Advanced Research in Electrical and Electronic Engineering
Print ISSN: 2349-5804; Online ISSN: 2349-5812 Volume 2, Number 10 April-June (2015) pp. 67-71

http://www.krishisanskriti.org/areee.html

Design of Solar Tree with Photovoltaic Panels using Fibonacci Pattern

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Abstract—*This paper presents a technology that emulates how trees convert sunlight into electricity. Sun daily radiates an enormous amount of energy to Earth, and that energy is still not properly exploited, neither in World nor in India. There is no systematic stimulation for usage of solar panels, purely relying on individual cases of installation on different types of objects. Solar photovoltaic (SPV) is a land consuming system. Scarcity of land is the greatest crisis of the Earth. Now a days 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. Solar Tree is invented for installing PV-module on a tall pole-like structure with branches like panels and takes only 1% of land than conventional SPV layout.*

1. INTRODUCTION

The object of this work is to design an installation that, using photovoltaic panels, could provide the electricity in the areas where the electricity grid is not reachable or areas in which we don't want to depend on it. Using the renewable energy source we'll get services efficiently with minimum environmental impact and large savings in electricity bills [1].

Here comes the idea of a Solar Tree [2] a new invention of installing PV modules on a tall pole like structure with leaf like branches surrounding it following a pattern of spiraling phyllotaxy as found in natural tree. It would take 1% of land area in comparison to general PV system [3,4,5]. One need to erect the PV panels under the sun so that the surface of panel gets maximum sun of the day being laid at an angle. Now for an example, the generation of 2 MW power from PV module system requires the land of 10 Acres approx. for housing the panels only [6]. But land is going to be greatest crisis of the earth rather is already a burning crisis in the most of the countries [7]. The cultivable land which is going to be the costliest commodity in the near future, if used for other than agriculture, it will be uncountable loss. Our many national projects are facing the severe problem of acquisition of land. Therefore if land area is used for capturing the solar power it would never be cost effective and viable for the human society [8, 9]. Therefore there is a need for devising a method and fabricating a suitable device so that the solar power can be absorbed without occupying much surface area, rather utilizing he minimum amount of land and the electricity must be economically viable [10].

2. SOLAR POWER

The energy emitted by sun within three minutes is equivalent to the world energy consumption during a year. Solar energy is unique source which can be exploited in many different ways as one such way is Photovoltaic conversion [11]:

In Photovoltaic conversion, solar radiation falls on semiconductor devices called solar cells which convert sunlight directly into electricity [12, 13]. When light falls on the junction between two types of semiconductor called p-type and N-type-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. Photovoltaic effect is shown in the Fig. 1.

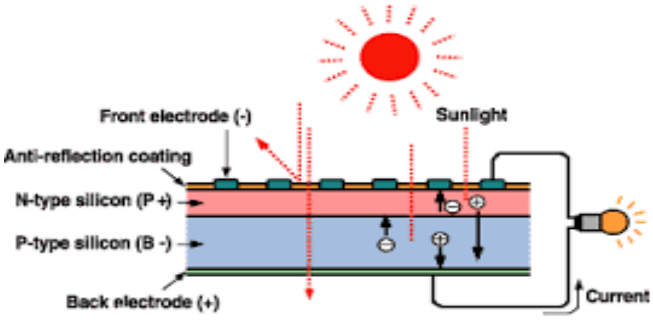

Fig. 1: Photovoltaic Effect

3. INSPIRATION

The idea for this project started with the following hypothesis. If we build a solar tree using solar panel in which each element follows the distribution of leaves in a tree, we will have good performance in capturing electromagnetic waves.

Tree can produce their food material by the process called PHOTOSYNTHESIS.

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 for the society. So it is very appropriate to called it as a tree**.**

3.1 Solar Tree

It is a combination of innovative design and advance technology. 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. Fig. 2 shows the design model of solar tree.

Fig. 2: Design model of solar tree

3.2 Components of Solar Tree

Solar Panels,

Long Tower,

LEDs,

Batteries,

Stems for connecting panels

3.3 Uniqueness of Solar Tree

The uniqueness of this single pole/tower solar tree is that the solar PV modules will be fixed throughout the tall pole following a pattern of spiralling phyllotaxy. So that the top panels wouldn't obstruct the bottom ones and each panel of the tree would get maximum sun in a day time.

The other uniqueness is that the panels will be naturally facing towards the sun at an angle as required so that they can fix up maximum solar energy in a day time. Foundation of pole and Battery Bank is shown in figures 3 and 4 respectively.

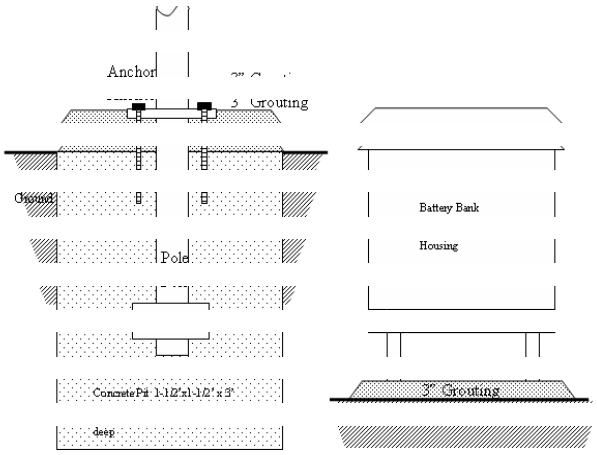

Fig. 3: Foundation of Pole

Fig. 4: Foundation of Battery Bank

4. WORKING OF SOLAR TREE

Storing of electric energy is a major problem for all electric power system. Ways to eliminate solar cell output fluctuations cause by day and night cycle and weather shifts. Solar tree panels charge batteries during the day. At dusk the solar tree automatically switches on its LEDs. The internal control can also regulates the amount of light produced on how much charge is left in the batteries [14]. 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 sunrise. Solar Tree is capable of functioning for three consecutive days of cloudy or overcast weather.

5. FIBONACCI PATTERN

Trees capture light in an efficient manner, due to the orientation and distribution of their leaves. One of the mathematical patterns that can be frequently found in nature is the Fibonacci sequence [15]. The angles and lengths of branches, the distribution of leaves, and the spiral forms in seashells are some examples of these patterns. The Fibonacci pattern comes from a numerical sequence discovered by the Italian mathematician Leonardo Fibonacci. He discovered the Fibonacci sequence by studying nature. The sequence is

(1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144 etc…..)

The Fibonacci sequence is defines as

$$F = \{F_0, F_1, F_2 \ldots\ldots\}, \quad (1)$$

$$F_0 = 0, F_1 = 1, \quad (2)$$

$$F_k = F_{k-1} + F_{k-2}, \text{ for } k = 2, 3,.... \quad (3)$$

In the specific case of trees, the angles and lengths of the branches follow a Fibonacci pattern in which it takes n branches to complete m turns around the trunk, with (m,n)∈ F.

Fig. 5 shows one example of the Fibonacci sequence found in nature.

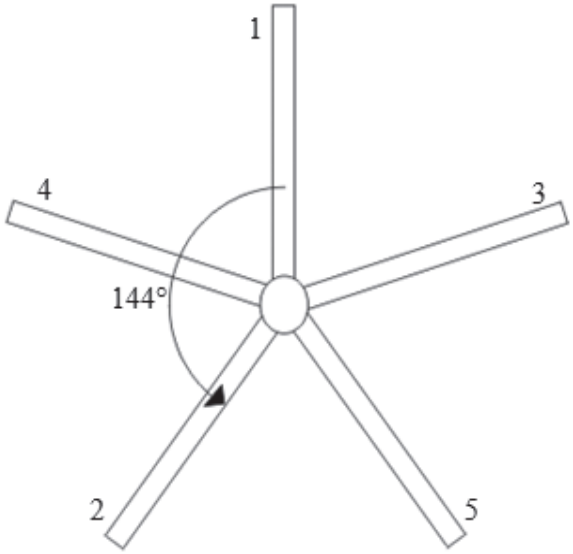

Fig. 5: A top view of the branch structure in oaks. The branches have an angular separation of 144°, and the vertical separation also follows a Fibonacci pattern.

5.1 The Angular Distribution of the Branches

The Fibonacci sequence was found in the number of branches needed to have an integer number of turns around the trunk. In the case of oaks, there are five branches in two turns (720°) around the trunk. Fig. shows the top view of the branches following this pattern, in which they are separated by 144°.

Table 1: The position of the branches.

Branch	Angle
1	144°
2	288°
3	432°
4	576°
5	720°

Fig. 6 shows the schematic diagram of general arrangement of Photovoltaic Plant.

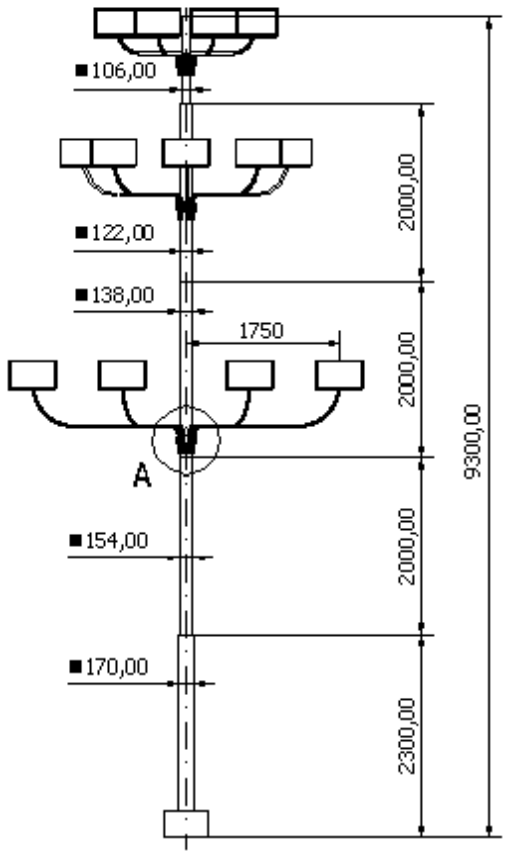

Fig. 6: Schematic diagram of general Arrangement of PV Plant

6. ADVANTAGES OF SOLAR TREE

This system does not require the acquired big landed property at a single place, rather for this type of solar power generation the Road sides, the islands, in between wide roads/highways, the boundary walls etc can be used.

Solar panels have no moveable parts and are very simple to use. After being set up properly, they do not need to be tinkered with and will continuing working for many years. In fact, many manufacturers have 25 year warranties on their panels.

No matter where you live, the chances are that you can successfully use solar panels for you electrical needs. They are rugged and are very adaptable to climate conditions and the latest panel models are efficient enough to work well without facing directly south and some will even produce electricity under cloud cover.

By switching to solar energy, you will save money on your electrical bills every month. Even if electricity bills continue raising in the next few months you will have the peace of mind knowing that your energy source is based on solar power.

For obvious reasons, the use of solar panels is Eco friendly and considered one of the most "green" electricity resources. Because they operate by interacting with a renewable energy source, sunlight, there is no fear of depleting yet another natural resource.

Private home owners are discovering the benefits to our environment and a way to live happily off the grid or are considering installing a grid-tied solar power systemto offset their electric bill or due to a belief in reducing their carbon emissions. These are great reasons to "go solar". Fig. 7 shows the applications of Solar Tree.

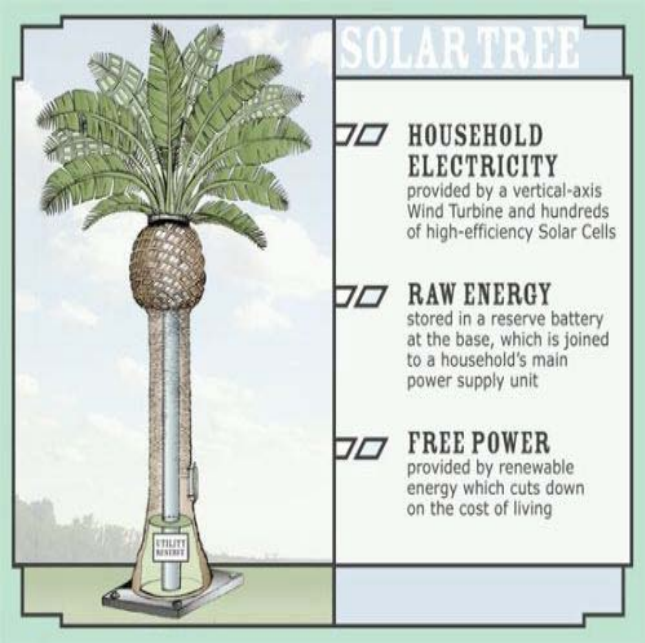

Fig. 7: Application of Solar Tree

7. CONCLUSIONS

The solar trees can be planted without any acquisition of vast land exclusively for this purpose in a particular place. They can be installed on the road sides as they consume around 4 Sq. Feet of area for a single tree.

Solar tree can provide electricity without any power cut problem. For the saving of land this project is very successful one as it takes 1% of land area in comparison to general PV system. Hopefully if this new method of solar tree plantation is adopted widely it would be possible to produce for the world keeping the best ecological balance and preserving the nature as it is.

Fig. 8 and 9 shows the bar graph of comparison of solar tree and traditional PV system in the months of March and April.

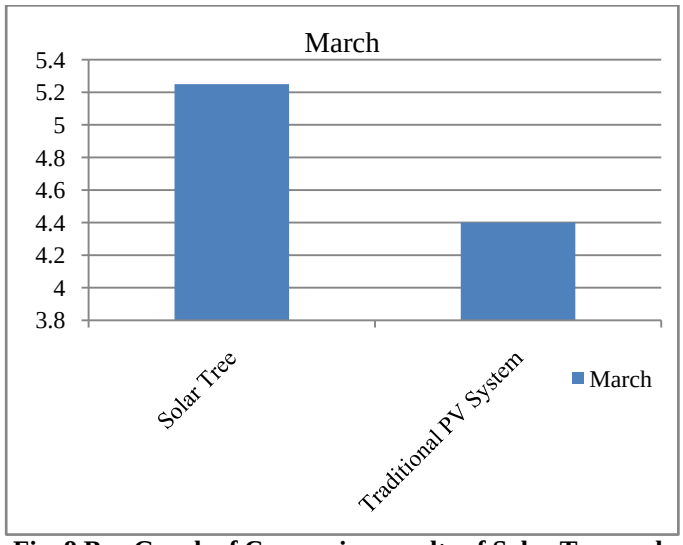

Fig. 8 Bar Graph of Comparing results of Solar Tree and Traditional PV system in March

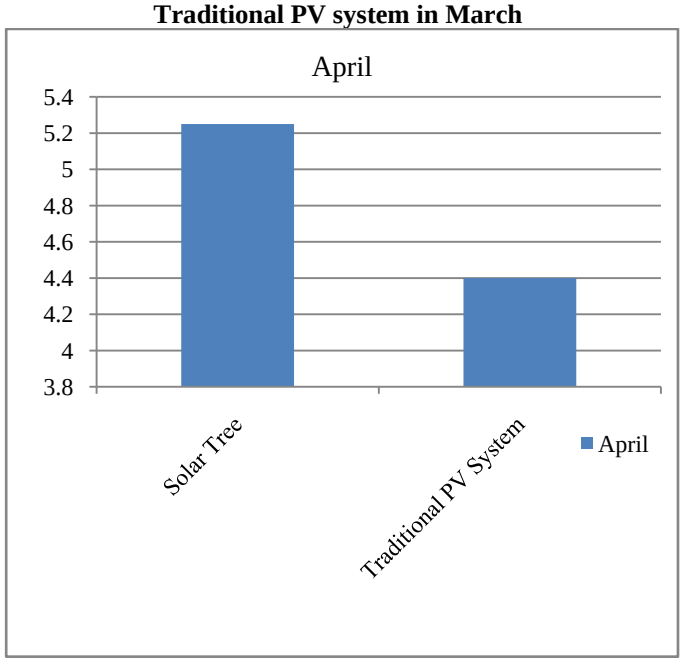

Fig. 9: Bar Graph of Comparing results of Solar Tree and Traditional PV system in April

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