Application of Solar Tree in Economic Electrification

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Abstract

This article introduces a new solar technology that emulates how trees convert sunlight into energy. Solar tree is a metal structure that looks like a real tree with branches at the top of which are solar panels. This solar panel collects solar energy and transfers it to electricity which can be used for batteries charging of mobile phones, tablets and portable computers. Also, collected electricity can be used as power for info panels and lighting. The article is focused on the design, technology and economy part of above-mentioned study. Except results of technology and economy parameters, three different design solutions of solar trees adjusted for urban environment will be presented. Using 3D CAD modeling software, different approaches were designed by means of getting photo-realistic pictures (rendering) of those solutions in chosen urban locations.

Introduction

Engineering communities in universities and private companies are putting many resources into the development of efficient renewable energy technologies, and clean technology development is furthermore receiving political focus in environmental and research policies. Renewable energy is energy produced from natural sources like sunlight, wind, rain, waves and geothermal energy which is renewable (power naturally). In most of the cases, renewable energy comes from sun energy, wind power, hydropower, biomass, bio fuel, etc. Sun to earth emits around 5.25 kWh/m^2 per day.

After centuries of using fossil fuels, global energy situation is changing; renewable energy takes more and more place every day. In 2006, renewable energy sources took 18% of global energy production, 13% of that was traditional biomass (burning the wood) and 3% hydropower. New technologies like geothermal, wind and sun energy take only 0.8% of global energy production. They have big potential, but they are not used properly [2].

Renewable Energy Sources

Most of the renewable energy sources get energy from the Sun. Earth atmosphere system is balanced, heat radiation from the earth to the space is equal to the sun radiation, because of this we have naturally produced energy on the surface of the earth; this energy is usually called the Earth climate. Hydrosphere (water) absorbs one part of the incoming radiation.

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Most radiation is absorbed at low latitudes around the equator, but this energy is dissipated in the form of winds and ocean currents around the globe. It can be said that winds and ocean currents transform heat energy to mechanical energy in the form of wave movement. Solar energy is also responsible for distribution of rainfall and for the cultivation of plants used for biofuel production around the globe.

Nowadays with the growing population and energy demand, we should take a renewable option of energy source and also we should keep in mind that energy should not cause pollution and other natural hazards. In this case, solar energy is the best option for us. India is a highly populated country, so we should take the advantage of such an energy which requires very less space to produce energy efficiently. In this case, solar tree could be the best one for us. We can also use the technique called "Spiralling Phyllataxy" to improve the efficiency of the plant.

Solar Power

The Sun gives out 3.7*1026 W of energy into space, out of which earth intercepts only 5*10-10th part of the solar energy output. The energy intercepted by earth is equivalent to 1.7*1017 W.

The energy emitted by Sun in three minutes is equivalent to the world energy consumption during a year. Most of the solar radiation reaches earth as electromagnetic waves of about 0.25 to 3 μ wavelength. Solar energy is a unique source of energy which can be exploited in many different ways as one such way is by direct conversion to electricity by photovoltaic.

Photovoltaic Conversion

In Photovoltaic conversion, solar radiation falls on semiconductor devices called solar cells which convert sunlight directly into electricity. When light falls on the junction between two types of semiconductors called P-type and N-type, N-type has an excess of electrons and P-type has a shortage of electrons. When a bright light shines on a cell, energy from the light (photons) enables electrons to break free from the junction between them. This is called photoelectric effect. The flow of electrons constitutes an electric current stored in batteries.

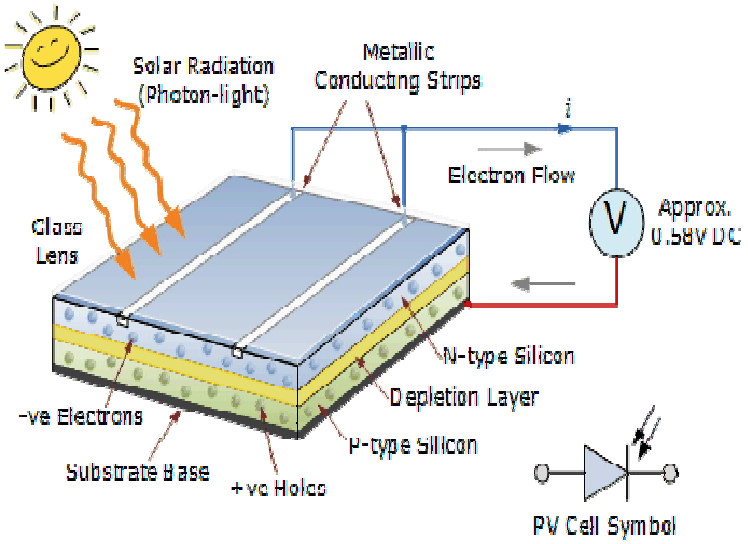

Figure 1.Photovoltaic Effect

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Solar Tree

The solar tree is a revolutionary urban lighting concept that represents a perfect symbiosis between pioneering design and cutting-edge eco-compatible technology. Solar tree opens up new prospects for urban lighting that satisfies today's most pressing environment, social, and culture and aesthetic demands.

A solar tree is a decorative means of producing solar energy and also electricity. It uses multiple numbers of solar panels which form 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

E-Electricity

This is a tree in which the stem connected acts as the branches of the tree and the solar panels act as the leaves. Green leaves are producing food materials for human beings, likewise these leaves are producing energy for the society. So it is very appropriate to call it a tree.

The solar tree panels charge batteries during the day. At dusk, the solar tree automatically switches on its LEDs. The internal control can also regulate the amount of light produced depending on how much charge is left in batteries.

Spiralling Phyllataxy It is a technique used in designing of solar tree and the arrangement of the leaves on the stem of a plant. It provides the way to help the lower panels from the shadow of upper ones, so that it can track maximum power from the Sun. This technology is used to improve the efficiency of the plant.

Components of Solar Tree

The solar tree consists of mainly five parts to design:

- Solar panels
- Long tower
- LDEs
- Batteries
- Stems for connecting the panels

Why We Call It A Solar Tree?

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 the Sun and the water present in soil during day time and can produce their own food material. By this process, they are indirectly providing food to human society because we are dependent on 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 act as the branches of the tree and the solar panels are like leaves. Green leaves are producing food materials for human beings, likewise these leaves are producing energy for the society. So it is very appropriate to call it a tree.

How Solar Panels Work?

Photovoltaic cell converts sunlight into electric energy and this effect is known as photovoltaic effect.

Solar cells essentially create electricity by converting photons of light into electrons. Solar cells produce direct current, or DC; this DC

current is converted to alternating current, or AC by using inverter circuits.

Working

Batteries are charged during the day time. LEDs are automatically switched on. These are used to indicate how much charge/energy is left in batteries, which are also used to store the energy so that we can use it at night and in cloudy days when no sunlight is there. They can power homes, reducing costs and air pollution. They would also collect energy from the wind.

Figure 2.Solar Tree

Solar trees deliver the following benefits:

- Build awareness and interest in solar technology, thereby promoting its adoption.
- Provide shade and meeting places.
- Differentiate properties, especially those with other hidden green building measures.

Why is It Needed?

1. Less land requirement: It is the best option for energy generation because it requires very less land as compared to the traditional PV system. Nowadays land becomes the costliest commodity for the human society because of high population growth. Example-To generate 2 MW power from a PV module we require 10-12 acres of land for housing of panels only. But for the same amount of energy we require only 0.10-0.12 acres of land in case of solar tree. So we require such a plant which can generate maximum energy using minimum land.
2. Efficient energy generation: It can generate energy very efficiently as compared to traditional system. Due to the technique called spiraling phyllataxy, its efficiency further increases. We can also use the technique called-spiralling phyllataxy to improve the efficiency of the plant. It can be applied in street lighting system, industrial power supply, etc. It is much better than the traditional solar PV system from area point of view and also more efficient.
3. Collecting energy from wind: As the name suggests, this is a device to generate energy from the Sun but it has some unique features to generate energy from the wind too. The stems are flexible so that they can rotate in any direction and by shaking themselves they produce energy also from wind as in the case of a natural tree. The unique technique is that flexible

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panels are connected to the stem which can be rotated as we desire, so that flexibility avoidance of wind pressure can be possible. Flexibility offers manual rotating so that maximum power can be obtained.

General Design Approach

Possible design solutions do vary according to many different factors. There are several of them. Authors tried to adjust their potential design solution with regards to some of them, which they believed to be the most influencing. Furthermore, with the beneath listed criteria, authors tried to establish a general design solution algorithm based on the available project and design documentations for some solar trees.

Location regarding light conditions: One of the most important factors is the potential location where the tree should be placed. Urban environment is very specific regarding the surrounding objects which substantially influence light conditions around the tree. The potential location should be chosen carefully to enable optimum light conditions during the day.

Available type and design of solar panels: According to the fact that the panels are the most important part in a solar tree construction, it is therefore a crucial part which influences the final look of the design. Mass, shape, number and the arrangement of the panels finally influence the rigidity, center of gravity and other calculation outputs of the tree which lead to the final look of the design.

Aesthetic requirements: If the design of the tree and its look should be preferred in regard to the purpose then this will eventually lead to more complexity throughout the whole design process. This parameter is closely related with the previously mentioned. This criterion is very difficult to generalize but requires detailed investigation of individual tree projects.

Financial costs: Even though it is mentioned as the last one, it is probably the most influencing criterion in every project. The complexity combined with the variety of previously mentioned parameters sets this criterion as a final justifier for every possible solar tree design solution.

Solar Tree Proposal for Powering Consumers

The idea includes two main consumers-charging devices and LCD monitors. In addition to that, an accumulation device should be stored at the pedestal region where the flange attaches the construction to the ground. To enable a place to rest for passers, an extra seat in circular shape is added around the main trunk. At the same time this seat should cover the accumulation device making the whole design more attractive. Simultaneously, it should isolate the accumulation device from climate impacts such as rain or snow. To simplify the design approach, calculation, maintenance and make the whole design at the same time look aesthetically acceptable, authors suggest a totally symmetric design with three axis of symmetry.

The main body is a simple hollow tube closed at one end to enable the attachment of the upper, smaller rod which should carry the upper panel. This panel is placed high above the other panels at a vertical angle. The angle provides a constant area for sunlight regardless of the sun trajectory during the day. The height at where it is placed enables a greater panel area which will not cover the lower-placed panels.

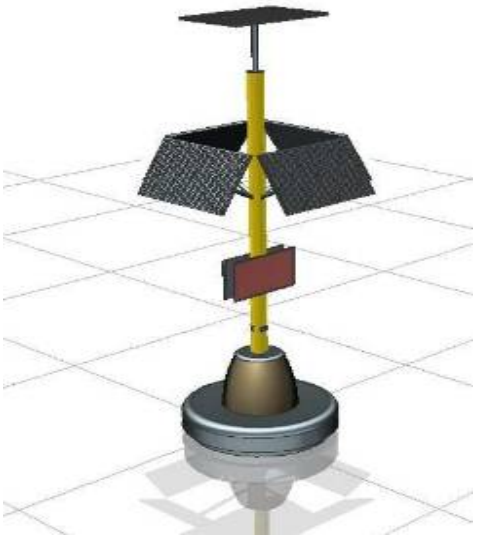

Figure 3.Solar Tree Proposal for Powering Consumers

Solar Tree Proposal for Street Lightning

This design approach is far simpler than the previous one. In general, solar tree designs for lightning purposes do not have to power such huge consumers in comparison with light bulbs. This simplification also applies to the design concept. No extra adds are needed in the case of a street lightning-dedicated solar tree. The basic three components regarding the design are: the pillar-trunk, solar panels and light bulbs. Urban environment causes the base to be out of a serious construction material like concrete. The previous simplification enables the design to be more aesthetically orientated so that it can fit more into a certain urban architecture where the tree is placed. Even though the concept looks pretty unusual, with lots of rare elements, it has to be said that branches are standard elements set up just at a different pattern which start at different angles of array. Light bulbs are attached to solar panels from the bottom side so they cover an area according to solar panel calculations.

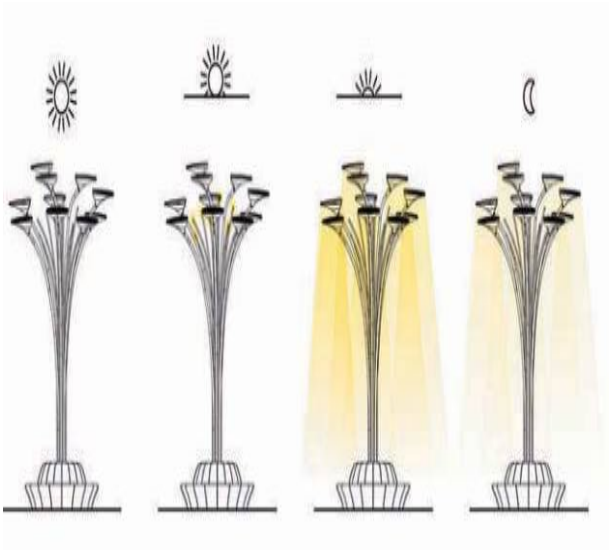

Figure 4.Solar Tree Proposal for Street Lightning

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Conclusion

To fulfill the increasing energy demand of the people and saving of land, the solar tree concept is very successful one and should be implemented in India to provide electricity without the problem of power cuts and the extra energy can be provided to the grid. Even though the concept looks pretty unusual, with lots of rare elements, it has to be said that branches are standard elements set up just at a different pattern which start at different angles of array. Light bulbs are attached to solar panels from the bottom side so they cover an area according to solar panel calculations.

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