POWER GENERATION IN AREAS OF HIGH PRECIPITATION

CONCEPT

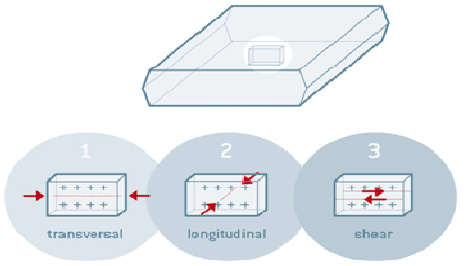
Use piezoelectric crystals, which have a property to convert pressure into energy installation for generation of power areas of high precipitation. The downpour in areas of high precipitation is with a tremendous gush and force. This gush will provide the necessary pressure for piezoelectric crystals to work and generate power.

WORKING

Piezoelectricity

To satiate our ever increasing thirst for energy we are determined to find new sources of energy in terms of non-renewable (coal, gas & oil) and renewable (like solar, wind or hydro). But each of these has their own disadvantages, as non-renewable sources pollute the environment and renewable sources of energy have their own disadvantages. As a consequence there have emerged needs to find new technologies. One such technology that can prove to be beneficial is the use of rain water for generation of electricity by using the concept of Piezoelectricity. There have been developments in this field in the past for example; Kymissis et al. (1998) examined the application of a piezo film in addition to the ceramic to provide power to light up bulbs in a shoe, entirely from walking motion. Kimura (1998) centered on the vibration of a small plate, harnessed to provide a rectified voltage signal to run a small transmitter fixed to migratory birds for the purpose of transmitting their identification code and location.

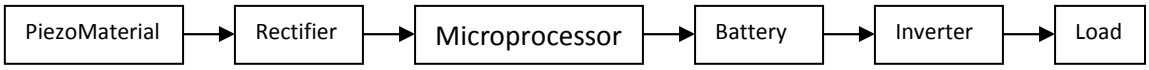
"Piezoelectricity" means generating electricity from pressure i.e. when a mechanical stress is applied to a piezoelectric material charge is developed along the material surface. Piezoelectric affect was first discovered by Jacques Curie and Pierre Curie. Piezoelectric crystals act the way they do because of asymmetry. These crystals have more atoms one side than the other side. When the crystal is squeezed, imbalance of charge occurs/a dipole is created. If both sides of crystal are connected in a circuit, electricity is generated. There are two main groups of materials used as piezoelectric sensors: piezoelectric ceramic for example; PZT (lead-zirkonite-titanate mixed ceramics), bismuth titanate or lead metaniobate and single crystal material for example; Quartz, Tourmaline, Rochelle salt, and Gallium Phosphate etc.



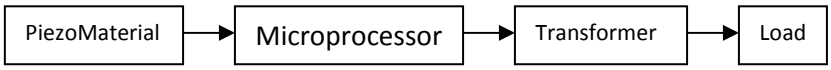
A piezoelectric crystal can undergo three types of operation- Transverse, longitudinal and shear. Once force is applied based on the type of operation, charges are developed on both sides of the crystal.

Orientation of Crystals

If we take a piezoelectric crystal for ex: quartz, which occurs naturally by applying mechanical stress to it then the crystal, develops charge on its opposite faces. This charge is analogous to AC (Alternate Current) in nature. Hence, if we wish to store the charge developed in a battery such that it can be used later, Case 1 can be used and if we wish to use this charge developed into effective power Case 2 can be used. To generate the power either piezoelectric crystals or piezocermaics can be used.



Case 1: Rectifier & Inverter circuit to store energy produced & use it subsequently



Case 2: AC power used directly

Use of rainfall for energy

When a raindrop falls to the surface of the Earth, it is acted on by two main forces, gravity and drag. A stationary raindrop initially experiences acceleration due to gravity of 9.8 m/s^2. As gravity increases the speed of the raindrop in its descent, drag retards the downward acceleration of the raindrop. The combination of these two forces causes a raindrop to reach a terminal velocity when the drag force is approximately equal to the weight of the raindrop. At this point, a raindrop experiences no further acceleration and therefore falls at a constant velocity. The phenomenon of rain is governed by the water cycle in which water evaporates and gains potential energy. This energy is then lost when the water precipitates. Potential energy is defined as the product of mass, height, and gravitational constant, g (9.81 m/s^2). For example, the potential energy of a cubic meter of water (1000kg) in a stratus cloud at 2000 m of elevation is about 20 MJ or 5.5 kWh.

1 unit(Power) = 1 kWh= 3.6 MJ, 1 kWh is the energy consumed in an hour @ 1000J/s. Using 1 kWh, Five, 100 watt light bulbs can be powered for two hours by 1 kWh of energy.

However, most of the potential energy associated with rain is lost during the free fall, thus substantial amount is not left for electricity generation by means of piezoelectric crystal. But, rain also kinetic energy i.e. energy obtained by motion (during free fall). Kinetic energy in an object is half the mass times the velocity squared. If we assume zero loss then the amount of kinetic energy falling on a 185 m^2 roof is about 59.2 kJ (0.016 kWh) per cm of rain. This sums up only to about 1.6 kWh per year in an area that receives a meter of rain per year. This may not be practical for electricity generation but, the conditions may be totally different in areas of high precipitation like Cherrapunjee & Mawsynram. These are the two wet places in the world Cherrapunjee & Mawsynram receiving around 11.067 m & 12.726 m of rain annually and covering an area of approx 1100 sq km.

Data	Area (m2)	Rainfall (2010) (m)	kinetic energy falling on a 185 m^2 roof	Power @ 185 sq m with 1 m rain annually(kwh)	Power (kwh) @ Total Area and actual rainfall Cherrapunjee/Mawsynram	Actual Usage(kwh)	Power Sufficient for (using assumption) (days)
Cherrapunjee	578000000	11.067	0.016kwh(59.2 KJ)	1.6	55323035.68	16596911	546.13497
Mawsynram	523000000	12.726	0.016kwh(59.2 KJ)	1.6	57562793.51	17268838	568.24529

Note: -
1.)Only assuming heavy rainfall area.
2.) Rainfall considered is average over a period of 5 yrs from 2006-2010.
3.) 1 sq km = 1000000 sq m.
4.) Actual usage factor of 0.3 is considered.
5.) Cherrapunjee is the headquarter of Shella Bholaganj block in East Khasi hills district of Meghalaya and Mawsynram is headquarter of Mawsynram block in the same district.

Assumption based on facts and assuming ideal cases where applicable: -
It is assumed that a normal household consists of 4 persons and they use 2 ceiling fans (40 W each) & 2 Tube lights of 4 feet (40 W each), so a normal household will be using up 160 W per hour or 160/ 0.16 kwh. Population [4] of each of Cherrapunjee & Mawsynram is 12,746 & 18,910 respectively. Since a normal household consists of 4 persons and hence there are around 3187 & 4727 households in each of these places, taking sum as 7914 households and together they use 1266.24 kwh.
It is assumed that the rainfall is applicable to the entire block of Mawsynram & Cherrapunjee/Shella Bholaganj. Please note that the population data may vary.

Data Analysis for High Precipitation

CONCLUSION

Owing to our growing energy demands and disadvantages associated with each of coal/oil/gas based energy & that associated with solar, hydel and wind power it is necessary that we work towards other sources of energy that are present with only requirement being analyzing and materializing the concept. One such idea studied here is using rain water in areas of high precipitation. With the data and analysis done here it can be seen that piezoelectric crystals/cermaics have the potential for electricity generation in areas of high precipitation.

REFERENCES

Generating electricity using piezoelectric material, Borneo Science, 24th March, 2009, Jedol Dayou, Man-Sang, C, Dalimin, M. N. &Wang, S.

A proposal for large scale electricity generation from high pressure applications using piezoelectric materials. International Journal of Science and Advanced Technology (ISSN 2221-8386).

Estimation of electric charge output for piezoelectric energy harvesting, LA-UR-04-2449, Strain Journal, 40(2), 49-58, 2004. Henry A. Sodano, Daniel J Inman, Gyuhae Park.

Rainfall as Energy Source, http://large.stanford.edu/courses/2010/ph240/harting2/

Meghalaya Planning handbook, http://megplanning.gov.in/handbook/2008.pdf

PiezoCryst Advanced Sensors GmbH, http://www.piezocryst.com/piezoelectric_sensors.php

The principle and applications of piezoelectric crystal sensors, Elsevier, Materials Science and Engineering C 12_2000.111–123, Sang-Mok Chang , Hiroshi Muramatsu , Chikashi Nakamura , Jun Miyake.