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Solar-Thermoelectric Hybrid Powergenerator

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Abstract: *Hybrid Photovoltaic and thermoelectric systems more effectively converts solar energy into electrical energy. Two sources of energy are used one of the energy is solar,that converts radiant light into electrical energy and heat energy which will convert heat into electricity.Photovoltaic cells and thermoelectric modules are used to capture and convert the energy into electricity.Furthermore solar-thermoelectric hybrid system is environmental friendly and has no harmful emissions.Solar-thermoelectric hybrid system increases the overall reliability without sacrificing the quality of power generated.In this paper an overview of the previous research and development of technological advancement in the solar-thermoelectric hybrid systems is presented.*

I. Introduction

Today the world daily oil consumption is 85million barrels of crude oil,and this is expected to increase to 123 million barrel per day by the year 2025[1].With this ever increasing oil consumption and growing concern on environmental protection ,there is pressing need to develop green energy sources.[2].With the known consequences of fossil fuel combustion on the environment there is urgent need to develop green energy sources.Solar energy is the largest and most abundantly available renewable energy resource on the planet,and is environmental friendly.Hybrid systems for solar energy utilization have gained considerable attention from the researchers and engineers during the last decade because of their higher efficiency and stability of performance in comparison to individual solar devices.

II. Solar Photovoltaic

Photovoltaic effect was discovered in selenium way back in 1839. The photovoltaic process converts sunlight directly into electricity. A Photovoltaic cell consists of two or more thin layers of semiconducting material,most commonly silicon. When the silicon is exposed to light ,electrical charges are generated andthis can be conducted away by metal contacts as direct current. Electrical output from single cell is small, so multiple cell are connected together and encapsulated to form a module also called as panel. The PV panel is the principle building block of a PV system and any number of panels can be connected together to give the desired electrical output. PV cell are made of various semiconductors, which are materials that are only moderately good conductors of electricity.These cells are packed into modules which produce a specific voltage and current when illuminated. PV modules are connected in series/parallel arrangement to meet voltage/current requirements. PV equipment has no moving parts and as a result requires minimal maintenance and has a long life. It generates electricity without producing emissions of greenhouse or any other gases, and its operation is virtually silent.[3].

III. Thermoelectric Generator

Thermoelectric phenomena were first observe about 180 years ago, the manufacturing of thermoelectric generators only emerged in early 1960’s .The thermoelectric generators are based on the principle of seebeck effect; if appropriated semiconductors are connected thermally in parallel and electrically in series, a voltage potential is established. The cause is a statistical process in the semiconductor. Heat is converted into electricity, with a low efficiency value ,but silently, without moving parts and thus without mechanical wear. A Thermoelectric generator typically consists of several hundred thermoelectric elements, a heat source and convection cooling, which is usually passive. The heat source is normally a gas or petrol burner; however for extraterrestrial applications or special tasks with long running times radio isotopes are also used.
The discovery of high ZT(~1) thermoelectric semiconductors(e.g. PbTe and SiGe) and the availability of isotopic and nuclear heat sources made it possible to fabricate relatively efficient thermoelectric generator. The advances in technnology created a new market for long life, high reliability and low maintenance power

sources.Over the following decade various radioisotope thermoelectric generators and fossil fuelled thermoelectric generators have been developed.

The discovery of high figure of merit materials and a sustained market demand provided a foundation for the development of thermoelectric power industry.

IV. Literature Review

Benson and Jaydev et al [4] presented the idea of using thermoelectric generators in very large scale installations to produce useful amounts of electricity from low grade heat sources. One possibility was to use thermoelectric generators in an ocean Thermal Energy Conversion system. The proposed temperature difference was 5-25°C. It was shown that some commercially available thermoelectric materials have an acceptable figure of merit in this temperature range. It was assumed that performance of 20% of Carnot efficiency could be achieved from the thermoelectric devices. Other potential sources of energy that were discussed included geothermally heated ocean water(85°C),solar ponds(50°C),natural lake thermoclines (10-20°C),and utility power plant waste heat(15C°C). Long term capital costs were taken into account in the discussion.

Lamley et al [5] presented an unusual application of a thermoelectric generator designed to produce power from the long wave infrared radiation leaving the surface of the earth. This project involved generation power for a high altitude, long duration communication platform. Energy would be collected by radiation from the earth's surface, and rejected by radiation into space. A thin-film thermoelectric device configuration was devised and tested. A total temperature difference of 58°C was used in the design.

Benson and Tracy et al [6].Discussed the development and use of thin-film thermoelectric generators for use with low grade thermal energy applications such as those discussed in Benson and Jayadev[4].

Chen, J. [7]. Performed the thermodynamic analysis of a thermoelectric generator powered by direct solar radiation. Four classes of important irreversibility's were identified and their effects were included in the analysis. These irreversibility's included: Finite rate heat transfer between the device and the surroundings. Heat leaks internal to the device, Ohmic heat production, and heat losses in the solar collector. The main conclusions of the analysis established performance limits for solar powered thermoelectric devices.

A.Steinhuser et al [8].Presented extensive investigations and have shown that there is still considerable potential for optimization, particularly concerning the gas burner and the connection of the thermoelectric modules to the heat source, and given the example that the total efficiency value and, in particular, the exhaust emission of the thermoelectric converter can be improved by using a large area burner or a catalytic burner.The Proposed system can also be used as the power supply for other facilities remote from the grid, such as environmental measurement stations, aviation safety equipment and traffic guiding systems. The economics of the proposed plant has been investigated in details.Analysis of all cost relevant parameters of the reference hybrid system shows that the thermoelectric generator size needs to be reduced as much as possible. Also the reference system has been compared with all relevant supply alternatives; PV battery system is always the cheapest solution for a small load, if site is located in tropical areas, but not in temperate zones. The fossil fuelled generators are too expensive due to their O&M costs.It is proved that the proposed hybrid system is cost competitive with pure thermoelectric generators, and the system also guarantees an higher reliability and avoids 2.4T CO2 annually.

NarongVatcharasathien et al. [9]Developed a design methodology for solar-thermoelectric power generation using TRYNSYS software which is an extremely powerful tool. The result do not show high system performance however, they demonstrate well the feasibility of this concept for power generation in Thailand. The result derived lay a foundation for further investigation of solar-thermoelectric power generation at large scale.

W.G.J.H.M. Van Sark [10] Developed a model to determine the combined efficiency of photovoltaic and thermoelectric converter. The result show that adding a TE converter to the backside of a PV module can lead 8-23% increase in efficiency, depending on the type of module integration, and assuming TE material with afigure of merit value of Z=0.004K-1. The efficiency increase depends on the assumption that the backside is sufficiently cooled and is at ambient temperature.

M.M.M. Daud et al[11]. Developed a prototype panel which utilizes solar radiation and heat from the sun to generate electricity, by using PV cells and TE modules. It is shown that the efficiency of PV thermal can be increased upto 0.79% without cooling system and 1.84% with integration of cooling system from tradiational PV panel at 600w/m2 of solar radiation.Result also show that at 868 w/m2 solar radiations, the prototype panel with liquid cooling can improve efficiency up to 3%. Also with the use of high efficiency of SiGe QW or PbTe QD TE module could contribute to electricity with overall higher efficiency.

V. Discussion and Conclusion

The various conclusions emerging out of this study are presented below.

1) Improved performance can be gained by development work on semiconductor material,which will lead to increased figure of merit.
2) Improve manufacturing techniques will lead to reduction in cost of fabrication of semiconductor material and improved quality.
3) PV-TEG hybrids have proven to be an ideal alternative power source at sites where; high reliability is an important factor, winter solar insolation vales are low and shelter heating is required.
4) The PV-TEG innovation has no emission and requires less maintenance.
5) Many applications have been reported on TEG, such as the aerospace industry, automobile, waste incineration plants, centralheating's systems in cold city and stove-top generators in remote country areas, where the PVG can also be used.
6) Future work should be focus to improve the efficiency of hybrid power system and its cost reduction so as to make it more competitive.

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