Renewable and Sustainable Energy Reviews 81 (2018) 799–812

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

A review of power generation with thermoelectric system and its alternative with solar ponds

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ARTICLE INFO

Keywords:
Renewable energy
Power generation
Thermoelectric
Solar energy
Solar pond

ABSTRACT

By using the Seebeck effect to produce electrical voltage, thermoelectric as a highly scalable, stationary and silent heat engine has undergone a state of vigorous research. Starting with the review on thermoelectric generators, it shows that thermoelectric is gaining more attention since the past decade. Generally, the research conducted on the thermoelectric generators concentrate on the material development, mathematical and numerical model development as well as the application of thermoelectric generators. For this article, attention is given to the application research of the thermoelectric generators. From the survey conducted, most of the application research carried out is based on intermittent electrical power generation (e.g. the direct use of solar energy available or waste heat recovery). Hence, it opens an opportunity for the research on the application of thermoelectric generators by utilising a heat source that is continuously ready for thermal-electrical energy conversion, such as phase change material, geothermal heat or solar pond. In the later section, the review is continued by introducing solar pond, a facility that has been used as a supply of low-grade heat source at the remote area or industrial process heating. The research on the fundamentals of solar pond and its applications, but not limited to, the power generation has also been summarised. The ultimate idea of this review is to provide an insight that a thermal-storage based heat source (e.g. in this review, the solar pond) could be useful for small-scale electric power generation, despite its ordinary function as low-grade heat source provider via heat extraction.

1. Introduction

Countries around the globe have been aware of the rise in global average temperature and start to implement energy policies that will hopefully curb the temperature rise below 2 °C at the end of the century. Some researchers have argued that the notion of global temperature rise is invalid and using the temperature rise as an 'achievement indicator' is futile due to its incapability in fathoming human activities that undermining the earth [1]. The Kyoto Protocol set up in 1997 aimed to reduce the emission of greenhouse gasses with an average cut around 5% relative to 1990 levels by 2012. Seemingly, not all of the countries with the binding target successfully achieve the aim and overall, the change in the global CO_2 emission had increased by 11.3 GT from 1990 to 2011, with China and other developing countries contribute the most increment in CO_2 emission. It was only in the recent COP21 meeting at Paris, a clear binding agreement in reducing the in CO_2 emission and aiming to keep the temperature rise at 1.5 °C in the end of the century. Clearly, in order to achieve the mission, there is a need to speed up the move to low carbon electric producing technology and preferably renewable energy. The selection of technology in implementing renewable energy power supply is depending on the types green resource that is conveniently available due to geographical advantage, human resources or technological resources that a country readily advanced. With the abundance of heat available, either from the sources that are freely available such as solar energy, geothermal energy or unutilised energy in the form of waste heat. This paper begins with a review on the thermoelectric generators (TEGs), a device that producing electric power as a result temperature difference through the flow of heat with the focus on recent development of TEGs' application. Current development on the thermoelectric materials is impeded by thermoelectric figure of merit, ZT. Unless there is a quantum leap in the breakthrough of, otherwise thermoelectric technology in driving a primary role in the electric source is impossible and it will remain as an supplementary technology that enhances the performance of current renewable energy power generation. Then, in the later part, the review of the solar pond, a facility that collects and stores solar energy is delineated. Realising the electrical storage-based system (i.e. the use of batteries at the post-electric generation stage)

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http://dx.doi.org/10.1016/j.rser.2017.08.010
Received 12 September 2016; Received in revised form 12 July 2017; Accepted 6 August 2017