated a vast space for putting flexible solar cells array with distinctive designs and blue translucent appearance. Modules were made using cheaper roll-to-roll (R2R) solution-based polymers. 2016. Membrane architecture, organic PV (OPV) polymer modules.	
Duque et al. (2017)	In Medellin, Colombia, researchers erected Solar PV trees to charge electronics. The solar PV tree was built after studying Medellin's climate. They put four solar PV panels as leaves on the 3.5-meter solar PV tree. The researchers received 6 USB ports for charging gadgets and two 110-to-200-volt electrical appliance switches. The researchers found 876-watt-hour energy savings each year. (2017)	
Hyder et al. (2017)	Researchers reviewed solar PV tree technologies, designs, and future research. The researchers compared the solar PV tree to flat conventional solar modules and addressed practical designs and use. Researchers examined all solar tree standard structures. Researchers explored solar PV tree issues and solutions. (Hyder, Sudhakar, Mamat 2018)	
Hyder et al. (2018)	Researchers created six semi-dome solar PV tree structures with increasing layers at varied tilt and orientation angles. These models were simulated against a flat PV system at three locations (2018). Key design Features: semi-dome solar PV trees	
Dey et al. (2018)	Based on locales and uses, the researchers recommended solar tree panel orientation for optimal power output. First, the researchers examined single panel optimization orientation at 15 locations across a wide latitude range. Researchers said latitude angle alone could not determine solar panel orientation. In a site with non-symmetric solar irradiation, an azimuth angle was needed. The team created four 1 kW solar trees. Ray optic modeling was used to create solar trees for two locations to demonstrate shadow effect reduction. Shading loss was around 2%. Dey, Lakshmanan, and Pesala (2018). Key design Features: Genetic algorithms optimize solar panel orientation.	
Gangwar et al. (2018)	Researchers presented two Fibonacci sequence-based spiral Phyllotaxy solar tree designs. Solar trees were prototyped using 3/8 and 2/5 phyllotaxy patterns. They rated all performance as a standard solar model. Researchers found that the solar tree got more sun irradiation than the traditional solar model throughout the day. The researchers also found that solar tree-generated power outperformed a typical solar model throughout the day (2019a). Key design Features: 3/8 and 2/5 Fibonacci sequence-based spiral Phyllotaxy pattern.	

Gangwar et al. (2019)	The researchers designed Phyllotaxy pattern-based solar PV trees using thermal and chemical treatments based on the end-of-life (EOL) approach for material recovery. Researchers said solar PV tree PV modules last 25 years. Researchers suggested recycling these solar PV trees after their lifespan. (2019b)	
Srisai et al. (2019)	Analyzed solar tree efficiency using the golden ratio. Designing solar tree lengths and branches using the golden ratio. Fibonacci divided the solar tree's main trunk into five branches. All angles were 137.5°, the golden angle between trunks and branches. All branches have solar cells. The solar tree and fixed-angle land-based construction were evaluated for power efficiency. Researchers found that the golden ratio solar tree construction was 1.295 percent more efficient than the fixed angle form. (Srisai 2019)	
Shanmukhi et al. (2019)	Designed and assessed a 3 kW solar tree. Designing the solar tree structure and its estimated 630 kg weight in Creo Parametric 2.0. Optimized solar tree construction weight without compromising strength. The trunk, base, and middle plates, stems, and gussets of the solar tree construction were optimized for weight and power production. This improvement lowered body weight by 373 kg for structural steel. Pre- and post-optimization static structural evaluation using ANSYS 16.2. This study quantifies external load and self-weight fluctuations in a structural steel solar tree construction sans panels. (Shanmukhi 2019)	
Oluwafemi et al. (2019)	Analyzed and designed a 3 kW solar tree structure. The solar tree structure and estimated weight of 630 kg were designed using Creo Parametric 2.0. Optimized solar tree structure design to minimize weight without weakening it. The solar tree structure's trunk, base and middle plates, stems, and gussets were optimized to decrease weight and maximize power production. This adjustment greatly lowered body weight, which for structural steel is 373 kg. Before and after optimization, used ANSYS 16.2 to analyze the static structure. This study quantifies fluctuations in a solar tree structure (without panels) with structural steel owing to external stresses and self-weight. Shanmukhi and colleagues (2019)	
Dey and Pesala (2020)	Designed and demonstrated a 3 kWp solar tree multi-objective framework in Chennai, India. They optimized solar tree power output and reduced structural materials. They employed genetic algorithm-based multi-objective optimization to arrange solar tree panels to reduce shading losses and land footprint. Ray optic simulation verified power production and shading losses. 2020 Dey-Pesala. Key design Features: genetic algorithm-based multi-objective optimization, land footprint analysis, and FRP lightweight material to reduce the solar tree's net weight.	

III. BASIC STRUCTURE AND COMPONENTS

Solar PV trees collect sunshine all day. Solar trees have the following parts:

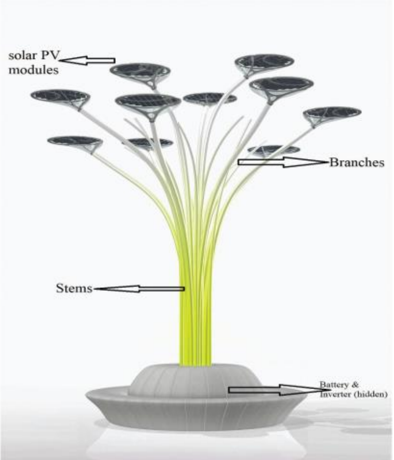


Figure 1 Primary structure of a solar tree

Crystalline silicon (c-Si), the most common PV material, was utilized to make the first practical solar cell. Silicon makes up over 95% of solar cells worldwide (Si). Commercial and residential silicon solar cells have the highest efficiency. Three solar cell generations: First-generation PV cells are based on expensive silicon wafers and represent 85% of the current monetary market. Second-generation PV cells include thin films of material like amorphous silicon, cadmium telluride, nanocrystalline silicon, or copper indium selenide. Third-generation PV cells include Copper zinc tin sulfide, Organic, Polymer, Dye-sensitized, and Quantum dot solar cells (Sugathan, John, and Sudhakar 2015).

Steel structure: Standard solar tree structures are meant to appear beautiful and use less space while shielding the leaves and PV modules from shadowing. Figure 1 illustrates Ross Lovegrove's typical solar tree design (available from 0000). The solar tree appears like a natural tree, thus it needs a steel framework for the stems and branches to store solar PV modules (Ross Lovegrove's solar tree, Available from 0000) in Table 1.

Cables link solar modules. Weather and ultraviolet-resistant cables with high mechanical strength can sustain mechanical and thermal stresses (Solar cable Available from 0000).

Inverter: The inverter converts solar module-generated DC electricity into AC voltage. Inverters are distinguished by conversion efficiency and power optimization. I–V and P-V properties vary for each solar panel in the solar tree, causing high conversion losses (Shukla, Sudhakar, and Baredar 2016).

Batteries: Energy supply and power storage. Batteries can solve PV intermittently. Lead-acid, lithium-ion, nickel-cadmium, and lithium-ion polymer batteries power solar PV (Gurung et al. 2018).

IV. SOLAR PV TREE DESIGNS

Batteries: Power storage and supply. PV intermittent can be solved using batteries. Solar PV uses lead-acid, lithium-ion, nickel-cadmium, and lithium-ion polymer batteries (Gurung et al. 2018).

Design	Pattern	Designer & Location	Advantages	Disadvantages	Description
	Fibonacci sequence	Aiden Dwyer, New York	Collected more sunlight.	It was too complex for high-power applications.	An oak tree's spiral leaves and branches were shown. Compared to solar panels, the solar tree gathered more sunlight. Compared to the flat-panel model, better output. (Updated 0000: 13-Year-Old Uses Fibonacci Sequence for Better Solar Power)
	Spiral Phyllotaxy	S.N. Maity, India	The solar tree was easy to build and cheap compared to previous comparable concepts.	Because all panels face the same way, they catch less light throughout the day.	Silicon-crystalline PV (SPV) panels and a metallic pole of 50 to 70 feet with a foundation of (2*2) square feet held this solar power tree. 26 solar PV panels are angled on this solar tree. This solar power tree produced

					1000Wh at peak hours. (2013)
	hemispherical semi-dome	Ecopower (Alertica consultant), Republic of Serbia	Very light-capturing. Other designs had less output power. High-efficiency	The vast quantity of solar panels made it expensive.	The 2220-watt solar tree was 6.5 meters tall with 13 PV panels. EUROCODE 2 protected this solar tree. Bench at tree's base. (ECOPOWER Solar tree 0000 Association)
	Natural Tree design	CSIR-CMERI, Durgapur, India	Powerful. Solar tree.		The solar tree features 35 330-watt panels. The solar tree produced 12,000–14,000 green energy units per year. Real-time or periodic power data tracking is possible. The solar tree can reduce CO_2 emissions by 10–12 tonnes.

V. PERFORMANCE OF SOLAR PV TREES

Solar PV trees capture sunlight creatively. PV panels were leaves on the solar tree, reducing the PV system's land footprint. It would farm and generate solar power. Rural areas may innovate too. Solar PV trees receive more sunlight and create 10–15% more power than flat solar PV since they are higher. Compared to the flat solar PV concept, solar PV trees use around 1% of the land (Maity 2013). Solar trees can create 5 kW of power from a 1 square-meter basement space, but flat solar PV needs 100 square meters. Sunlight and temperature affect solar PV tree performance. Table 3 shows solar PV tree energy, economic, and environmental performance.

Table 3. Solar PV trees for energy, economy, and environment.

Author	Energy performance	Economic performance	Environmental performance
Yuji and Yachi (2010) (Yuji and Yachi 2010)	In their simulations, single-stage and two-stage FPMs generated 70 percent and 140 percent more electricity than standard PV modules.		
Bernadi et al. (2012) (Bernardi et al. 2012)	They found that the 3DPV solar tree generated 2.25Wh (2.27Wh in simulation) whereas the traditional module generated 1.22Wh (1.01Wh).		
Avdic et al. (2013) (Avdic et al. 2013a)	Solar tree promotes renewable energy efficiency in Bosnia-Herzegovina.	The solar tree generated 1943kWh/year and required 77.3kWh/month and 927.6kWh/year. It means 1015.4kWh of energy might be sold annually.	The way a guy acts in his surroundings decides whether such "growth" will be welcomed or resisted. The solar tree provides free solar energy, saves money, and reduces environmental impact.
Dimitrokali et al. (2015) (Dimitrokali et al. 2015)		It helps meet global energy needs and optimize space use. The solar tree saves space and boosts power output.	The biophilia notion promotes most people's visual (or auditory) gain through association. Solar tree structures can be created in metropolitan areas to add functionality and employ natural elements to create positive subjective experiences that can improve health and well-being.
A P R Srinivas (2016) (Srinivas 2016)	Solar tree efficiency is 45.4 percent with 55.1 watt-hours of battery power. To keep the battery healthy, two 5-watt CFL bulbs can be lit for 2.5 hours or one for 5 hours.	It helps satisfy energy needs and maximize space. Solar tree saves space and increases power output by several folds.	
Deepak M. Patil (2016) (Patil and Medical 2016)		Local content reduces domestic solar tree costs. Simple, imaginative tree	Solar trees can meet expanding energy demand, save property, and minimize grid dependence in India.

		structure design reduces costs. Solar Tree costs Rs.60000 and has a 10-year payback.	
Mafimidiwo & Saha (2016) (Mafimidiwo and Saha 2016)	Three-dimensional photovoltaic power over flat construction rose by 16%. Three-dimensional photovoltaic cells produce far more energy than two-dimensional planar systems.	Installing PV panels atop towering structures takes longer and costs more than on the ground. Depending on land pricing, raising solar equipment may be cheaper.	
Takahashi & Yachi (2017) (Takahashi and Yachi 2017)	Solar tree power was 1.5 times conventional power.		
Duke et al. (2017) (Duque et al. 2017)	An operating year saved 876Wh energy.	Solar trees consume 209.375 kW per month, saving 81645.78 gr of CO2 every year, enough to plant 2.085 trees.	Solar trees consume 209.375 kW per month, saving 81645.78 gr of CO2 every year, enough to plant 2.085 trees.
Jyoti Yadav (2017) (Yadav 2017)	The Fibonacci series trees create 120 percent more energy in half the time than flat solar panels. The solar tree generates 8.28 kWh, while the series and parallel flat panels generate 2.31 watts.		An array of solar panels requires 10–12 acres to generate 2 MW of electricity, whereas the solar tree requires only 1 percent, or 0.10–0.12 acres, making it better for the future. The solar tree cleans CO2 and other pollutants.
Ayneendra et al. (2018) (Ayneendra et al. 2018)	The solar tree design collected sunlight 50% longer and produced 50% more power.	It saves money and helps the environment. Free and convenient for life and community.	It benefits the environment, saves money, and is easy to use in every home. It’s free and convenient for life and the community.
Dey et al. (2018) (Dey, Lakshmanan, and Pesala 2018)	San Francisco and Paris optimized solar trees produce 2.04% and 7.38 percent more electricity than latitude tilt. Compared to horizontal panels for San Francisco and Paris, the solar tree reduces standard energy curve deviation by 21.5 percent and 3.35 percent.	Instead of Tilt latitude panels, the solar tree can use ground space.	

VI. APPLICATIONS, CHALLENGES, AND FUTURE SCOPE OF SOLAR TREES

The solar trees applications can be applied to the following fields and it is showing in Figure 2:

I. Urban/rural PV trees can work in urban and rural regions with little space. It meets a house's daily electricity consumption with less land. Most rural households are off-grid. The solar tree powers dwellings and agricultural gear.
II. Streetlights Roadside solar PV trees may brighten urban and rural areas.
III. Deserts With current PV efficiency, desert solar energy might provide all electricity demand in industrialized and developing countries. Studies suggest that 4% of the desert's solar system area can supply the world's electrical energy.
IV. Solar PV tree-based electric car systems are put anywhere to charge electric and hybrid vehicles.
V. Highways Highway dividers and roadside solar PV trees can provide nighttime lighting.
VI. Agriculture irrigation Solar PV trees can power irrigation tools without wasting land.
VII. Battery and electronic device charging Solar PV trees can be planted in public spaces or parking lots.
   a) Charges (Solar tree applications 0000a)
   b) Electric car charging (Solar tree applications 0000b)
   c) Urban households (Solar tree applications 0000c)
   d) Highways (Small scale solar set up outside of a local business park 0000)
   e) Streetlighting (Solar tree applications 0000d)
   f) Agriculture irrigation (CSIR-CMERI creates World's Largest Solar Tree 0000)

		
Figure 2(a)For charging purposes [47]	*Figure 3(b) For electric vehicle charging purposes [48]*	*Figure 4(c)For urban households [49]*
		
Figure 5(d) For highways [50]	*Figure 6(e) For street lighting [51]*	*Figure 7(f) For agriculture irrigation [42]*

The solar tree is a great idea, however, it has certain drawbacks:

1. Solar tree capital cost is its biggest issue. Due to metals, solar trees are expensive to build. We can use wooden elements with a plastic abutment or a basic design with fewer metal parts to lower the capital cost of the solar tree.
2. Solar trees have distinct P-V and I-V characteristics because each solar panel has a varied angle and orientation and receives different solar irradiation, which increases inverter losses and lowers conversion efficiency. Inverter losses prevent direct grid connection of the solar tree. Battery energy storage and grid power delivery can solve these issues.
3. Solar trees have numerous stages, creating shadows. Upper solar panels may shadow lower ones. We should pick shadow-free designs.
4. Solar tree designs for low-power applications are being improved for high-power applications.
5. Solar tree heat dissipation can kill birds. For bird safety, apply insect repellents.

VII. CONCLUSIONS

The notion of a solar tree is advantageous for power generation because it uses only 1% of the land required by traditional solar modules, a problem that affects every country in the globe. For a higher energy output per unit of ground footprint, the solar tree concept is quickly gaining favor. In cities with fewer open places, the PV tree concept may be an appropriate alternative. Analyzing the different PV tree designs is the driving force for this review. Compared to typical PV modules, solar PV trees provide more power because the solar panels' orientations allow for more chances of gathering solar radiation. The most promising "green" energy source may turn out to be the solar tree design concept. Diverse uses in a decorative style, such as charging and street lighting, are used with the various solar tree design structures. It has a wide range of uses, including powering laptops and mobile devices, lighting up the streets, supplying homes and businesses, and supplying extra energy to the grid. The field of solar trees has undergone a wide range of research. However, there is a lot more unfinished research that needs to be done in the future, such as tracking the maximum power point, dependability, cost-optimization, and inverter design. Because solar PV cells are expensive and if they are installed in a region where sunshine cannot reach owing to various obstructions because of shadow, the amount of energy generated is greatly reduced. It is, therefore, necessary to research to determine the precise shadow impact and sunshine intensity at each location.

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