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SOLAR TREE: New Proposed Model For Harnessing Solar Energy And Its Scope In India

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Abstract
This review paper consists of study of a new design solar model which can overcome the drawbacks of conventional method of collecting solar light. In present work we study a solar tree model which structure is based on the pattern of natural tree. As in natural trees leaves and branches are arranged in a manner so that they can capture more sunlight for their living. And by arranging this way they avoid shading from each other. This special arrangement is called phyllotaxy which is directly related to the Fibonacci number and Golden ratio. In a similar way if solar panels are being arranged by using specific pattern they will be oriented in different directions. As sun moves through different locations in the sky throughout the day, each panel gets good share of sunlight at different instant of time and boost up the overall power of solar tree.

Keywords- solar photovoltaic; three-dimensional; phyllotaxis

1. INTRODUCTION

At the present time people are being aware of the importance of use of renewable energy sources in which *solar energy resource* is playing a crucial role. Solar power dominates fossil fuels greatly in two manners: (a) Solar power is renewable form of energy and it is never going to run out. (b) It is eco-friendly. Among all the energy sources available, solar energy is the most promising.

Solar power can fulfill the world's energy need either directly or indirectly. But solar energy must be utilized properly. However extracting power from sun efficiently is a major challenge. Several techniques are being devised for extracting power from sun efficiently. The P-V cells available in solid silicon crystalline forms are being used for conversion of insolation to electricity. Other form like amorphous or thin film cells are also available but most efficient is the solid crystalline PV cells for direct absorption of sunlight. The other applications of solar energy are water and building heating etc. However these uses are less efficient as compared to PV technology. Solar PV technologies convert solar energy into usable energy forms by directly absorbing solar photons-particles of light that act as individual units of energy-and either converting parts of energy into electricity as in a PV cell or storing part of the energy in chemical reactions. The main focus of this work is on the PV cells.

Generally in solar power generation system PV panels are erected on a hut like fixed structure in open space under the sun and for large power generation these structures require large area of land surface in acres. Land is already a burning crisis in most of the countries and it would be uncountable loss if land is used for other purposes than agriculture. Along with most of the agriculture areas are in need of electricity but are far away from the conventional power plants. Hence, using vast land, for capturing solar power would never be cost effective and viable for human being.

The above stated problem motivated us to go through and study new models which can utilize minimum land for maximum solar power absorption by creating maximum solar surface termed as a solar tree. From here comes the idea of solar tree design in which solar panels are arranged along the branches of solar tree stem such that at each node there is only one solar panel. This technique of arranging solar panels is termed as spiraling phyllotaxis which is usually followed by natural trees.

This paper is organized as follows. In section 2, we present basis of solar tree design. In section 3, we discuss how performance analysis of solar tree can be done. In section 4 we present different modifications to be done in solar tree design and its future scope.

2. BASIS OF SOLAR TREE DESIGN

Design of solar tree model is bio-inspired so that solar panels can absorb more sunlight similar to the leaves of a natural tree. Hence there is a need to know about some terms which are the basis of solar tree design and plays an important role in growth of natural plants.

2.1 Phyllotaxy is the arrangement of leaves on a tree. Phyllotaxy shows the apical meristems growth of a plant. This is defined by meristems consist of organogenic cells that are established during plant embryogenesis and are found in plant segments where growth takes place. Apical means at the top-peak or summit of a structure. **(Barabe, *et al.,* 1997)**

The basic phyllotactic patterns in the plant kingdom are (a) opposite phyllotaxis (b) whorled phyllotaxis (c) alternate phyllotaxis

2.2 Alternate phyllotaxis pattern is used in our solar tree model. Hence there is only one solar panel at each node. The spiral patterns, natural trees follow, include **Fibonacci numbers**. As spiral pattern of oak tree, almond tree, elm tree, poplar tree, beech tree etc. can be given as respectively 2/5, 5/13, 1/2, 3/8 and 1/3. All these numbers 1, 2, 3, 5, 8, 13…. form the **Fibonacci sequence**. The formula of Fibonacci sequence is

$$F_{n+1} = F_n + F_{n-1} \quad (2.1)$$

This Fibonacci pattern is the basis of design of our solar tree model. **(Grigas, 2013)**

2.3 Proposed material and methodology for solar tree design

For the design of solar tree materials to be used are listed as below:

(a) a PVC rod as a trunk of tree
(b) Al sheets as branches of tree
(c) solar panels as leaves of tree
(d) a base structure made of Al for holding solar tree model

Solar tree model can be designed by copying a fibonacci pattern of any tree suppose oak tree which is 2/5 (spiral phyllotaxy). In this pattern spiral takes two spirals around the main trunk to cover all the 5 branches and 6th branch is placed at the same position as of first branch from the main trunk. This can be understood with the help of Fig.2.1.

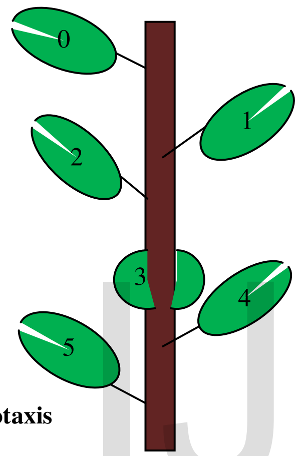

Fig.2.1 2/5 Phyllotaxis

As pattern is 2/5, hence angle between each branch can be calculated as follows:

$$\frac{2}{5} \times 360^{\circ} = 144^{\circ}$$

If we consider first branch from the top of main trunk as a reference then next branch is placed at an angle of 144° in anticlockwise direction (216° in clockwise direction). Similarly other branches are placed such that angle between successive branches remains 144° in anticlockwise direction. As the pattern is spiral phyllotaxy, at each node there is only one branch. Position of panels of solar tree will depend upon latitude of the site where solar tree is to be installed as maximum solar exposure by a solar panel can be done when its tilt angle becomes equal to latitude of site.
Depending on a location if tilt angle of first panel is 29° then other panels can be oriented in following ways

2.3.1. Design layout of solar tree model

Design specifications of solar tree model can be given with the help of Fig.2.4

Calculation of circular distances between different points in Fig.2.5 can be done using following formula:

Table 2.1 Orientation and tilt angle of different panels

	Tree Solar						Conventional Panel
	From Top to Bottom of Main Trunk						
	1st panel	2nd panel	3rd panel	4th panel	5th panel	6th panel	
Tilt angle	29°	**7°**	43°	79°	65°	29°	29°
Orientation	South	North-East	West-South	South-East	North-West	South	South

$$arc = angle(made\ by\ arc\ at\ the\ centre\ of\ circle\ in\ radian) * radius \quad (2.2)$$

2.4 Analysis of solar tree performance

To analyze the performance of solar tree model a conventional panel of same rating can be used so that parameters of both models are compared under sunlight. We can compare power values and irradiation level of different duration in a day as well as of different days on both models. By using instruments like solar power meter, multi-meter, rheostat as load, wires, connecting leads and probes voltage and current parameters of both models and irradiation level at both models can be calculated. And by using these parameters power values (P= V*I) for both model can be calculated.

2.5 Modifications in solar tree design and its scope in India

As in proposed model of solar tree different panels are oriented in different directions, we can use mppt techniques at each panel so that each panel can receive maximum amount of sunlight in every direction. Using this solar tree model will become more efficient. As we use 6 panels in our solar tree model according to 2/5 pattern, it is one-stage model. We can increase number of stages in solar tree model to increase amount of power generation. As we increase height of solar tree to increase number of panels, to avoid shading effects we can use blocking and bypass diode across each panel.
in length it would be possible to produce 110 MW by installing solar power trees of 2KW capacity through the road sides at a certain interval (say 15 meter between two trees). This would actually require 660 Acres of land for the same power generation at a single place by the existing method of laying out solar panels in a conventional way i.e. over the roofs of low height fixed structures. The village roads and the big boundary walls of paddy lands can provide sufficient space for planting solar power trees that can supply enough power for electrification of villages and irrigation activities.

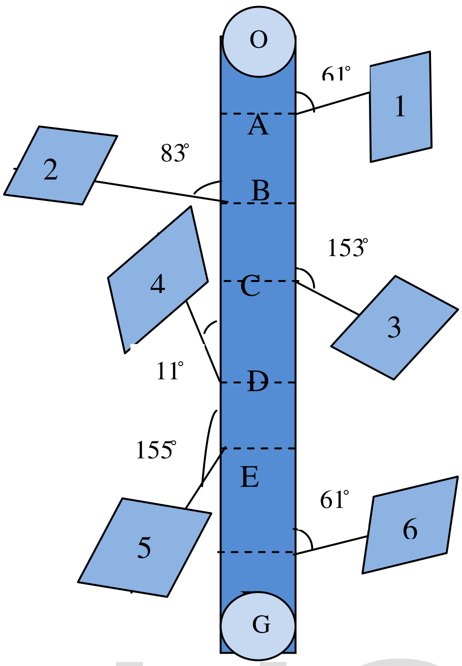

Fig.2.4 Structure of solar tree model

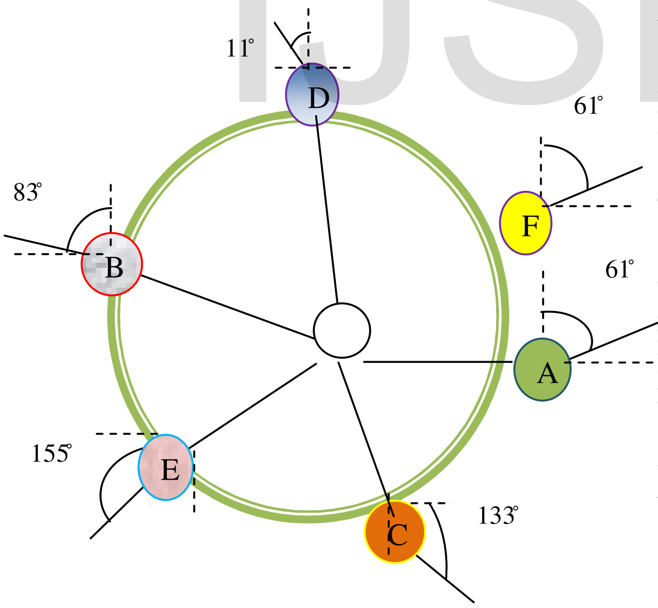

Fig.2.5 Position of different branches from top-view of solar tree

The state and national highways are big sources for Solar Power Tree (SPT) plantations. Two sides of single road high ways and the three sides of double road highways including island in between can be utilized for solar power trees. A simple calculation shows that if the National Highway is used for plantation of solar power trees from Kolkata to Asansol which is around 300 km

3 CONCLUSION

On comparing it can be concluded that Fibonacci tree design will overcome drawback of the flat panel model due to its specific design. Electricity will drop in the flat-panel array when shade fell on it but the tree design will keep making electricity as the Fibonacci pattern helps some solar panels to collect sunlight even if others are in shade. Fibonacci pattern helps branches and trees to avoid shading from each other. Bad weather like snow doesn't hurt it as panels are not flat. Hopefully if this new method of solar power tree plantation is adopted widely it would be possible to produce sufficient energy and to satisfy the demand of power for the world keeping the best ecological balance and preserving the nature as it is. A design like this may work better in urban areas where space and direct sunlight can be hard to find.

REFERENCES

[1] Adams, W. 1876. The action of light on selenium. *Proc R Soc*, 25: 113-117.

[2] Armstrong, S. and Hurley, W.G. 2010. A new methodology to optimize solar energy extraction under cloudy conditions. *International Journal of Renewable Energy*, 35: 780-787.

[3] Avdic, V.; Zecevic, S.; Pervan, N.; Tasic, P. and Muminovic, A.J. 2013. Different design solutions of solar tree in urban environment. *In*: GDC 2013 2nd Green Design Conference, Green Cities, Building and Products, Sarajevo, International Council for Research and Innovation in Building and Construction (CIB), Working Commission W115 and The University of Twentes, The Netherland. pp. 40-45.

[4] Avdic, V.; Zecevic, S.; Pervan, N.; Tasic, P. and Muminovic, A.J. 2013**.** Implementation of solar tree project in Sarajevo. *In*: GDC 2nd Green Design Conference, Green Cities, Building and Products, Sarajevo, International Council for Research and Innovation in Building and Construction (CIB), Working Commission W115 and The University of Twentes, The Netherland. pp. 60-67.
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[5] Bidwell, S. 1885. On the sensitiveness of Selenium to light and the development of a similar property in Sulphur. *Proc Phys Soc, London*, 7: 129-145.

[6] Barabe, D.; Adler, I. and Jean, R.V. 1997. A History of the Study of Phyllotaxis. *Annals of Botany*, 80(3): 231-234.

[7] Douady, S. and Couder, Y. 1992. Phyllotaxis as a physical self organized growth process. *Phys Rev Lett.,* 68(13): 2098-2101.

[8] Douady, S. and Couder, Y. 1993. Phyllotaxis as a self organized growth process. *In*: Douady, S. and Couder, Y. Growth Patterns in Physical Sciences and Biology. 304, New-York, Springer-US, pp. 341-352.

[9] Einstein, A. 1905. On a heuristic point of view concerning the production and transformation of light. *Annalen der Physik*, 17: 132-148.

[10] Grigas, A. 2013. The Fibonacci Sequence: Its history, significance and manifestation in nature. Thesis, Graduation Honors Program, Liberty University, United States, 334p.

[11] Jenkins, T. 2005. A Brief History of Semiconductors. *Phys Educ*, 40(5): 430-439.

[12] Koch, V.P.; Hezel, R. and Goetzberger, A. 2009. High efficient low cost photovoltaic: Recent Developments, Springer, pp. 1.

[13] Kuhlemeier, C. 2007. Phyllotaxis. *Trends in plant science, Rev.,* 12(4): 1360-1385.

[14] Markvart, T. 2000. Solar Electricity, Wiley.

[15] Maity, S.N. 2013. Development of Solar Power Tree: An innovation that uses up very less land and yet generates much more energy from the sun rays by SPV method. *Journal of Environmental Technology*, 2: 59-69.

[16] Nelson, J. 2003. The Physics of Solar Cells. Imperial College Press.