ISBN : 978-93-87793-50-7

DEVELOPING MODEL TO CONVERT HEAT GENERATED ON THE ROOF INTO ELECTRICITY USING CONCEPT OF SEEBECK EFFECT

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ABSTRACT

The worldwide energy demand is continuously growing and according to the forecasts of the InternationalEnergy Agency it is expected to rise by approximately 50% until 2030. Currently over80% of the primary energy demand is covered by fossil fuels. Although their reserves will last for the next decades they will not be able to recover the worldwide energy consumption in the long run.

This increase in the consumption of electricity demands study of its causes and effects of increased consumption of electricity on the environment. The main causes of increase in consumption of electricity are 'Industrialization' and 'Modernization'. Other small-scale causes areas follow-

1) Weather- Due to Global Warming, there has been an overall increase in global temperature which has resulted in very hot summers and very cold winters. These adverse conditions demand the excess use of electrical appliances like Air Conditioners and Heaters which increase the overall electricity consumption.

2) Increased Population- It is one of the other causes of increased consumption of electricity. More the number of people, more is the electricity consumed in the household.

3) Advanced Technologies- Upcoming advanced technologies favouring the use of electrical gadgets lead to consumption of electricity. Every gadget is battery powered which has to be charged periodically.

All these causes have led to the increased consumption of electricity which has adverse effects on environment. The fossil fuels are getting deteriorated due to its increased consumption. Further excessive use of fossil fuels causes emission of Green House Gases which cause Global Warming. According to studies, the non-renewable

sources of energy wouldn't last for more long a few decades. Therefore, it's necessary to use renewable sources of energy. These after steps should be taken on a personal level. To reduce the consumption of electricity, our project has studied these various aspects of personal level "Electricity Power Consumption"

According to the International Energy Agency, nearly 240 million Indians lacked lack access to electricity in 2017. One out of every five people around the world without access to power lives in India.According to official data, only 1,417 of India's 18,452 villages, or 7.3% of the total, have 100% household connectivity, and about 31 million homes are still in the dark.

Electricity is one of the greatest inventions of the mankind. But electricity generations is one of the leading sources of greenhouse gas emissions, and as the icing on the cake, there has been a drastic increase in the consumption of electricity. This has lead to substantial increase in the consumption of fossil fuels. This has had a severe impact on the environment. But this does not indicate the renewable sources like wind, solar and geothermal do not have environmental impacts. The renewable sources do leave their footprints, but they are overshadowed by those of the non-renewable resources.

Thus, it is important to reduce the consumption of electricity which will lead to decrease in the production of electricity. If it is not conserved it is going to lead to a future with no fuels and a unsustainable environment. This project highlights the growing consumption of electricity and its effect on environment. This has now become a major global issue and many international organizations are working to create awareness about this issue. No doubt a massive accomplishment, but a closer look at what constitutes "electrified" reveals how much further India has to go.

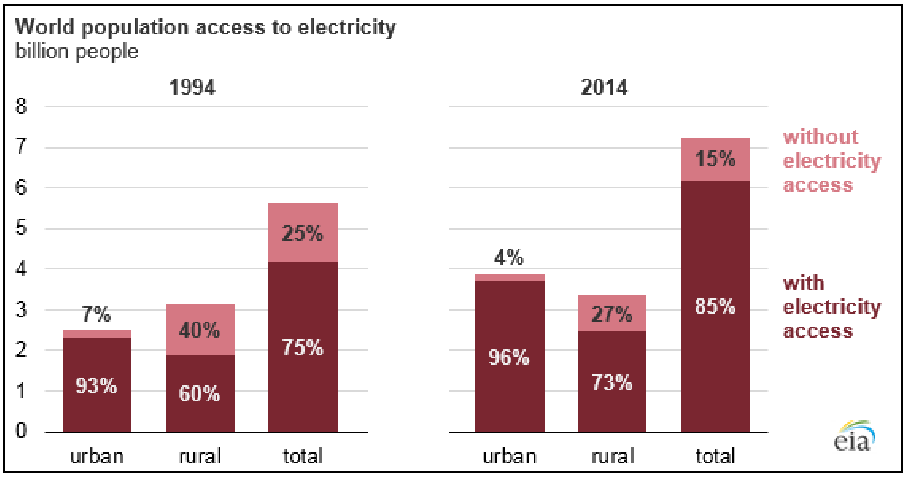

Fig. 1

Key Words *Consumption, Electrical appliances, Electricity, Global warming, Renewable sources.*

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1.INTRODUCTION

The main principle of our project is Seebeck effect which is the production of electricity due to temperature difference. In our project we have tried to efficiently create temperature difference between the two terminals which have been joined by conductors which have high difference in the Seebeck coefficients. The model could be a helping hand in remote rural areas where everybody can have access to cheap and efficient electricity. In the course of the project we have come to the conclusion that graphene can be used for the betterment of everyone as it can replace other metals and enhance the efficiency of production of electricity. India receives abundant sunlight all year long. But due to lack of fundingfor installation of solar panels in rural areas and low efficiency, the solar technology is not yet reachedup to required extent. Our model with some developments can be used to produce electricity in near future.

2.PRELIMINARY CONCEPTS INVOLVED IN PROJECT

2.1 SEEBECK EFFECT

The Seebeck effect is a phenomenon in which a temperature difference between two dissimilar electrical conductors or semiconductors produces a voltage difference between the two substances.

The Seebeck effect is the direct conversion of temperature differences to electric voltage and vice versa via a thermocouple. A thermoelectric device creates voltage when there is a different temperature on each side. Conversely, when a voltage is applied to it, heat is transferred from one side to the other, creating a temperature difference. At the atomic scale, an applied temperature gradient causes charge carriers in the material to diffuse from the hot side to the cold side. When heat is applied to one of the two conductors or semiconductors, heated electrons flow toward the cooler one. If the pair is connected through an electrical circuit, direct current (DC) flows through that circuit.

This effect can be used to generate electricity, measure temperature or change the temperature of objects. Because the direction of heating and cooling is determined by the polarity of the applied voltage, thermoelectric devices can be used as temperature controllers.

In general, the Seebeck effect is described locally by the creation of an electromotive field;

$E_{emf} = -S\ \Delta T$ (1)

where S is the Seebeck coefficient (also known as thermopower), a property of the local material, and ΔT is the temperature gradient.

2.2 SEEBECK COEFFICIENT

The Seebeck coefficient (also known as thermopower, thermoelectric power, and thermoelectric sensitivity) of a material is a measure of the magnitude of an induced thermoelectric voltage in response to a temperature difference across that material, as induced by the Seebeck effect. The SI unit of the Seebeck coefficient is volts per kelvin (V/K), although it is more often given in microvolts per kelvin (μV/K).

The use of materials with a high Seebeck coefficient is one of many important factors for the efficient behavior of thermoelectric generators and thermoelectric coolers. More information about high-performance thermoelectric materials can be found in the Thermoelectric materials article. In thermocouples the Seebeck effect is used to measure temperatures, and for accuracy it is desirable to use materials with a Seebeck coefficient that is stable over time.

Physically, the magnitude and sign of the Seebeck coefficient can be approximately understood as being given by the entropy per unit charge carried by electrical currents in the material. It may be positive or negative. In conductors that can be understood in terms of independently moving, nearly-free charge carriers, the Seebeck coefficient is negative for negatively charged carriers (such as electrons), and positive for positively charged carriers (such as electron holes).

One way to define the Seebeck coefficient is the voltage built up when a small temperature gradient is applied to a material, and when the material has come to a steady state where the current density is zero everywhere.

The Seebeck effect is generally dominated by the contribution from charge carrier diffusion (see below) which tends to push charge carriers towards the cold side of the material until a compensating voltage has built up. As a result, in p-type semiconductors (which have only positive mobile charges, electron holes), *S*is positive. Likewise, in n-type semiconductors (which have only negative mobile charges, electrons), *S* is negative. In most conductors, however, the charge carriers exhibit both hole-like and electron-like behaviour and the sign of *S* usually depends on which of them predominates.

A material's temperature, crystal structure, and impurities influence the value of Seebeck coefficients.

Following table gives value of Seebeck coefficients of some important materials that can be used in electricity generation

ISBN : 978-93-87793-50-7

TABLE 1

Sr. No.	Material	Seebeck coefficient (μV/K)
1	Copper	6.5
2	Silicon	440
3	Germanium	330
4	Cadmium, Tungsten	7.5
5	Chromel	22
6	Alumel	-18
7	Constantan	-39
8	Graphene	90
9	Bismuth	-72

2.3 PELTIER MODULE

A typical Peltier module consists of an array of Bismuth Telluride semiconductor pellets that have been "doped" so that one type of charge carrier– either positive or negative– carries the majority of current. The pairs of P/N pellets are configured so that they are connected electrically in series, but thermally in parallel. Metalized ceramic substrates provide the platform for the pellets and the small conductive tabs that connect them.

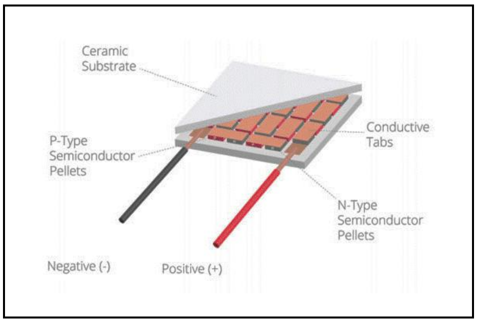

Fig. 2

When dc voltage is applied to the module, the positive and negative charge carriers in the pellet array absorb heat energy from one substrate surface and release it to the substrate at the opposite side. The surface where heat energy is absorbed becomes cold; the opposite surface where heat energy is released, becomes hot. Reversing the polarity will result in reversed hot and cold sides.

The amount of heat to be transferred through a Peltier module from the cold side to the hot side is denoted Q and is specified in Watts. This parameter may be the heat generated by an object to be cooled or it may be the heat conducted to the ambient environment from the object being cooled. It should be understood that Peltier modules do not possess the ability to absorb thermal energy. Peltier modules only transfer thermal energy and the energy being transferred will need to be dissipated on the hot side of the module. In our project we used Peltier module in the reverse way and we confirmed that Peltier module have the ability to convert thermal energy into electrical energy. They are made of two unique semiconductors, one being p-type and another being n-type and they are static in nature. The working operation is based on Seebeck effect (conversion of heat into electricity) which occurs inside the Peltier modules. As the heat spreads and starts flowing so does the free charge carriers from the hot side to the cold side. The end voltages are proportional to the temperature difference and the system keeps on generating voltage as long as the temperature difference remain intact. Generated voltages from each Peltier module increases with respect to time and temperature difference. They are connected in series so that the end voltages will be high. The temperature keeps on changing so instability occurs which may damage the connected equipment so a chopper is connected before connecting the device to the system which provides pure and stable dc voltages. The device is not only useful for isolated areas but it can also be used in the industrial sector where latent heat is produced which can be used as the source of heating and extra amount of energy can be produced with it.

3. APPARATUS USED FOR MODEL

- Copper plate
- Peltier module
- Conducting wires
- Digital Multi meter
- LED bulbs
- Switch
- Miniature wooden house (made from scrap)
- Thermometer

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4. DIAGRAM

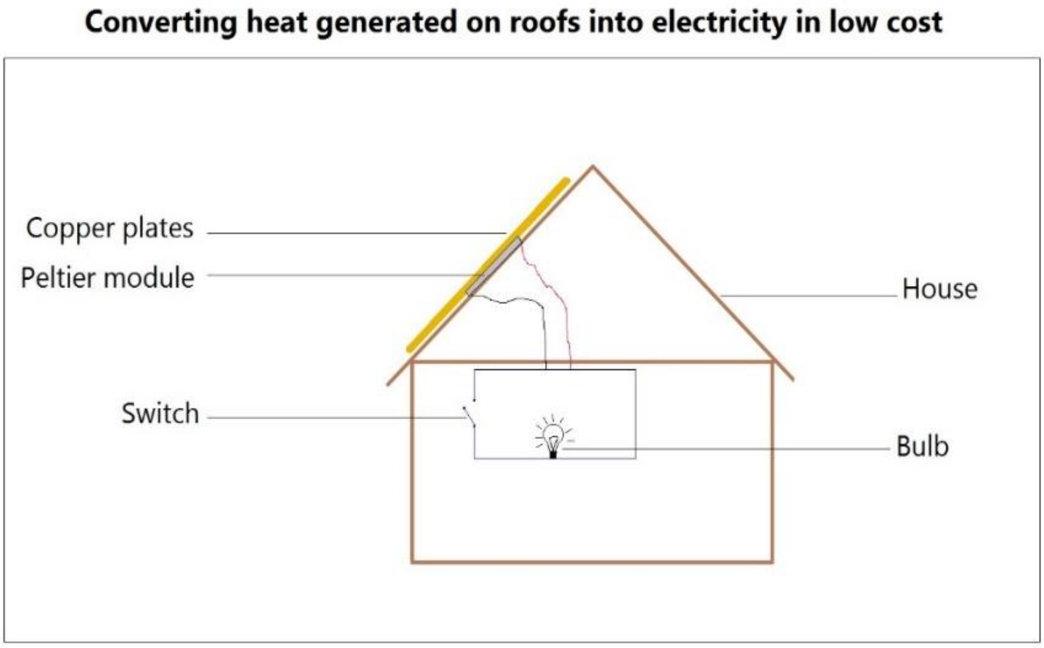

Fig. 3

5. PICTURES

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6. WORKING

In our project we designed and constructed model of a small house which will convert heat generated on the roof into electricity. A copper plate is fitted on the roof which absorbs sunrays and heats up. As copper has high thermal conductance it heats up to very large extent. A peltier module kept in contact with copper plate from bottom. When copper gets heated a high temperature is developed on one side of the peltier module. Other side of the module is at room temperature hence temperature difference is created between two sides of the peltier module. The charge carriers inside the material and the semiconductors move freely while carrying both charge and the heat. Creating temperature difference causes the carries at hot end to diffuse at the cold end. This build-up of carrier charge at hot end results into a build-up of net charge at the cold end thus resulting in the voltage production. The semiconductors are highly doped by pollutants to increase the electric conductivity. The voltage produced can be utilised for domestic purposes. All this phenomenon is based on Seebeck effect and we can use other materials instead of copper with high conductance and high Seebeck coefficient.

7. RESULT

The data collected from our model is given in the following table which shows the temperature of copper plate and corresponding voltage generated.

Sr. No.	Temperature of copper plate (C)	Room temperature (C)	Temperature gradient (C)	DC voltage (V)
1	55	27	28	**1.2**
2	48	25	23	**0.9**
3	50	26	24	**0.9**
4	52	27	25	**1.0**

Average value of DC voltage produced = 1.0 V (Within the limits of experimental errors)

8. CONCLUSION & FUTURE SCOPE

We successfully discovered that heat generated on the roofs can be utilised for electricity generation. Our model has capability to generate DC voltage that can be used in the rural areas where people face hardships due to lack of electricity. We used copper plates which is economical and moderately rich in thermal conductivity. But there are materials like graphene, Chromel, Alumel, Constantanwhich are extremely conductive and can generate large amount of electricity efficiently. Graphene is an allotrope of carbon that exists as a two-dimensional planar sheet. Graphene is technically a non-metal but is often referred to as a quasi-metal due to its properties being like that of a semi-conducting metal. Each carbon atom is covalently bonded (sp2 hybridized) to three other carbon atoms in a hexagonal array, leaving one free electron per each carbon atom. This free electron exists in a p-orbital that sits above the plane of the material. Each hexagon in the graphene sheet exhibits two pi-electrons, which are delocalized, allowing for an efficient conduction of electricity. The holes in the structure also allow phonons to pass through unimpeded, which gives rise to a high thermal conductivity. The repeating structure of graphene makes it an ideal material to conduct heat in plane. Interplane conductivity is problematic and typically other nanomaterials such as CNTs are added to boost interplane conductivity. Regular structure allows the movement of phonons through the material without impediment at any point along the surface. Graphene can exhibit two types of thermal conductivity- in-plane and inter-plane. The in-plane conductivity of a single-layered sheet is 3000-5000 W m-1 K-1, but the cross-plane conductivity can be as low as 6 W m-1 K-1, due to the weak inter-plane van der Waals forces. Monolayer of graphene shows several Seebeck coefficient, but the Seebeck coefficient of graphene increases with increasing its layers. It even reaches up to 77%.

Graphene conducts 100 times better than copper! It also conducts heat in an oddly direct way. Energy is transferred through graphene from end to end without any heat remaining in between.

Alloys like Chromel, Alumel, Constantan have high Seebeck coefficient and can be used as heat absorbers in our model.However, non-availability of graphene at lower levels is still a major problem. Though we can conclude that graphene can be used in our model as the ultimate source of clean, limitless and sustainable energy and development.

9. ACKNOWLEDGEMENTS

We wish to express our sincere gratitude to honorable director Prof.(Dr.) Rajesh Jalnekar, respected DESH HoD Prof.(Dr.) C.M. Mahajan, project guide Prof. Manasi Ghamande, the Machining Workshop faculty for their help and support as and when required. This project would not have been possible without the help of the Vishwakarma Institute of Technology and the above-mentioned faculty.

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