Energy Scavenging Trees: A Literature Survey

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Abstract *— This paper presents a new Energy harvesting technique for capturing minute amounts of energy from one or more of the surrounding energy sources, accumulating them and storing them for later use. Another name given to energy harvesting is energy scavenging. In the view point of energy conversion, human beings have already used energy harvesting technology in the form of windmill, watermill, geothermal and solar energy. The energy extracting from natural sources i.e. renewable energy, is emerging as a future power source due to limited stock of fossil fuels. Since the renewable energy harvesting plants generate kW or MW level power, it is called macro energy harvesting technology. Micro energy harvesting technology is based on mechanical vibration, mechanical stress and strain, thermal energy from furnace, heaters and friction sources, sun light or room light, human body, chemical or biological sources, which can generate mW or μW levelpower.*

Energy harvesting as an alternative technique that has been applied to solve the problem of finite node lifetime and it refers to harnessing energy from the environment or other energy sources for converting it to electrical energy. Examples of such energy sources include light, thermal gradients, vibrations, electromagnetic wave, etc. Harvesting energy from the surrounding environment is of growing interest to the research community, but in practice, design challenges limits its viability and ability to penetrate the market. So a technique has been presented here which can be used for the efficient energy harvesting by creating trees. The tree-sun relationship is perhaps the strongest, simplest, and most pertinent example of our thermodynamic paradigm.

Keywords- *synthetic, botanic photovoltaic, thermo voltaic, piezoelectric, Nano leaf etc.*

1. INTRODUCTION

In the future there will be scarcity for non-renewable energy sources, but renewable sources like solar power and wind power lasts for millions of years. By using this new technology, we can harvest the energy of the sun and wind. Also existing source of renewable energy, solar panels, parabolic sun collectors, wind and tidal turbines are inefficient, expensive and environmentally insensitive. One of the emerging nanotechnologies related to renewable energy is Nano leaves and stems of artificially created trees or plants. They are an emerging form of renewable energy through collecting energy from the sun and wind and converting it to electrical energy. [2]

The leaves are distributed throughout artificial trees and plants, and when operating at optimum efficiency can supply a whole household with electricity. They are intended to harness energy provided by the wind and sun, thereafter converting it into electrical energy.

Solar Botanic will introduce artificial trees that make use of renewable energy from `the sun and wind, they are an efficient, clean and environmentally sound means of collecting solar radiation and wind energy.

Here at Solar Botanic, they have amassed a wealth of information relating to Solar Botanic Trees and Nano leaves and the field of photovoltaic, thermo-voltaic and piezoelectric technology. We will be amazed how efficient these Trees are, how they make use of light, heat and wind and turn it into useable electricity for your home or car.

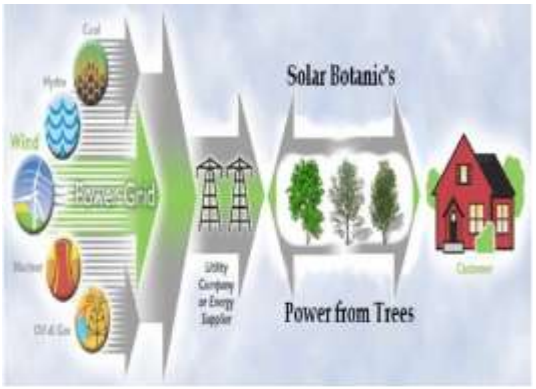


Fig1.Flow of power using Botanic Trees[6]

Solar Botanic residential solutions offer up to 50% more power than conventional solar systems, and our Green trees and shrubs blend in beautifully with your environment

With solid performance and the highest-efficiency solar products, Solar Botanic is the right choice for the City, Neighborhood, or large-scale green energy project. Solar Botanic solar systems can be deployed on ground, roof, or parking structures[6].

These species can provide between 3500kWh and 7000kWh per year. They offer an abundance of added value: providing shade, cooling the air, green ambiance and much more. Installation is quick. The trees are durable and natural looking, to fit any environment. Also, they are flexible, similar to an

original tree, and well secured to the ground with our Octopus root system.

These species can provide between 2500kWh and 7000kWh per year. They can be placed as single trees or to fence garden properties. Also, for mountainous regions and hill sides, very good noise and sound abatement.

A wide range of shrubs for all our electrical needs are already available. Solar Botanic Nano-leaf roof Carpets can be installed in minutes on any roof design, various leaf and vegetation designs are available. Solar Botanic Wall carpets, easy to apply, you can cover unsightly walls, or apply it as fencing and generate electricity, creating a natural ambiance in a matter of minutes. Various leaf design are available. These products come with a guaranteed international quality control and assurance Technology specification.

II. OVERVIEW OF NANO LEAVES

One of the emerging nanotechnologies related to renewable energy is Nano leaves and stems of artificially created trees or plants. They are an emerging form of renewable energy through collecting energy from the sun and wind and converting it to electrical energy. The leaves are distributed throughout artificial trees and plants, and when operating at optimum efficiency can supply a whole household with electricity. They are intended to harness energy provided by the wind and sun, thereafter converting it into electrical energy. The fundamental of Nano leaves can be understood by a technology called Bio mimicry.

The Nano leaves have been specially designed to imitate the natural process of photosynthesis. A mechanism by which, typical plants absorb the light emitted by the sun and CO2 in the atmosphere. The artificial trees do even copy the natural re- cycling process of oxygen. It can harvest thermal energy as well. Moreover, the leaves fixed on artificial trees are also able to collect energy derived through movement of the wind, known as kinetic energy, which is as well converted into electrical energy.

In this bio mimicry theory, the artificial trees are implanted with Nano leaves, a composite of Nano photovoltaic nano thermo voltaic and Nanopiezo sources transforming light, heat and wind energy into eco-friendly electricity.

The Nano leaves transform the whole solar scale converting detectable light, infrared and Ultraviolet in a unification with piezo electric generators that alter wind energy into electricity giving you efficient, cost efficient and attractive looking solutions, whilst providing the greatest electric power.

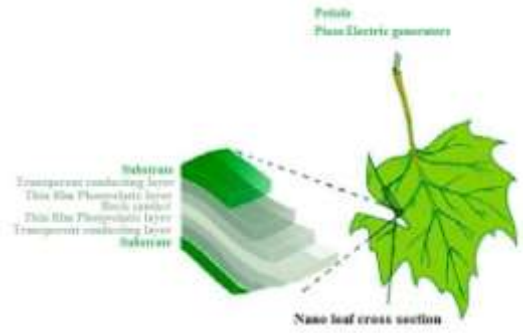
Solar Botanic tree will offer up to 50% more energy than traditional solar systems, and in addition will blend in beautifully with your surroundings.

Solar Botanic trees will have the capability of supplying an individual home or can be placed in regions where natural growing bunches of trees would formerly have been utilized.

III. SOLAR BOTANIC TREE

Solar botanic tree utilizes the Nano-technology which was initially developed to harness the solar energy. But, nowadays it has widespread uses. It utilizes various alternative sources of energy like wind, solar and thermal energy. Furthermore, these highly advanced artificial plants and/or trees use tiny cells to capture energy.

The main part of the Solar Botanic tree is Nano leaf and in order to construct the Nano leaves we need solar panel, thermo voltaic cell, piezo voltaic cell and photo voltaic cell. The construction of Nano-leaves is very easy. It consists of two transparent conducting layers of silica which will act as the outer body of the leaf. And one solar cell is placed in between these two layers which is used to convert the solar energy into electrical energy then the piezo voltaic cell, thermo voltaic cell and photo voltaic cell are used. All these cells are interconnected to the highly conducted metal film to complete the circuit for the flow of electrons and protons. The piezoelectric generator is placed on the bottom of the leaf which is used to convert the stress due to rain and wind into the electrical energy. Now these leaves are connected to the twigs of the artificial tree. And these small twigs are connected to the stem of the tree with the means of the piezoelectric crystal to covert the stress of the twig also into electrical energy. The electrical energy from all the leaves and twigs is stored at the bottom of the tree by using the storing device. And the solar botanic tree is about 20 feet height.



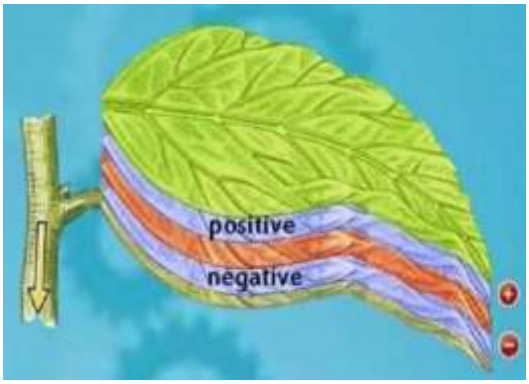


Fig. structure of Nano leaves [7]

Existing source of renewable energy, solar panels, parabolic sun collectors, wind and tidal turbines are less efficient and expensive. Other sources like wind mills and solar panel are limited up to air and solar energy respectively. Leaves convert the invisible light(radiation) to electricity.

COMPOSITION OF A NANO-LEAF

It consists of Nano-photovoltaic generators. If the light falls on the Nano-leaf, then photo voltaic produces the electricity. It also consists of Nano-thermoelectric cells and $TiO2$. When the environment is hot, the thermo voltaic layer produces the electrical energy. Nano leaf stems consist Nano-piezoelectric generators (graphene coated with zinc oxide nanowires). If leaf is getting stress due to wind or rain, then piezoelectric layer produces the electricity. It usually consist of two conducting Nano sheets. Out of these two sheets, one layer should be positive and the other should be negative. Keep positive layer over the negative with a very minute gap to create an electric field just like a battery. Now insert the piezoelectric, thermoelectric and photovoltaic cell inside two conducting Nano sheets.It is to be estimated that six meter area of Nano leaves can produce enough energy for an average household. Best place to use Nano leaves are:

1. Desert: The earth has large areas of unexploited deserts which can be used to generate a massive amount of electricity. It would protect inhabitants from sandstorms and provide constant shade form the sun.
2. Recreational grounds and parks.
3. Office Parking and industrial Zone provides electricity to office, parking lights and other uses[7].

IV. WORKING

It works based on the principle of Photo synthesis in which, typical plants absorb the light emitted by the sun and CO2 in the atmosphere. Similarly an artificial tree utilizes light energy from the sun to generate the electricity. Electrical energy from the Solar Botanic Nano leaves can be generated by using Thermo voltaic cells, Photovoltaic cells and Piezoelectric cells which are integrated in the tree. When Sun light falls on the nano-leaf, the photons are absorbed into the nano-leaf, their energy causes the electrons to become free. The electron moves towards the bottom of the nano-leaf and exit through the connecting nano wires working as trunk. This flow of electrons causes generation of electricity.

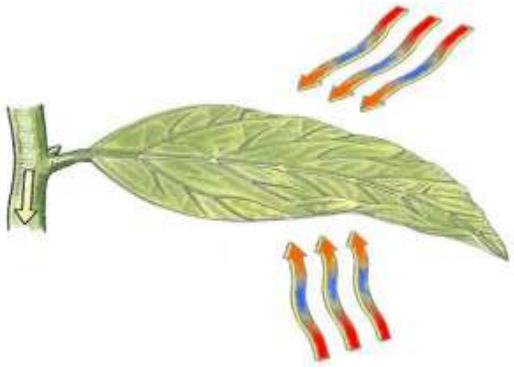


Fig2. Generation by Solar and Thermal energy[11]

Thermal energy is captured through the use of thermo voltaic (TV) cells. It consists of two junctions T1 and T2 in which T2 is kept at constant reference temperature. Hence it is referred as cold junction and the temperature changes to be measured are subjected to the junction T1, which is referred as hot junction. When T1>T2, an EMF is generated due to the generator gradient. The magnitude of emf depends on the materials used for wires and temperature difference between T1 and T2.That emf is produces electrical energy.

Piezoelectric cell works based on the piezoelectric effect i.e. when two opposite faces of a thin, slice of certain crystals are subjected to a mechanical force, then opposite chargers are developed on the two faces of the slice. In this technology a crystal is placed in between two metal electrodes and when outside forces like wind pushes the Nano leaf back and forth mechanical stresses appear in the petiole, twigs and branches.

When thousands of Nano leaves flap back and forth due to wind, millions and millions of Pico watts are generated by converting kinetic energy into electrical energy.

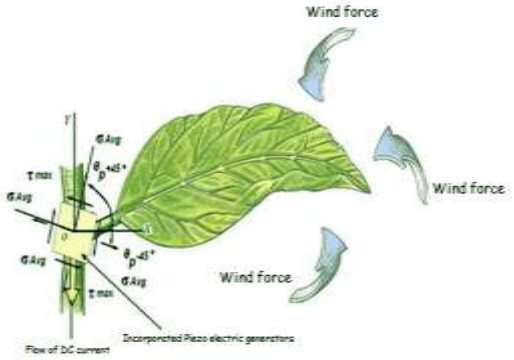


Fig3. Generation by Peizo electric cells[10]

The photovoltaic, piezoelectric and thermo voltaic energy harvesters are linked to individual junction boxes, from where they are amalgamated and fed collectively into an inverter. This converts the electricity from Direct current (DC) into Alternating Current (AC). And now the stored electrical energy is utilized.

A Solar Botanic's comprehensive application portfolio help us to find-

I. To find the best place for the trees.
II. To find greater productivity.
III. To find better scenic values.

There is always light. Sometimes bright sometimes diffuse.

Solar Botanic Nano leaves are able to pick up any light, from the visible spectrum to the invisible spectrum, Infrared light - you don't see it, but you can feel it, it's warm; the Nano-leaf is an innovative combination of photovoltaic and thermo-voltaic materials that enable the leaf to produce electricity even long after the sun has set.[10]

Also there is always wind, even on a hot day. Even if there is a small amount of it. Solar Botanic leaves; twigs and branches are moved by the wind they are sensitive to external pressure caused by wind, the incorporated Nanopiezo generators produce millions and millions of Pico watts day in day out, they join the stream of power.

Thus Sun, wind and heat come together in the tree canopy, a synergy of natural design and high tech materials, a fusion of dynamic processes and Darwinian laws, providing us with the power we need.

Besides converting the visible spectrum of light, our Nano leaves also convert the invisible light, known as infrared light or radiation, we can't see it, but we can feel it - it's warm - that's why we call it radiation. Due to the unique combination of photovoltaic and thermo voltaic in our Nano leaves it converts this thermal radiation into electricity, even hours after the sun has set.

The more wind there is, the more Nano leaves are moved. Wind that is moving thousands of Nano leaves in a tree canopy are causing mechanical strain in the petiole, twigs and branches. Nano piezo-electric elements incorporated in the petiole twigs and branches are the tiny Nano piezo-electric elements that will generate millions and millions of Pico watts as these thousands of Nanoleaves flap back and forth due to wind. The stronger the wind, the higher the "flap" frequency, and therefore the larger the watts generated in the petiole, twigs and branches

With the progress in nano technology, the photovoltaic, thermo voltaic and piezo electric materials are becoming more efficient and combined in one system it will give our products more efficiency and we believe that soon, Solar Botanic will be a mainstream green energy provider, more reliable/cheaper and above all better looking

V. MERITS, DEMERITS AND APPLICATIONS

Merits

i. The tree fully created based on artificial and it doesn't produces any kind of harmful effects such as creation of chemical gases, smokes and etc

ii. Like that of natural tree it also provides sheds, sometime due motion of air it will produce air motion

iii. Land requirement is very less

iv. As the tree is aprox. 7 meters high

v. Triple efficient and durable

vi. Easy to install and maintain

vii. Weather resistant : rain , dust, lightning, wind

Demerits

i. Difficult to interface nano cells

ii. Difficult to interface inverter to the trunk

iii. Cost is high.

APPLICATIONS

- Urban and Rural
- Recreational parks, city parks
- New housing estates
- Golf courses and resorts
- Mountainous regions
- Coastlines
- Highways
- Airports
- Deserts
- Penthouses, balconies, verandas
- Private gardens
- De-forested areas
- Areas of commercial interest; Islands, nature resorts
- Ponds, lakes, seas and oceans
- Crop Protection
- Solar Botanic flowering plants to harvest colorful your electric power

VI. CAPACITY OF SOLAR BOTONIC TREES

An average tree with a canopy of about 6 sq. meters can create enough energy to provide for the needs of an average house hold and a tree with a 20 ft. solar canopy could generate enough power between 2000 and 12000 KWh per year. An unremitting operation over two decades could produce 1, 20,000KWh of energy. On a larger scale, a kilometre of solar botanic trees would be able to generate approximately 350,000 kWh per year, enough electricity to power approximately 60 average size houses. Solar Botanic solutions offer up to 50% more power than conventional solar systems.

Generation and Estimation

Solar botanic tree consists of many nano leaves and by these nano laves electrical energy is obtained. One nano leaf produces the electrical energy of 1.25V and 100 mA. And hence the power generated per nano-leaf will be 0.125 W. And the output of this tree will be from 2,000 kwh to 12,000 kwh.[1].

The total cost required to construct a Solar botanic tree is $12,000 to $20,000. And the tree can generate electrical energy about 1,20,000 kwh over 20 years. The life span of this is 20 years.

Comparison with other sources

Solar botanic tree utilizes renewable sources for the generation of electricity which is abundantly available. This tree is cost effective in comparison to other sources as well as efficient.

Table1. Comparison of Nano tree with other sources

S.NO.	SOURCE	GENERATION	COST	AVAILABILITY
1	WIND	0.3%	$35000/HOUSE	UNLIMITED
2	SOLAR	0.5%	$25000/HOUSE	UNLIMITED
3	HYDRO POWER	4%	$47000/20 HOUSES	UNLIMITED
4	BIO FUEL	37%	$2000/HOUSE	LIMITED
5	SOLAR BOTANIC TREE	NIL TILL NOW	$5000/HOUSE	UNLIMITED

Table2.Comparison between Solar cells & Nano leaves

S.No.	SOLAR CELL	NANO LEAVES
1	90kwh/in^2	130kwh/in^2
2	It can produce power from solar energy only.	It can produce power rom solar, wind and from rain also

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VII. Conclusion

These super eco-friendly synthetic trees will make use of renewable energy from the sun along with wind power, which is an effective clean and environmentally sound medium of gathering solar radiation and wind energy. Solar nano technology has wide ranging potential. Using such technology, power producing solar products could be applied to just about any surface downtown or anywhere. These artificial trees not only will make the world stable in the field of energy but also will reduce the use of fossil fuel which is the main cause for global warming.As the solar botanic trees are a non-conventional source, we have many advantages of producing electricity compared to the other resources. Green energy is the need of the hours and it is our responsibility to ensure a safer planet for the future generation.

Solar power is an affordable, efficient and abundant source of domestic electricity. It is pollution free and cost competitive with energy from solar tree plants in many reasons. The paper first deals with the current scenario of the solar energy in India.Solar energy is available without any cost and it does not emit any greenhouse gases. This makes it a great source of energy production for any developing state. The field of solar energy has tremendous scope for innovation, translating to real world applications and tremendous economic opportunity. It is crucially important for India, as our economy continues to evolve. For that we will need greater resources. Clean, sustainable, renewable and equally important, domestic sources of energy are essential to fulfill the potential of India in the coming years and it is certain that solar energy will play a major part in shaping India's future.

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