

# Solar Tree-Working Principle, Arrangements- A Study

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## Abstract:

Now a day energy demand is increasing. To fulfill the required demand of energy, renewable energy sources are best option. It's also important that the generated energy should not cause pollution and other natural hazards

There are different renewable energy sources available but energy from the Sun is the most excellent alternatives among all renewable energy sources. It is at no cost, unlimited, nonpolluting, eco-friendly and constant source of energy. Among all the different techniques available to harness solar energy, the most popular and mature technology is the photovoltaic conversion of sunlight into electricity. However the main problem associated with tapping solar energy is the requirement to install large solar collectors, which occupy very big space. To avoid this problem solar tree can be installed in spite of solar panels, which require a small space .It's a metallic structure like real tree having branches. Solar panels are connected at top of branch. The panels connected in series and parallel fashion. To increase voltage, panels are connected in series while to increase current panels are connected in parallel. These panels accumulate solar energy from Sun and transfer it to electrical energy. This energy can be utilized for various devices like mobile phones, tablets and portable computers. Also, can be used for street light and domestic purpose.

**Index Terms - Renewable Energy, Photovoltaic, Solar Tree, Tracking.**

## I. INTRODUCTION

Climate change is one of the major issue or challenge which mankind is facing .Based on statistics available, this challenge will produce serious impact on economy development. To overcome these challenges one of best solution is to increase use of renewable energy sources or non conventional energy sources [7]

These non-conventional sources are produced continuously in nature. There are different renewable sources which used for electric power generation, such as solar energy, wind energy, geothermal etc [8]

Renewable energy is produced by renewable natural sources like sunlight, wind, rain, waves and geothermal energy. In the majority of cases renewable energy comes from sun, wind, hydro, biomass and biofuel etc. [9]

**Wind Energy:** Winds are caused because of two factors. 1. The absorption of solar energy on the earth's surface and in the atmosphere. 2. The rotation of the earth about its axis and its motion around the Sun.

A wind mill converts the kinetic energy of moving air into Mechanical energy that can be either used directly to run the Machine or to run the generator to produce electricity.

**Tidal energy:** Tides are generated primarily by the gravitational attraction between the earth and the Moon. They arise twice a day in Mid-Ocean. The tidal range is only a Meter. Basically in a tidal power station water at high tide is first trapped in an artificial basin and then allowed to escape at low tide. The escaping water is used to drive water turbines, which in turn drive electrical generators [6]

**Solar energy:** Solar energy is a free, clean and inexhaustible source of energy which is available everywhere. [10]

The Sun's energy comes from nuclear fusion reaction that takes place deep in the sun. Hydrogen nucleus fuse into helium nucleus. It has been identified as an alternative electricity source with respect to the increase in energy demand and cost [11]

With depleting conventional sources of energy, the world is looking towards renewable energy sources viz solar, wind, tidal etc. Sun, a star, radiates lot of solar energy onto earth surface and is a permanent source of energy. The amount of solar energy incident on the earth's surface is approximately  $1.5 \times 10^{18}$  kWh/year. The density of power radiated from the sun (referred to as **solar energy constant**) is  $1.373 \text{ kW/m}^2$  [3]

## I. CONCEPT OF PHOTOVOLTAIC:

Solar energy is directly available from sun in the form of sunrays. Photovoltaic effect is used to convert the sun's energy into electrical energy.

The photo voltaic effect is defined as the generation of the electromotive force which results from absorption of ionizing radiation. The device which is used for this effect is called as photo voltaic cell (PV /solar cells). A single converter cell is called a solar cell or PV cell, and combination of such cells, designed to increase the electric power output is called a solar module or solar array.

Photo voltaic cells are made of semi conductors that generate electricity when they absorb light. As photons are received, free electrical charges are generated that can be collected on contacts applied to the surface of the semi conductors. [6]

While designing any solar based system, performance of PV cell is considered to be very important. This performance is depending upon climate, radiation, angle of incidence etc. If angle of incidence is fixed or tracking then the performance of

PV cell is different. Intensity of sunrays is different throughout the day. Therefore solar modules fixed at a particular angle may not be entirely optimized.[1]

**II. WORKING PHENOMENON OF SOLAR CELL:**

A photovoltaic cell is a solid state electric component which converts the sunlight/sunray without delay into power by using photovoltaic effect. The power of light is transmitted through photons-small packets or quantum of light. For this energy conversion first requires a material which absorbs the sun energy (photon), and then increases an electron to an enhanced energy nation, and then goes with the flow of this high-power electron to an outside circuit. Silicon is one such a semiconductor that uses such process. A solar cell shape is shown in Figure 1 and a solar panel configuration in Figure 2. [5]

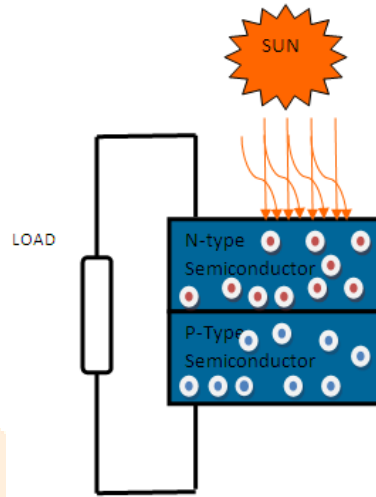


Figure 1 Building Blocks of Solar Cell

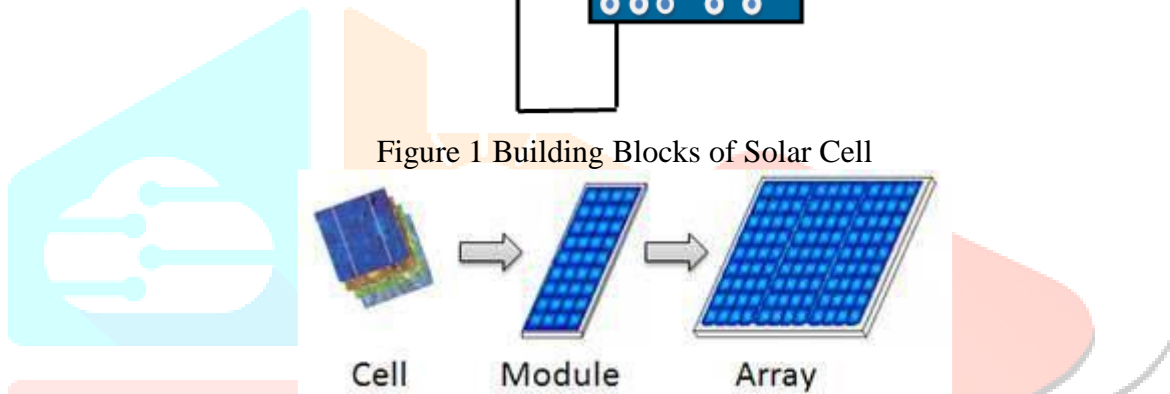


Figure 2: Solar Panel Configuration [5]

Solar cell (crystalline silicon) consist of N type semi conductor (Emitter), P-type semi conductor (Base). Hence it forms P-N junction. The surface is coated with anti reflection coating to avoid the loss of incident light energy due to reflection. Installation of PV cells requires more space so roof top solar is an alternative to overcome space problem. But roof top also having limited space in order to arrange solar array in urban areas.

If tracking system is used then the cost increases significantly and it requires maintenance also. Solar PV trees can be one such innovative concept to put together solar PV into the constructed environment.

Solar Tree or Solar PV Trees are a solar structure that looks similar to trees. These can be structured from small scale like a bonsai tree to large scale like the size of the wind turbine. It's a combination of art and technology. This is somewhat new concept to use new technology relating to harvesting and use of solar energy. [2]

“TREE stands for

- T = Tree generating
- R = Renewable
- E = Energy and
- E=Electricity

Solar tree uses a steel structure It has a tree like an edifice and panels are arranged as leaves on the branches of the energy tree. It's just like a natural tree but with solar panels instead of leaves. [12].

On top of branch solar panels are connected which collect Sun's radiant energy and convert it into electrical energy. This energy can be used for various electronic gadgets. It can also be used for street lights.

All panels on solar tree are arranged in such a way that tree is able to capture the sunlight throughout the day, irrespective of position of sun. The three-dimensional structure of solar tree can enhance the total surface area for Sunlight capture [1]

In solar trees, PV panels are arranged in a Fibonacci series pattern instead of leaves. The solar tree produces more power than a conventional flat arrangement of solar cells. It requires only 1% land as compared to the conventional flat arrangement [13]

The panels of flat mounting for homes are inefficient, as the angle of sun's rays is not constant, particularly during the changes in seasons.

These solar trees have been designed to provide different means of power to different urban and built environments. These ranges from powering mobile phones, electric cars, buildings and street lighting and covering large and small scale area. Solar trees are really a practical solution for urban street lighting. There is a rapid increase in the use of PV systems in India due to continuous reduction in prices of solar cells. But there are some hurdles for adoption of this technology in rural and remote areas due to the security of the system and its components from theft. Most of the rural street lighting PV system installed by

the government is not in working conditions because of above-mentioned reasons and lack of maintenance. Hence presently PV systems prove to be suited mainly for urban & corporate use. [2]

### III. DIFFERENT ARRANGEMENTS OF SOLAR TREE

The concept of solar tree or arrangement of PV cell in a Fibonacci series has been stated by many researchers in their work. Such combination of the solar cell can be done on trees like coconut, palm or other natural trees to reduce the cost of mounting. [14]

For generating 2MW power from PV module system requires the land of 10 Acres. Solar power Tree a tall pole-like structure would take only 1% of land area in comparison to general PV housing [15] To get the maximum sun in a day time the top panel should not get in the way of bottom panels. The panels which are connected on tree can be made fixed at a particular angle or made rotate following the sun's path throughout a day.

The panels will be naturally facing towards the sun at an angle as required so that they can collect maximum solar energy in a daytime. These solar trees can be mounted anywhere .like terrace or anywhere near the house, roadsides, in between wide roads / highways, on boundary walls.Maintenance and dust cleaning is also not a big issue. [16]



Figure 3 Artistic design solar tree



Figure 4 Typical design of solar tree



Figure 5 Mounting of Solar Tree near the house

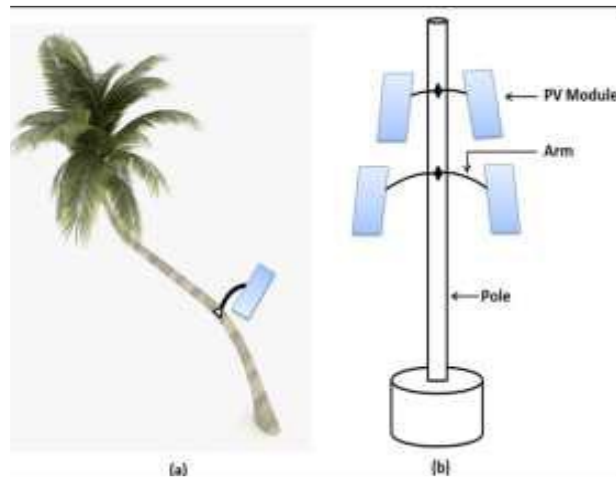


Figure 6 Mounting of PV panels to natural trees & simple pole structure.

#### IV. WORKING OF SOLARE TREE

It is difficult to store electrical energy in for all electric power system. Solar tree panels charge batteries during the daytime. At dusk, the solar tree switches ON its LED automatically. The internal control can also regulate the amount of light produced on how much charge is left in the batteries. A sensor measures an amount of light in the atmosphere and triggers the solar lamps to switch ON automatically at sunset and OFF at dawn. Tracking system reduces solar cell output fluctuations caused by day and night cycle and weather shifts. [2]

Basic components of a solar tree

1. Photo voltaic modules
2. Cables for connecting modules
3. Inverter:
4. Batteries:
5. Steel structure:
6. Charging points/ LED's [1]

Depending on the application the components may vary.

#### V. APPLICATIONS

The solar trees look a lot like a real tree, but the branch is changed for solar panels, that takes Sun's energy and generates electrical energy.

1. This energy can be used for
  - ✓ Charge your smart-phones
  - ✓ Tablets
  - ✓ Cold water drinking fountain
  - ✓ Computer monitor
  - ✓ Decorative night lightning
  - ✓ Shed to park vehicles.
  - ✓ Street lighting
  - ✓ Wi-Fi modules
2. No pollution: Solar energy emits very less emissions.
3. Solar energy is becoming more economical and required less maintenance.
4. The structure can be designed with storage /rechargeable battery for cloudy days and lights up LEDs at night.
5. Solar power Tree harnesses solar power to charge mobile devices, cool water, and

There are many factors responsible to believe that solar energy will take a leading role in addressing the climate crisis and future aspects. [6]

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