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Cropping Electricity Using Vibrations

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ABSTRACT: We all are aware of expanding requirement of electricity worldwide. In rural areas shortage of electricity is still an issue of large apprehension. Other sources of electricity or power production are not enough to fulfill world population needs. Piezoelectricity is a technique in which mechanical vibrations produced by any process naturally or artificially can be utilized as a source of energy production. Piezoelectric components are used to switch mechanical energy into electrical energy. It is an efficient method of producing electricity without disturbing Nature only using the unavoidable waste part of energy. Piezoelectricity concept can be easily executed on roadways, Airports runways, Metro stations and railway stations since the large amount of mechanical vibration energy emitted at these places and can be converted into electrical energy through the piezoelectric materials.

KEYWORDS: Piezoelectric effect, Renewable energy, Mechanical strain, vibration

I. INTRODUCTION

When people use electricity, the electrical power was possibly produced by burning petrol, by a nuclear reaction, or by a hydroelectric plant on a water reservoir. Therefore petrol, nuclear, and hydro are called energy sources. When people fill up a gas tank, the source might be petroleum refined from crude oil or natural gas from wells.

Energy sources are categorized into two groups as Conventional or nonrenewable where energy source that cannot be easily replenished and Non-conventional or renewable where energy source that can be easily replenished. Renewable and nonrenewable energy sources can be used as primary energy sources to produce useful energy such as heat or used to produce secondary energy sources such as electricity.

With increasing requirement for energy and with fast depleting conventional sources of energy such as coal, petroleum, natural gas, etc. the non-conventional sources of energy such as energy from sun, wind, biomass, tidal energy, geothermal energy and even energy from waste material are gaining importance. This energy is abundant, renewable, pollution free and eco-friendly. In this paper energy production through vibration as non conventional energy resources has been discussed.

Confine vibrations and renovate them into electricity is an idea whose time has appear. The Center for Energy and Greenhouse Technologies, of Australia, has developed a kinetic energy cell capable of generating electricity from vibrations or motion. Researchers at the University of Bristol, in the UK, are investigating devices which use springs with a mass on the end to capture vibrational energy. At the University of Calgary, they are experimenting with harvesting electricity from the movement of musicians and the vibrations of their instruments.

II. NON CONVENTIONAL ENERGY RESOURCES

There are main renewable energy sources as solar energy from the sun, Wind energy, Biogas from plants and carbon waste, Hydropower from flowing water, geothermal energy from heat inside the earth and tidal energy in sea waves.

A. Solar Energy:

Availability of renewable energy sources are even larger than the conventional fossil fuels and can easily meet the world's energy needs. 8.9×10^{16} Watt [1] of solar power hits on the earth's surface. It is not possible to take all of this energy but even confine less than 0.02% would be enough to fill the current energy demands. Problems in solar generation include the high cost of manufacture solar cells and these solar cells do not produce electricity at night and also in foggy areas specially in winters. Globally, solar generation is the fastest increasing source of energy, seeing an

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annual average growth of 35% over the past few years. Japan, Europe, China, U.S. and India are the major growing investors in solar energy. Solar power's share of worldwide electricity usage at the end of 2014 was about 1%. [2]

B. Wind Energy:

Airflows can be used to run wind turbines. Modern utility-scale wind turbines range from around 600 kW to 5 MW of rated power, although turbines with rated output of 1.5–3 MW have become the most common for commercial use. The largest generator capacity of a single installed onshore wind turbine reached 7.5 MW in 2015. The power available from the wind is a function of the cube of the wind speed, so as wind speed increases, power output increases up to the maximum output for the particular turbine. [3] Areas where winds are stronger and more constant, such as offshore and high altitude sites, are preferred locations for wind farms. Typically full load hours of wind turbines vary between 16 and 57 percent annually, but might be higher in particularly favorable offshore sites. [4]

Wind-generated electricity met nearly 4% of global electricity demand in 2015, with nearly 63 GW of new wind power capacity installed. Wind energy was the leading source of new capacity in Europe, the US and Canada, and the second largest in China. In Denmark, wind energy met more than 40% of its electricity demand while Ireland, Portugal and Spain each met nearly 20%.

Globally, the long-term technical potential of wind energy is believed to be five times total current global energy production, or 40 times current electricity demand, assuming all practical barriers needed were overcome. This would require wind turbines to be installed over large areas, particularly in areas of higher wind resources, such as offshore. As offshore wind speeds average ~90% greater than that of land, so offshore resources can contribute substantially more energy than land stationed turbines. [5] In 2014 global wind generation was 706 terawatt-hours or 3% of the world's total electricity. [6]

C. Biogas:

Production of biomass and biofuels are growing industries as interest in sustainable fuel sources is growing. Utilizing waste products avoids a food vs fuel trade-off, and burning methane gas reduces greenhouse gas emissions, because even though it releases carbon dioxide, carbon dioxide is 23 times less of a greenhouse gas than is methane. Biofuels represent a sustainable partial replacement for fossil fuels, but their net impact on greenhouse gas emissions depends on the agricultural practices used to grow the plants used as feedstock to create the fuels. While it is widely believed that biofuels can be carbon-neutral, there is evidence that biofuels produced by current farming methods are substantial net carbon emitters. [7][8][9] Geothermal and biomass are the only two renewable energy sources that require careful management to avoid local depletion. [10]

D. Hydro Power:

In 2015 hydropower generated 16.6% of the world's total electricity and 70% of all renewable electricity. [11] Since water is about 800 times denser than air, even a slow flowing stream of water, or moderate sea swell, can yield considerable amounts of energy. There are many forms of water energy:

Historically hydroelectric power came from constructing large hydroelectric dams and reservoirs, which are still popular in third world countries. The largest of which is the Three Gorges Dam (2003) in China and the Itaipu Dam (1984) built by Brazil and Paraguay.

Small hydro systems are hydroelectric power installations that typically produce up to 50 MW of power. They are often used on small rivers or as a low impact development on larger rivers. China is the largest producer of hydroelectricity in the world and has more than 45,000 small hydro installations. [12]

Run-of-the-river hydroelectricity plants derive kinetic energy from rivers without the creation of a large reservoir. This style of generation may still produce a large amount of electricity, such as the Chief Joseph Dam on the Columbia river in the United States.

Hydropower is produced in 150 countries, with the Asia-Pacific region generating 32 percent of global hydropower in 2010. For countries having the largest percentage of electricity from renewables, the top 50 are primarily hydroelectric. China is the largest hydroelectricity producer, with 721 terawatt-hours of production in 2010, representing around 17 percent of domestic electricity use. There are now three hydroelectricity stations larger than 10 GW: the Three Gorges Dam in China, Itaipu Dam across the Brazil/Paraguay border, and Guri Dam in Venezuela. [13]

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Wave power, which captures the energy of ocean surface waves, and tidal power, converting the energy of tides, are two forms of hydropower with future potential; however, they are not yet widely employed commercially. A demonstration project operated by the Ocean Renewable Power Company on the coast of Maine, and connected to the grid, harnesses tidal power from the Bay of Fundy, location of world's highest tidal flow. Ocean thermal energy conversion, which uses the temperature difference between cooler deep and warmer surface waters, has currently no economic feasibility.

E. Geothermal Energy:

Estimates of exploitable worldwide geothermal energy resources vary considerably, depending on assumed investments in technology and exploration and guesses about geological formations. According to a 1999 study, it was thought that this might amount to between 65 and 138 GW of electrical generation capacity 'using enhanced technology'. [14] Other estimates range from 35 to 2000 GW of electrical generation capacity, with a further potential for 140 EJ/year of direct use. [15] A 2006 report by MIT that took into account the use of Enhanced Geothermal Systems (EGS) concluded that it would be affordable to generate 100 GWe (Gigawatts of electricity) or more by 2050, just in the United States, for a maximum investment of 1 billion US dollars in research and development over 15 years. [16] The MIT report calculated the world's total EGS resources to be over 13 YJ, of which over 200 ZJ would be extractable, with the potential to increase this to over 2 YJ with technology improvements - sufficient to provide all the world's energy needs for several millennia. [16] The total heat content of the Earth is 13,000,000 YJ. [15]

F. Tidal Energy:

At the end of 2005, 0.3 GW of electricity was produced by tidal power. [17] Due to the tidal forces created by the Moon (68%) and the Sun (32%), and the Earth's relative rotation with respect to Moon and Sun, there are fluctuating tides. These tidal fluctuations result in dissipation at an average rate of about 3.7 TW. [18]

Another physical limitation is the energy available in the tidal fluctuations of the oceans, which is about 0.6 EJ (10^{18} joules). [19] Note this is only a tiny fraction of the total rotational energy of the Earth. Without forcing, this energy would be dissipated (at a dissipation rate of 3.7 TW) in about four semi-diurnal tide periods. So, dissipation plays a significant role in the tidal dynamics of the oceans. Therefore, this limits the available tidal energy to around 0.8 TW (20% of the dissipation rate) in order not to disturb the tidal dynamics too much.

Waves are derived from wind, which is in turn derived from solar energy, and at each conversion there is a drop of about two orders of magnitude in available energy. The total power of waves that wash against our shores add up to 3 TW. [20]

Vibration as Energy Sources

Piezoelectric Materials

Piezoelectric effect is the generation of electrical charge resulting from mechanical strain (force), and the materials which are used to show this type of property are termed as piezoelectric material or crystals. Piezoelectric materials have a crystalline structure with the help of which one can produce electrical energy from mechanical vibrations. The materials showing this property as inherent property are crystals of tourmaline, quartz, topaz, and Rochelle salt. Since piezoelectric materials directly convert mechanical strain to electrical energy, they have now become most attractive functional materials for sensors and actuators. When vibrations through spring is produced on the piezoelectric material through mechanical stress like through load from vehicles, humans foot, railway tracks, dance floors, etc. then positive and negative charge centre's shift which results in an external electrical field. For such conversion firstly, mechanical strain causes generation of mechanical energy which is then converted into a.c voltage and then again converted to d.c voltage. Thus electronic charge gets accumulated in response to mechanical strain applied. When certain crystals are strained, polarization takes place and the amount of polarization is directly proportional to the stress applied. And thus piezoelectric crystals are used to harvest the energy produced by the vibrations from traffic on the road or moving vehicles on highways expressways.

Conversion of vibration energy caused by vehicles into electrical energy occurs in the given manner. When vehicles/traffic passes on through the chosen particular area, it tends to contract the springs placed at the level of the road sometimes just below the road (one with increased sensitivity and long lasting life can be buried (0.5-1.5 m). Now when vehicle passes, spring continuously expands and contracts, which continuously comes in contact with

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piezoelectric crystals which creates a pressure on the crystals. When pressure is exerted, it results in deformation and movement of positive and negative charges which induces electric field and finally electrical energy. This output is further fed to rectifier which converts a.c into d.c. either of the half wave or full wave rectifier can be used in for this purpose. Further microcontroller displays the live status of battery that is, what percentage of battery gets charged whenever vehicle passes on from the layer of piezoelectric transducers. After this output is fed to inverters; an electrical device that converts d.c to a.c. and finally electrical energy gets saved in inverters only and can be used further when needed. The output obtained from a single piezoelectric crystal is in millivolts range. So, we arrange many piezoelectric crystals in series so as to obtain higher voltage. And the received energy is stored in lithium batteries. A general experiment was conducted in for Piezoelectric material used under different loads and a graph between Piezoelectric voltage and Load was plotted which is shown in Graph no.-1. This experiment gave a clear picture as what level of voltage can be gained out from the piezoelectric material under the roads having load of thousands of tons per day sometimes per hour.

III. METHODOLOGY

A. Flooring Tiles

The flooring tiles are made up of rubber which can absorb the vibration and under these the piezoelectric materials are placed so as when the movement is felt by the material they can generate the electricity. When these kind of tiles are installed in locations where large crowd movements are expected such as in Railway station, Bus stations, Airports, Malls, footpaths etc, and when a person steps on them, then by piezoelectric effect small charge is built up. So the energy generated by one human would be too less but if number of steps on these kind of tiles increase then energy produced by it would increase too. When a person steps on such tiles piezoelectric crystal under the tiles would experience some mechanical stress which makes electric charge to built up on crystal's surface which can be collected by use of electrodes. This kind of energy can be stored in capacitors and power can be transfer to energy deficient regions. Japan has already started experimenting use of piezoelectric effect for energy generation by installing special flooring tiles at its capitals' two busiest stations. Tiles are installed in front of ticket turnstiles. Thus every time a passenger steps on mats, they trigger a small vibration that can be stored as energy [21].

B. Road side to Power street lights

The present invention relates generally to methods of electrical power generation and more particularly is a method and device to generate electricity by using traffic on existing roadways to drive an electrical generator [22]. The idea of constructing the special types of roads which generate the electricity is a unique application in power harvesting methodology. This system works by embedding tiny piezoelectric crystals into the road. When automobiles or vehicles drive over through this road then the piezoelectric crystals sense the force and pressure which generates the small electrical charge. Though small charge is generated by single car but 1 km stretch of such road could generate around 400kW-enough to run eight small cars. Such experimenting have already started in Israel [21].

C. Dance Floors

Apart from roads and railway stations, piezoelectric effect is also being in use in the dance floors. In Europe, certain Nightclubs have already begun to power their night clubs, strobes and stereos by use of piezoelectric crystals [23]. These floors are using the piezoelectric effect. As the floor is compressed by the dancer's feet the piezoelectric material makes contact and generate the electricity around 2-20 watts. It depends on the impact of the feet. The constant compression of piezoelectric crystals causes a vast amount of energy to be generated, which can comfortably drive the remotely placed low power consuming devices [24].

D. Inside the Footwear heel

Apart from tiles, roads, dance floors, efforts are made to crop energy from our daily movements by establishing piezoelectric crystals in the footwear also. These footwear would have piezoelectric crystals at the rear end or near heel. Thus with each step piezoelectric crystal would go through pressure and force which in turn can create enough energy to charge up the small electronic devices or gadgets. Often we can do that with a piezoelectric transducer, a transducer

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is simply a device that converts small amount of energy from one kind to another for instance converting light, sound or mechanical pressure into electrical signals [25].

E. Roads and Highways

The traffic is more in day than night and sometimes traffic run 24hrs and the traffic varies throughout in a day. The total force exerted by moving automobiles on the road surface can be calculated by considering the average number of vehicles passing through certain point, for a certain time period. In a survey, Israel is putting PEG 6cm under the road level and at a distance of 30cm apart. From this trial, it has been seen that a vehicle weighing at around 5 tons can generate 2000V, and a 1Km cluster of such generator can generate 400Kwh energy. If 600 vehicles are allowed to go through this road for an hour, it can power up to 600-800 homes [26].

F. Power Generating from Footpaths

Footpath is most common place on where we can insert the piezoelectric tiles to produce the small amount of energy by using the human footstep over it. The produced charge is stored in battery and then that stored charge can be use for charging low power electronic equipments.

G. Power Generating Railway Tracks

The railway tracks are the important place which is accountable for production of large amount energy as the huge amount of pressure is exerted by trains on the railway tracks. The embedded piezoelectric crystals at the railway tracks where wheels make contact with the tracks and these materials get excessive pressure and force, due to this greater amount of energy is stored.

H. Power Generating Airport Runway

The large amount of pressure is exerted on aerodrome runways, when the aircraft takes off or lands. If we place the piezoelectric clusters here then we can convert this mechanical energy. The efficiency of system can be improved by placing the stacked structure which is consist of several layers of piezoelectric clusters and have the capacity to handle the huge amount of pressure. The maximum takeoff weight for the airbus aircraft (A380) is 560 tones, which can produce 224 KV, so if one considers the total number of landing in the runway a large amount of energy could be produced. Nearly 8138 kWh energy could be produced which can power up to 12207-16276 homes [10].

I. Schools, Colleges, Shopping Malls and Gyms

The flooring of piezoelectric material will cause to create the more energy in the crowded area as malls and schools. One can place the piezoelectric tiles at the entrance of the malls and schools. The idea of using the vibrations caused by the equipments in the gym and at office also while sitting on the chair, the energy can be stored in the batteries by putting the piezoelectric crystals in the chair.

IV. CONCLUSION

According to Albert Einstein "Energy can neither be created nor be destroyed it can be transferred from one form to another" as this method of generating electricity by the use of piezoelectric material has already being started in many countries as in Japan, Israel, Netherlands. Use of piezo-electric material is eco-friendly causes no pollution. It is an inexpensive way of creating electricity and is easy to install. In future this method will be a promising method for generating eco-friendly electricity. We also contribute this method at common places like home entrance gates, parking area, bus stands etc. This method will utilize various areas of electricity production.

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