International Journal on Emerging Technologies (Special Issue on ICRIET-2016) **7**(2): 272-277(2016)

ISSN No. (Print) : 0975-8364
ISSN No. (Online) : 2249-3255

Review on Energy Harvesting

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(Received 28 September, 2016 Accepted 29 October, 2016)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: This paper describes Electrical Power Generation using Tidal Energy, Nuclear Energy, Wind Energy, Solar energy and Piezoelectric and electrostatic as non conventional energy sources. All the natural wastage energies are used for production of Electricity. Thus, the Electrical Power or Electricity is available with a minimum cost and pollution free to anywhere in the world at all times. This process reveals a unique step in electricity generation and availability from natural resources without disturbing the ecological balance. We can have an uninterrupted power supply irrespective of the natural condition without any sort of environmental pollution. Moreover this process yields the least production cost for electricity generation. It will bring a pollution and accident free homogeneous nature to safe guard the world in a unique way.

I. INTRODUCTION

Now-a-days it is very necessary to find out the renewable energy or power sources for domestic and small commercial purposes and also for large commercial purposes. At present in World, more than 60% of people and in India 70% of people are not getting electricity in their daily life. For electricity such as lighting, cooking, moderate machine operating etc, they are extremely depending on oil like kerosene, diesel, petrol, bio-oils and other bio-materials like trees, extracts of food grains etc. These firing of oils or bio-materials cause extreme pollution to nature. Also natural resources like coal, oil, radio-active materials etc will come to shortage stage or an end in near future. Hydro-electric power generation, thermal power stations which are the most popular and highly power generation method adopted throughout the world at present. The power generating systems like Hydro- Electricity power generating plant cannot afford much power, although it causes less pollution. Therefore, it needs urgent invention to go for non-conventional energy resources. The most popular non-conventional power resources are solar energy power plant which converts solar energy or solar heat to electricity. Solar power generation system has some drawback, that is, it cannot generate power in cloudy or rainy days. Therefore, people using this solar system have to remain without electricity (power) after battery gets discharged during the rainy season or the sun's shortcomings, since it is totally depended on appearance of the sun in the sky. Moreover, it has very much limited capacity and we cannot take all available solar energy, because it is urgently required in all other fields also e.g. biological body or health care, agriculture, chemical reactions, industries etc.

Classification of energy harvesting:

1. Large power harvesting
2. Macro power harvesting
3. Micro power harvesting

II. LARGE POWER HARVESTING

A. Tidal energy harvesting

Tidal power, also called tidal energy, is a form of hydro power that changes the energy of tides into useful forms of power, mainly electricity. Although not yet wide used, tidal power has potential for upcoming electricity generation. Among the sources of renewable energy, tidal power has regularly suffered from relatively high cost and limited availability of sites with sufficiently high tidal flow of velocities, thus decreasing its total availability. Generation of electrical power from ocean tides is very similar to traditional hydroelectric power generation. The simplest generation system for tidal plants involves a dam, known as a barrage, across an inlet. Usually, a tidal power plant consists of a tidal pond created by a dam, a powerhouse containing a turbo-generator, and a sluice gate to allow the bidirectional tidal flow.

The rising tidal waters fill the tidal basin after opening the gate of the dam, during the flood tide. The gates are closed, when the dam is filled to capacity. After the ocean water has receded, the tidal basin is released through a turbo-generator. Power can be generated during ebb tide, flood tide, or both. Ebb tide occurs when the water is pulled back, and flood tide occurs when the water level increases near the shore. The tidal power will be economical at sites where mean tidal range exceeds 16 ft.

One of the advantages of tidal energy harvesting is that the tidal current is regular and predictable. Furthermore, tidal current is not affected by climate change, lack of rain, or snowmelt.. Tidal power can also be used for water electrolysis in hydrogen production. However, tidal power generation is a very new technology, which needs further investigations and developments. Similar to the wind turbines, tidal turbines can be used for tidal energy harvesting. Tidal turbines and wind turbines are similar in both appearance and structure, to some extent. Tidal turbines can be located in river estuaries and wherever there is a strong tidal flow. Since water is about 800 times as dense as air, tidal turbines have to be much stronger than wind turbines. They will be heavier and more costly however, they will be able to capture more energy at much higher densities.

B. Nuclear power harvesting

In a nuclear-fueled power plant water is turned into steam, which in turn drives turbine generators to produce electricity. The difference is the source of heat. At nuclear power plants, the heat to make the steam is created when uranium atoms split it is called fission. There is no combustion in a nuclear reactor. Here's how the process works is as shown in figure 1.

Pressurized Water Reactor. Pressurized Water Reactors (also known as PWRs) keep water under pressure so that it heats, but does not boil.

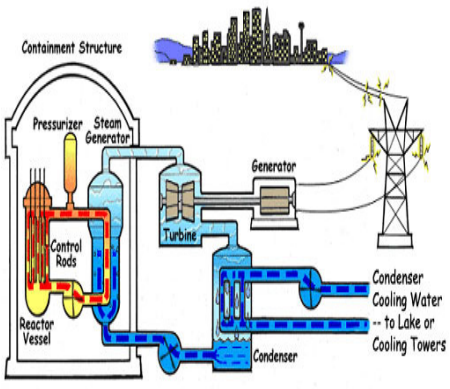

Fig. 1. Nuclear Pressurized water reactor.

This heated water is circulated through tubes in steam generators, allowing the water in the steam generators to turn to steam, which then turns the turbine generator. Water from the reactor and the water that is turned into steam are in separate systems and do not mix.

1. The Fuel. The fuel used in nuclear generation is primarily uranium 235. It is manufactured as small round fuel pellets. A single pellet is less than an inch long, but produces the energy equivalent to a ton of coal. The pellets are placed end-to-end into fuel rods that are 12 feet long. Over 200 of these rods are grouped into what is known as a fuel assembly.

2. Reactor. The process of producing electricity begins when uranium atoms are split (i.e., fission) by particles known as neutrons. Uranium 235 has a unique quality that causes it to break apart when it collides with a neutron. Once an atom of uranium 235 is split, neutrons from the uranium atom are free to collide with other uranium 235 atoms. A chain reaction begins, producing heat. This reaction is controlled in several ways, including by control rods which absorb neutrons. Control rods are inserted among the fuel assembly rods that hold the uranium pellets. When they are in place, they absorb the atomic particles that would normally initiate the chain reaction. When they are withdrawn from the fuel assembly, fission is allowed to occur.

3. Pressurizer. The heat produced in the reactor is transferred to the first of three water systems: the primary coolant. The primary coolant is heated to over 600 degrees Fahrenheit. In a pressurized water reactor, a pressurizer keeps the water under pressure to prevent it from boiling.

4. Steam Generator. The hot, pressurized water passes through thousands of tubes in nearby steam generators. These tubes are surrounded by another water system called the secondary coolant. The heat from the primary coolant is transferred to the secondary coolant, which then turns into steam.

The primary and secondary systems are closed systems. This means that the water flowing through the reactor remains separate and does not mix with the water from the other system or the lake.

5. Turbine. The steam is piped from the containment building into the turbine building to push the giant blades of a turbine. The turbine is connected to an electric generator by a rotating shaft. As the turbine blades begin to spin, a magnet inside the generator also turns to produce electricity.

6. Condenser Coolant. After turning the turbines, the steam is cooled by passing it over tubes carrying a third water system, called the condenser coolant or lake water. The steam is cooled so it condenses back into water and is returned to the steam generator to be used again and again.

7. Lake or Cooling Towers. At some nuclear stations, lake water flows through thousands of condenser tubes to condense steam back to water. It is then discharged down a long canal (for cooling) and eventually enters the main part of the lake.

At other plants, the condenser cooling water is circulated through cooling towers to remove the extra heat it has gained. The water is pumped to the top of the cooling towers and is allowed to pour down through the structure. At the same time, a set of fans at the top of each tower pulls air up through the condenser water. This lowers the temperature of the water. After it is cooled, the condenser water flows back into the turbine building to begin its work of condensing steam again.

Boiling Water Reactor

In Boiling Water Reactors (also known as BWRs), the water heated by fission actually boils and turns into steam to turn the turbine generator. In both PWRs and BWRs, the steam is turned back into water and can be used again in the process.

C. Wind Energy Harvesting

Wind energy is presently the fastest growing among all renewable energy systems. Among the WECSs, variable speed ones in recent years have become the industry standard because of their advantages over fixed speed ones such as improved energy capture, better power quality, reduced mechanical stress and aerodynamic noise. Further, variable speed WECS can be controlled over a wide range of wind speeds to enable the WECS to operate at its maximum power coefficient thus, allowing it to obtain a larger energy capture from the wind. However, conventional variable speed WECS with speed-up gears due to its many disadvantages have given way to direct drive (DD) WECS. Maximum power extraction from WECS has been the subject of several recent research investigations. In order to extract maximum possible power from the available wind power. The MPE control, in conventional wind energy conversion systems, is implemented using wind speed data obtained from wind speed sensors In this paper, a new wind speed sensor less maximum power extraction controller for a variable speed PMSG WECS is proposed. The method uses active power and air density as inputs and generates optimum reference speed signal for the machine side converter control system to enable maximum power extraction. Unlike the optimum power constant based PSF control methods presented in the proposed method takes into account the variation in the optimal power curve due to the change in system efficiency with the change in system operating point as a result of change in wind speed. Further, unlike PSF methods, the proposed method generates optimum speed reference signal and not optimum power reference signal.

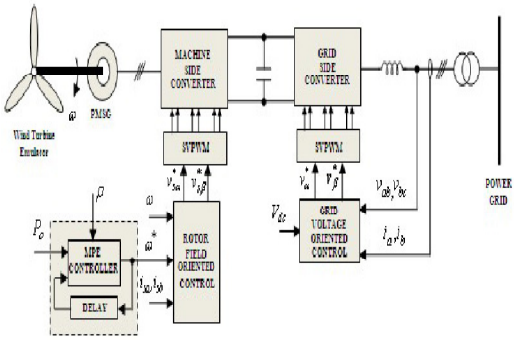

Fig. 2. Block diagram of wind energy conversion system.

The block diagram of the grid side converter control system is shown in Fig. 2. Active and reactive power control is achieved by controlling direct and quadrature current components respectively. Two control loops are used to control the active and reactive powers. An outer dc voltage control loop is used to set the d-axis current reference for active power control. This assures that all the power coming from the rectifier is instantaneously transferred to the grid by the inverter. The second channel controls the reactive power by setting a *q*-axis current reference to a current control loop similar to the previous one. The current controllers provide a voltage reference for the inverter that is compensated by adding rotational emf compensation terms.

III. MACRO POWER HARVESTING

A. Micropower Energy Harvestors

Electromagnetic and piezoelectric transduction methods are the most promising approaches for kinetic energy harvesting and both are used in the current research to convert ear canal dynamic motion into electrical current.

B. Hydro Electromagnetic Energy Harvestors

A hydro electromagnetic system is composed of a magnet element in a thin tube filled with water that is surrounded by 40μm copper wire with 1000 turns coil. One end of the tube is attached to an expandable earplug. By injecting water into the system using a water filling syringe, the earplug expands to perfectly fit against the ear canal walls of the wearer. At the same time, the water level rises in the tube and the water sinks the magnet. By placing a second magnet fixed in such a way that the same poles face each other, a repulsive force is produced that can suspend the first free magnet inside the tube.

C. Solar Energy Harvesting

The sun is a continuous fusion reactor in which hydrogen combines to form helium and evolving huge amount of heat energy as per the following reaction: 4 1H1 2He4 + 26.7 MeV

This heat energy from the sun , is emitted in the universe and the earth by transmission of tiny bundles of energy particles called photons which move with finite speed (almost speed of light) and energy. When photons strike an atom, they interact with the electrons by transferring their energy and hence they are absorbed. The Sun rays are composing of different wavelength spectrum from the low to the very high ranges, but UV (ultra-violet) radiation, other low and very high range wavelength radiations are absorbed by ozone, oxygen, nitrogen, water vaporetc lying above the earth's atmosphere. Thus, the sun rays consist of wavelength (λ) radiation between 0.29 μm to 2.3 μm (approximately). A solar cell [8] consists of a basic element, named photovoltaic (PV) generator, usually as doped semiconductor materials e.g. photodiode, phototransistor etc. Photovoltaic (emf) generation is caused by the sun light radiation i.e. the photons absorption that separate positive and negative charge carriers in the absorbing semiconductor materials. These charges, constitute an electric voltage, can afford a current for use in external circuit or load. Different type of solar cell materials is single crystal, polycrystalline and amorphous silicon and compound of thin film semiconductor materials. Variety of semiconductor compounds such as CuInSe2, CdS, CdTe,Cu_2S, InP etc are used to manufacture thin film solar cells. The combination of different band gap (Eg) material lead to photovoltaic generator of much higher efficiencies. The Solar Power Generation System is planned accordingly Fig. 1. The solar cell array or panel consists of an appropriate number of solar cell modules connected in series or parallel to provide the required current and voltage.

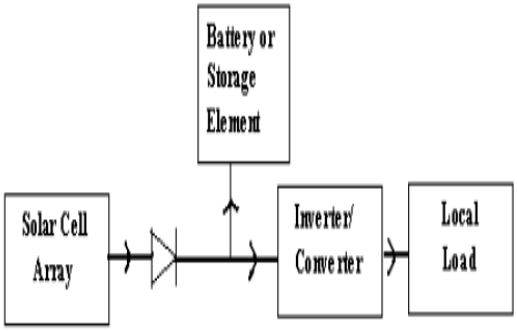

Fig. 3. Basic Solar (Photovoltaic) System.

Storage batteries as shown in Fig. 3 provide the back up power during no sun shine period by storing the excess power or some portion of power from the solar arrays.

This solar power generating system is used for private power consumption, meteorological stations, radio or TV relay stations, entertainment places like cinema, hotel, restaurant etc, villages and islands. The small size solar array or panels are fitted in addition on the roof to the wall, the sunsets, the balcony etc of a building or a structure, such that full solar energy falling onthe building can be utilized. In this arrangement, inside of the building will remain in very moderate temperature even in hot summer times.

Generating Electricity Using Piezoelectric Material

The recent fluctuations in the price of petroleum and coal have affected world economy which has enforced increase in the price of other items including food, shelter and clothing Other solutions which can be explored are nuclear energy, ocean thermal energy, and hydroelectric power generators The process of acquiring the energy surrounding a system and converting it into usable electrical energy is termed as ambient energy harvesting. In ambient energy harvesting one of the promising options for power generation is by using piezoelectric material.

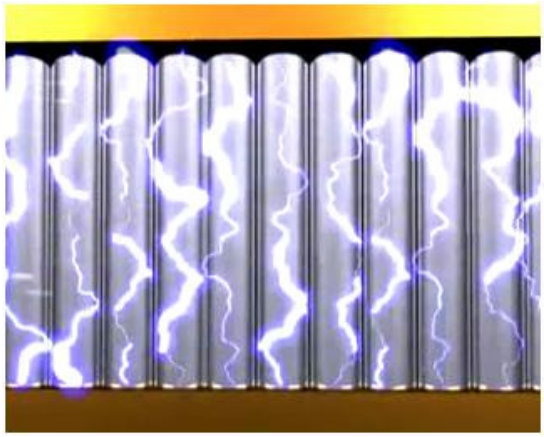

Fig. 4. Piezo electric material.

Working of Piezoelectric Material. The piezoelectric phenomenon was first described by the Curie brothers, who observed that certain materials generate electric current when they are deformed. The piezoelectric effect exists in two domains: the first is the direct piezoelectric effect that describes the material's ability to transform mechanical strain into electrical charge; the second form is the converse effect, which is the ability to convert an applied electrical potential into mechanical strain energy. Thus, they can be used as either actuators or sensors.

The direct piezoelectric effect alters mechanical energy into electrical energy by straining a piezoelectric material. Strain or deformation of a piezoelectric material causes charge separation across the device, producing an electric field and consequently a voltage drop proportional to the stress applied. The voltage produced varies with time and strain, effectively producing an irregular AC signal on the average. Piezoelectric energy conversion produces relatively higher voltage and power density levels than the electromagnetic system.

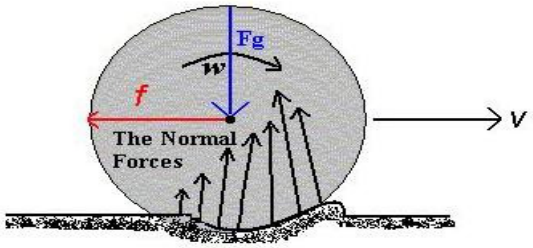

Fig. 5. Forces exerted by a vehicle moving ahead on a road.

INSTALLATION: It is known that the vertical load of the vehicle's wheels yields compression stress, diminishing with depth. Piezoelectric generators are embedded at a depth of about 5 cm; the area where the compression stresses is maximal. Installation method of piezoelectric generators is very easy. Piezoelectric generators are installed contiguously in two rows according to the wheel imprints.

MAINTAINANCE: Piezoelectric generators have very low maintenance as there are no moving parts with the generators placed under asphalt. They need to be repaired or replaced once every 30 years.

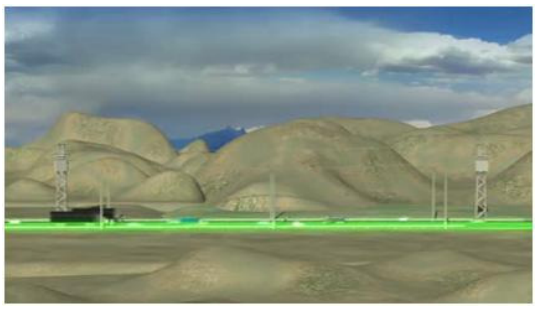

Fig. 6. Road with Piezoelectric Generators.

ADVANTAGES OF PIEZOELECTRIC GENERATORS AGAINST OTHER ENERGY SOURCES

- It maximizes retrieval of wasted mechanical energy converting it into electrical energy.
- It then stores the energy with minimal energy waste.
- The energy is also produced close to its end users.
- It does not require the use and development of vast new areas as do solar and wind farms.
- Additional benefits are that the system records weight, frequency and speed of the vehicles, giving extra information to "create smart roads".
- The solution is applicable to any place with heavy vehicle travel and not confined to specific climate and geographic areas as are solar and wind energy.

Micro Power Harvesting

Electrostatic Energy Harvesting

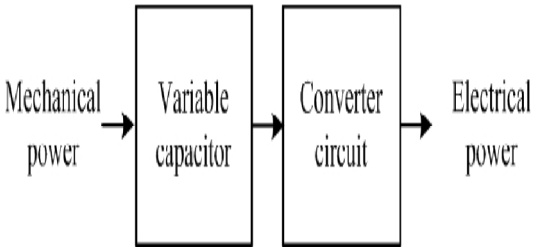

Fig. 7. Block diagram of electrostatic energy harvesting.

In electrostatic macro type energy generator Due to a potential difference across the conductors, an electric field develops across the insulator. This causes the positive charges to accumulate on one plate and the negative charges to accumulate on the other. The capacitor value is usually denoted by its capacitance, which is measured in Farads. It can be defined as the ratio of the electric charge on each conductor to the voltage difference between them.

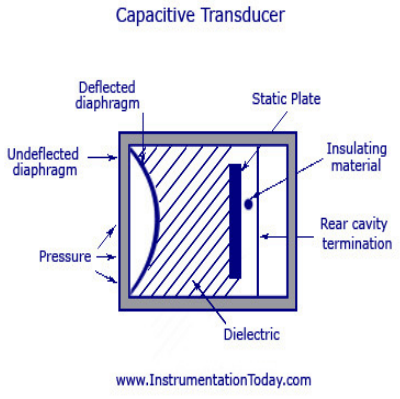

Fig. 8. Capacitive Transducer.

The value of capacitance C and the distance between the parallel plates, are inversely proportional to each other. An increase of distance between the parallel plates will decrease the capacitance value correspondingly. The same theory is used in a capacitive transducer. The transducer is used to convert the value of displacement or change in pressure in terms of frequency. Higher amounts of power, higher capacitance variations, and less fringing. The multiple pole capacitors have a number of parallel plates separated by air as the dielectric material. Each capacitor plate can produce a specific amount of power during energy harvesting. The number of plates is proportional to the amount of harvested power. When number of poles is increased, it increases the speed of capacitance variation. As a result, number of harvesting times per cycle increases.

Vibration energy Harvesting. Vibration harvesters contain piezoelectric substances that create an electric voltage when mechanically bent. By fabricating piezoelectric materials into cantilevers that resemble a diving board, these devices can oscillate from ambient vibrations and generate electricity. The sensor node can harvest mechanical energy in the form of vibration and strain in situations where solar optical energy is not dependable i.e. cloud cover, for embedded applications. Of various types of energy harvesting technologies in use today, piezoelectric energy harvesting has the unique ability to generate electrical energy simply through the input of vibration or external force impulses. This system employs a fluidic transfer mechanism where force, when exerted on the wear-resistant cover, is transferred into the fluid layer below the encapsulated compliant piezoelectric membranes. The fluid can either be compressible, reducing the applied force, or non-compressible, maximizing the amount of force that is transferred to the piezoelectric membranes. The system is asynchronous, means that it does not require consistent or predictable force or vibrational frequency to function efficiently. It can generate electricity for practical applications. It increases the efficiency of energy harvesting.

III. CONCLUSION

This paper covers the harvesting of the electrical power and classification of energy harvesting. With this we can generate large, medium and low amount of power using the power harvesters.

These methods would help in placing the energy harvesters as one of the best sources to generate electric power. It is useful to urban and city areas, simultaneously with the commercial power supply to minimize power supply load . By using this system, people can save electricity charge and very less maintenance charge to this equipment is required As Natural resources power generation system is affordable. Moreover there is no power failure or load shedding situation at any times. Therefore, it is the most reliable renewable power or electricity resources with the
least expenditure.

ACKNOLEDGEMENT

We acknowledge our thanks to B.V.B College of Engineering Technology word of gratitude appear to be very small when we recall at this moment, the help rendered to us, in this paper presentation to complete it successfully. Our heartfelt thanks to department of Electronics And Instrumentation Technology for by providing all the facilities.

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