ISSN NO. 2320-5407

Journal homepage: http://www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH

RESEARCH ARTICLE

Thermoelectric generation using combination of solar and geo-thermal energy

R K Aggarwal and Sangeet Markanda

1. Department of Environmental Science, Dr Y S Parmar University of Horticulture & Forestry, Nauni (Solan) - 173 230 India.
2. Department of Physics, University College Dhilwan, Dhilwan (Barnala), Punjab- 148108, India.

Manuscript Info

Manuscript History:

Received: 11 June 2013
Final Accepted: 25 June 2013
Published Online: July 2013

Key words:
Thermocouple,
Solar Energy,
Geo-thermal Energy,

Abstract

Thermocouple generates power using the solar heat trapped in a greenhouse and geo thermal energy from the natural hot water sources. Traditionally thermo power is generated using coal, natural gas, and biomass causing emission of greenhouse gases. Since the Era of the space programs thermo power is being provided to the space craft's. Solar cell and wind energy are the technologies produce clean energy that can be direct introduced to the backup electricity for houses for saving the energy from main grid. The study aims to utilize solar and geothermal simultaneously with thermocouple in a manner to develop a new way of eco-friendly power generation that can be used for smaller power consuming events like charging phone, lighting LED lamps, even can be stored for use during main power cut.

Introduction

One of many reasons behind the lack of solar power production and more emphasis on other non-renewable energy sources is lack of the variation in research of solar power production in India. There are number of technologies for solar power production other than solar cells like solar thermal power, concentrating solar power etc. In the present research we use solar thermal power apply to thermocouple.

The emergence of thermoelectric generators as a viable alternative for the production of electricity is because of the relatively low energy conversion efficiency, which is only about 5% to 7% whereas photovoltaic (PV) are now in excess of 40%[1,2,3]. Unfortunately this low efficiency rating also had a negative impact on further research and development of thermoelectric generators (TEGs). However, comparing TEGs with PV panels on watt rating basis is a grossly inaccurate comparison and makes it appear that TEGs are simply too expensive option. This paper discusses the utilization of the two energies with thermocouple simultaneously to develop a new way of eco-friendly power generation.

Thermoelectric technology

Thermoelectric technology has been in wide spread commercial and industrial use for over 50 years yet the true value of thermoelectricity has been seriously underestimated resulting in almost no advancements in the technology. Although this state of affairs is not all that surprising if you consider that energy costs have been very low over the same time frame. Cheap energy means there is no incentive to use, improve or develop alternative methods of using or producing energy. However as we all know circumstances have changed and the days of cheap and abundant energy are over and the race to invest in the development of new alternative energy sources and improving energy efficiency of the devices we use is on.

In 1821, the German–Estonian physicist Thomas Johann Seebeck discovered that when any conductor is subjected to a thermal gradient, it will generate a voltage. Any attempt to measure this voltage necessarily involves connecting another conductor to the "hot" end. This additional conductor will then also experience the temperature gradient, and develop a voltage of its own which will oppose the original. The magnitude of the effect depends on the metal in use. Using a dissimilar metal to complete the circuit creates a circuit in which the two legs generate

different voltages, leaving a small difference in voltage available for measurement. That difference increases with temperature, and is between 1 and 70 micro volts per degree Celsius (μV/°C) for standard metal combinations[4]. Thermoelectric Power Generation (TEG) devices typically use special semiconductor materials which are optimized for the Seebeck effect[5]. Thermo power production basically subjected to the coal, biomass, oil or natural gas, and in traditional ways using wood. Since the starting era of the space programs, nuclear energy is also introduced for thermo power production for providing the electric power to the space craft's[1]. Rreplacing thermocouples by free-piston sterling engines, NASA plans to raise the efficiency to 30% and thus reduce both the mass and the very high cost of the plutonium heat source[6]. But these came under the category of polluted ways. The use of renewable energy will open an additional field of power production that can accelerate the concept of backup energy in houses. The solar power source can be used for smaller power consuming events like charging phone, lighting LED lamps, even can be stored for use during main power cut.

Various chemical compounds present in Earth's atmosphere allow direct sunlight (relative short wave energy) to reach the earth unimpeded. As the shortwave energy heats the surface, longer wave (infrared) energy (heat) is reradiated to the atmosphere. Greenhouse gasses (GHGs) absorb this energy, thereby allowing less heat to escape back to space, and trapping it in the lower atmosphere, this process is known as greenhouse effect [7]. The process of global warming is not only due to the increase in CO_2but increase in combination of all GHGs generated at high extant in last few decades [8].

Same phenomena can be applied with bounding the GHGs in a closed container, with one end covered with transparent glass sheet that will absorb solar energy and can maintain high temperature for longer time. This energy can be utilized as hot junction of thermocouple for electricity production. In common thinking we assume that GHGs especially CO_2 traps the direct sun heat however, solar rays contain very small component of infra - red radiation (IR), it just stop the reflected IR from the surface of earth back to space. Alone CO_2 is not enough effective for the greenhouse effect [8].

Thermoelectric power generation

In thermocouple generator, source part is subjected to collect the energy from sun in the form of heat. The concept of collection of heat based upon the simple phenomena of increase in the wavelength of the falling radiation after refraction through a transparent glass sheet. Glass is transparent to wave of visible light but opaque to ultraviolet and infrared waves. Glass acts as valve of one way short, it allows the visible light to enter but prevent the longer wavelength to leave[9]. One Thermocouple is sandwich between the solar heat trapping using greenhouse and a simple heat sink, which is made of thin aluminium sheets. The bottom side of heat sink in connect with another thermocouple, which again touches to a metallic sheet touches the geo thermal heated water. The heat transferred to the hot junction of the thermocouple through the aluminium body of the thermocouples. Output from the thermocouple mounted in-between the heat source and sink was taken out and output wires were protected using shielding of cylindrical shape.

Thermoelectric power generation as acombination of solar and geo thermal energy

It is the combined effect of the solar and geothermal energy together to make effective output simultaneously. Moreover combined source model utilized the space (area) and energy available at the same time. Output obtained from the combined approach either subjected to the series combination then voltage will add and then constant current will flow through the circuit towards the load using DC battery or subjected direct to load without DC battery. Since load in the form of DC battery, hence no option of the output mode.

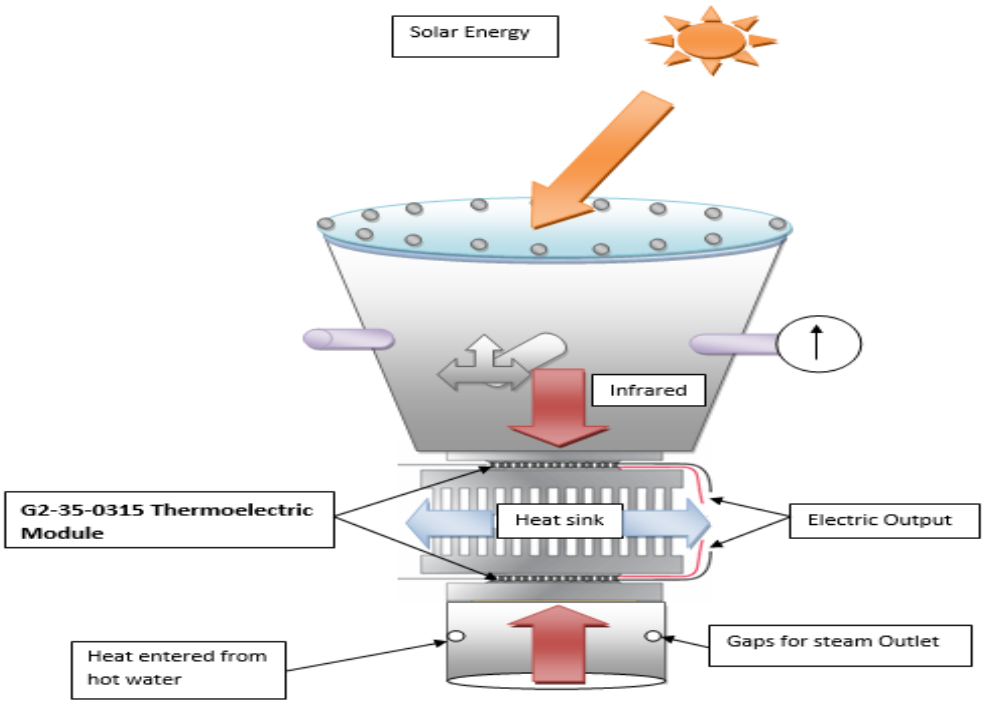
In final model of the source for electric output, fixed amount of GHG/GHGs was filled in the source at constant pressure. The heat transferred to the hot junction of the thermocouple through the aluminium body of the thermocouple. Thermocouple G2-35-0315 used was manufactured in Tellurex Corporation 1462 International Drive in Traverse City, Michigan, 49686 United States of America. All the G2 Tellurex power generation modules also include an effective and smooth thermal interface material that eliminates the need for thermal grease during installation and use. Heat rejection side should not exceed 100˚C and the heat collection side will be on top when holding the module with red wires facing you and extending to the right. Compliant, Ceramic material: Alumina (Al2O3, white 96%), Bonding: Proprietary (withstands 320˚C), Flatness/Parallelism: Not more than +/- 0.025mm.Output from the thermocouple mounted in-between the heat source and sink was taken out and output wires were protected using shielding of cylindrical shape [10] .

Hot springs have temperature ranges from 30-90^{0}C, near the boiling temperature of water[11]. Direct connection of hot side of thermocouple with geothermal source is harmful and protection from the excess of humidity is necessary. A protection layer of solid polythene was mounted by us in outer side of the thermocouple with the tape. Hot side of thermocouple was attached to a closed side of hollow container. Half portion of the container was dipped inside the boiling water (hence protected from the direct connect of hot water). Other side of the thermocouple was attached to the heat sink. The most common heat sink materials are aluminium alloys [12]. Heat taken from hot water by the aluminium container and then it transferred to the hot junction of the thermocouple. Heat was lost from the cold junction by heat sink attached to thermocouple. Fraction of heat was converted into the electric energy.

Since the temperature of the hot spring lies in 30-90^{0}C resulting excess steam. In the source part steam produced the pressure and even starts circulating inside the source part. This condition avoided by using the simple idea of making hole in axis perpendicular to the cylindrical axis. Steam generated left the source through these holes. Since the density of the hot water was low it flown over the cold water hence these helped in flow of hot water through the source.

As shown in Fig.1 heat sink of solar and geothermal sources were attached to each other. The model was placed in such a way that one was toward the sun and other source was placed on hot spring.

Fig.1: Combined approach of solar and geo-thermal energy



Output voltage and current

Output voltage from solar and geothermal integrated approach of the both energies is taken by subjecting the output to series combination (Fig. 2)**.** Maximum output voltage obtained during the mid-day time. It supported the outcome obtained when subjected to these energies individually. Output from that combination utilized when make applicable to the large extent. It observed that during day time grid is on maximum load. Hence, it became a better option for the commercial production of electricity. Same patron of variation observed in output current as shown in Fig. 3.

Fig. 2: Combined output voltage from solar and geo-thermal energy

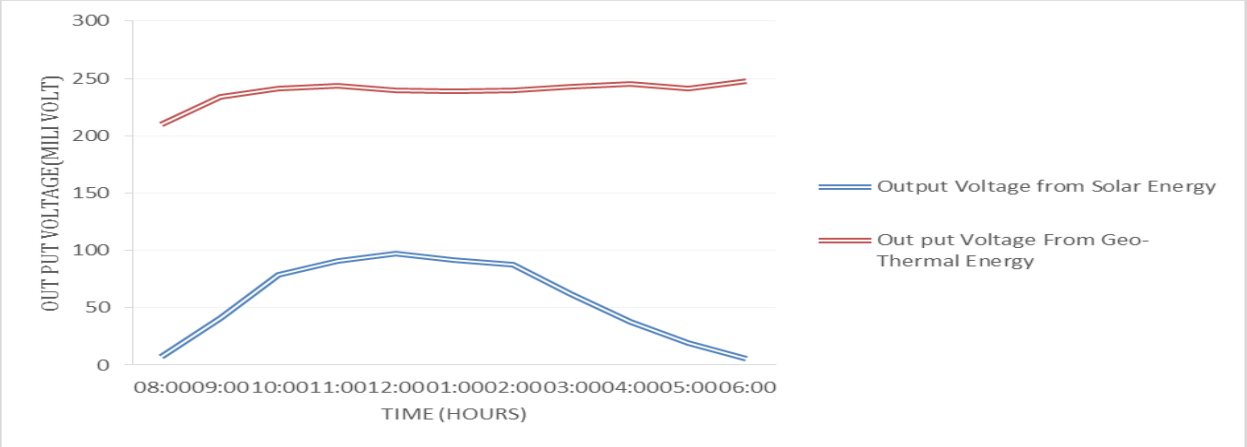
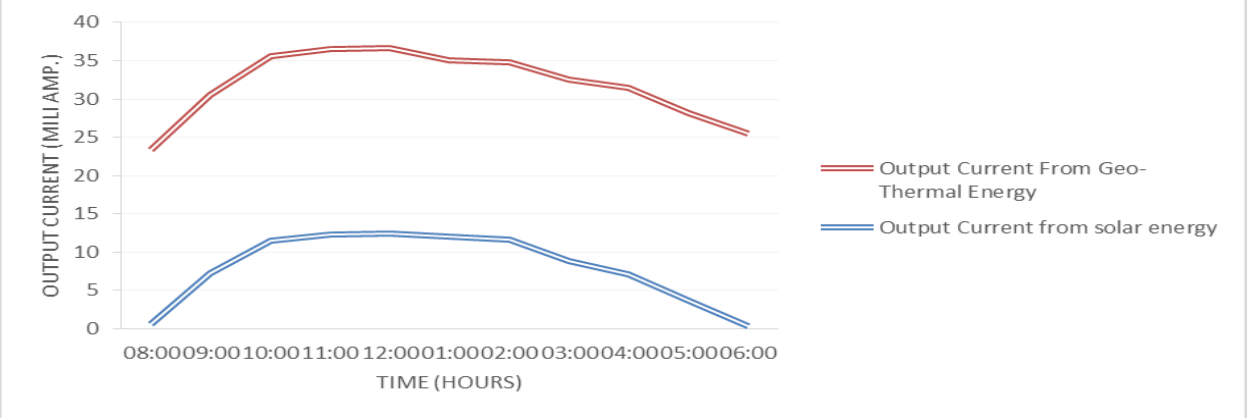


Fig. 3: Combined output current from solar and geo-thermal energy



Results from solar energy portion are influenced by Sun's path through the sky. Variation in output voltage as well as in the current is due to the maximum and minimum heating during the noon and evening/morning time[13]. Down fall observed in-between the noon time for the output voltage from geo thermal part because of rise in the surrounding temperature causes the effects on the performance of the heat sink used. Its working based on the heat released to the surrounding. During the noon the mean temperature of the surrounding increase to 30-40 ^{0}C, hence mean temperature difference between the source and sink decrease which further causing decrease in the output voltage. Variation in voltage can be regulated as DC voltage regulation[14].

COMPERISON BETWEEN SOLAR AND GEO-THERMAL POWER PRODUCTION

Fig. 2 shows the difference between the maximum voltages difference as more than the double in case of the geothermal than in the case of the solar. It indicates the continuity in output voltage in the case of geo-thermal and discontinuous line of the output voltage of the solar energy power production. Same patron observed in case of the output current as shown in Fig. 3.Total comparison between the outputs from solar and geo-thermal is shown in Fig. 4.

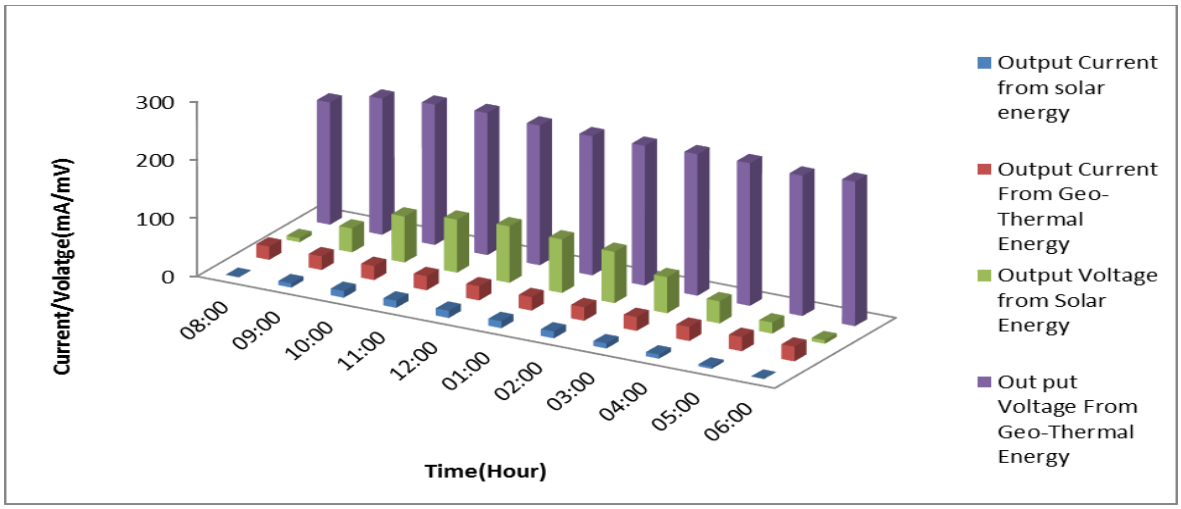


Fig. 4: Variation of current/voltage with time

Discussion

The solar energy is converted into the electricity using the thermocouple with efficiency from 6-8%. Nanotechnology may be the key to better thermoelectric materials. Future research may be for trying to transform silicon (a terrible thermoelectric material due to its very large lattice heat conduction) into an acceptable material. The motivation is the cheapness of the raw silicon and the enormous technical knowhow accumulated in industrially handling it [15, 16].Smaller output from the solar part is improved by subjecting it to the solar concentrated reflected mirror. Certain limits are there on the applications of the solar reflector, hence not considered in the present study**.** Combined output voltage from solar and geo-thermal from the integrated approach of the both energies taken by subjecting the output to series combination. On the basis of the outputs from solar proposal of the concentrated concave reflector suggested along with utilization of the output power subjected to the load.

Conclusion

The thermal electricity using thermocouple can be produced by harnessing the solar and geothermal energy has been established in the newly developed model. The electricity produced can be utilized for charging small equipments and during electric break down.

References

[1] Aldo Vieira da Rosa, (2009). Fundamentals of Renewable Energy Processes, Publisher Elsevier, 2nd Edition, Pp. 179, ISBN: 978-0-12-374639-9.

[2] Schaller, R. D., and V. I. Klimov, (2004). High efficiency carrier multiplication in PbSenanocrystals: Implications for solar energy conversion, *Phys. Rev.Lett.* **92**, Pp. 186601–4.

[3] Schaller, R. D., Vladimir M. Agranovich, and V. I. Klimov, (2005). High efficiency carrier multiplication through direct photo generation of multiexcitationsvia virtual single-exciton states, *Nature Physics* **1**,

[4] Bell, Lon E., (2002). Use of thermal insolation to improve thermoelectric system operating efficiency. International Thermoelectric Society Conference (ITC2002), Long Beach, CA, Pp.26–29.

[5] Boukai, A.I., Bunimovich, Y., Tahir-Kheli, J., Yu, J.-K., Goddard III, W.A., Heath, J.R (2008). Silicon nano wires as efficient thermoelectric materials, *Nature 451* (7175), Pp. 168–171.

[6] Steven M. Geng, Maxwell H. Briggs, David S. Hervol (2011). Performance of a Kilowatt-Class Sterling Power Conversion System in a Thermodynamically Coupled Configuration (NETS). NASA/TM—2011-217098, http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20110016523_2011017533.pdf**.**

[7] Griggs, J. A., Harries, J. E. (2004). Comparison of spectrally resolved outgoing long wave data between 1970 and present. Proceedings of SPIE - The International Society for Optical Engineering. Vol. 5543, Pp.164-174.

[8] Aggarwal R.K., Markanda S., (2013). Eco Friendly Power Generation using Geo-Thermal Energy in thermocouple, Elixir Energy & Environment. Vol.59, Pp.15759-15762.

[9] Devine, Betsy (2006). Fantastic realities: 49 mind journeys and a trip to Stockholm. Wilczek, Frank. World Scientific, Pp. 62. ISBN 978-981-256-649-2.

[10] Tellurex, G2-56-0375 Thermoelectric Module Specifications, (Revised 2013) pp.1Availablefrom: http://www.tellurex.com/pdf/G2-56-0375-Specifications.pdf.

[11] A. A. Perevalova, T. V. Kolganova, N. K. Birkeland, C. Schleper, E. A. Bonch-Osmolovskaya, and A. V. Lebedinsky, (2008). Distribution of Crenarchaeota representatives in terrestrial hot springs of Russia and Iceland, Applied and Environmental Microbiology. Vol. 74, no. 24, Pp. 7620–7628.

[12] Nouredine Zettili, Quantum Mechanics (2009): Concepts and Applications, Second edition, Chapter 1, John Wiley & Sons. ISBN 978-0-470-02678-6 Pp. 4.

[13] David H. Kelley, Eugene F. Milone, (2011). Exploring Ancient Skies: A Survey of Ancient and Cultural Astronomy, Vol. 10, Springer Publications, Pp. 41. ISBN 978-1-4419-7623-9.

[14] U.A.Bakshi, A.P.Godse (2009). Analog and Digital Electronics, Technical Publicationspp. 6/42. ISBN 978-8-1843-1700-8.

[15] Hochbaum, Allon I., (2008). Enhanced thermoelectric performance of rough silicon nano wires, *Nature 451* (10), Pp. 163–167.

[16] Poudel, B, Hao, Q., Ma, Y., Lan, Y., Minnich, A., Yu, B., Yan, X., Wang, D., Muto, A., Vashaee, D., Chen, X., Liu, J., Dresselhaus, M.S., Chen, G. , Ren, Z (2008). High-thermoelectric performance of nanostructured bismuth antimony telluride bulk alloys, *Science* 320 (5876), Pp. 634–638.

****