

A CHARACTERIZATION OF THERMOELECTRIC ENERGY  
HARVESTING FROM ELECTRIC KETTLE

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**A CHARACTERIZATION OF THERMOELECTRIC  
ENERGY HARVESTING FROM ELECTRIC KETTLE**

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I hereby declare that I have read this thesis and in my opinion, this thesis is sufficient in terms of scope and quality for the award of Bachelor of Electronic Engineering with Honours.

Signature : .....

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Date : 31/5/2019

## **DEDICATION**

I would like to dedicate my work to my supervisor, family and lecturers who willing to guide me and support me throughout this final year project and thanks to my beloved friends to help me along my final year projects.

## ABSTRACT

Thermoelectric energy harvesting defined as the energy conversion of waste heat energy to electrical energy without grid connection. This project conducted by using the electric kettle as a heat source to produce heat from a surface electric kettle. In this project, a module named as a thermoelectric generator (TEG) utilized heat energy from a surface electric kettle to produce electrical energy in 0.4V. The voltage gradient produced by TEG is insufficient to power up the application and it required a boosting circuit to boost the input voltage to 5V. Since the output power is an unstable condition, a supercapacitor and battery are used to store energy in order to power a small application such as USB fan and smartwatch. Finally, the Arduino hardware is used to capture the voltage data from the circuits and analysed their results in LABVIEW software. Overall, TEG can be used to improve charging in thermoelectric technology by recycling the heat from electric kettle.

## ABSTRAK

Penuaian tenaga haba merupakan satu proses untuk mengumpulkan tenaga haba dan tenaga haba buangan tanpa sambungan grid. Penuaian tenaga haba diperlukan untuk memberi kuasa kepada peranti elektronik dan aplikasi kecil yang berkuasa rendah. Projek ini dicipta dengan menggunakan cerek elektrik sebagai tenaga haba lalu menghasilkan haba daripada permukaan cerek elektrik. Di dalam projek ini, satu peranti bernama pengara thermoelektrik (TEG) menggunakan tenaga haba buangan dengan menyerap haba daripada cerek untuk diubah menjadi tenaga elektrik. Pengeluaran voltan daripada TEG tidak cukup untuk menampung kuasa kepada peranti elektronik dan memerlukan satu litar pengajak bagi meningkatkan voltan dari voltan masukan kepada 5V. Dalam ketidakstabilan keluran voltan, superkapasitor dan bateri diperlukan untuk menyimpan tenaga daripada litar dan memperbaiki kuasa kepada aplikasi kecil dalam keadaan norma seperti kipas USB dan jam pintar. Akhirnya, perkakasan arduino digunakan untuk mengambil data voltan daripada perisian proteus. Semua data voltan akan ditangkap daripada perkakasan Arduino dan keputusan dianalisis daripada perisian LABVIEW. Keseluruhannya, pengara thermoelektrik boleh memperbaiki pengecasan dalam thermoelektrik technology dengan mengitar semula haba daripada cerek elektrik.



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## LIST OF SYMBOLS AND ABBREVIATIONS

For examples:

TEG	:	Thermoelectric generator
EH	:	Energy Harvesting
PCB	:	Printed Circuit Board
WSN	:	Wireless Sensor Network
DAQ	:	Data Acquisition System
LABVIEW	:	Laboratory Virtual Instrument Engineering Workbench
$T_H$	:	Hot side Temperature
$T_C$	:	Cold side Temperature
LIFA	:	LABVIEW Interface for Arduino
VISA	:	Virtual Instrument Software Architecture

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# CHAPTER 1

## INTRODUCTION

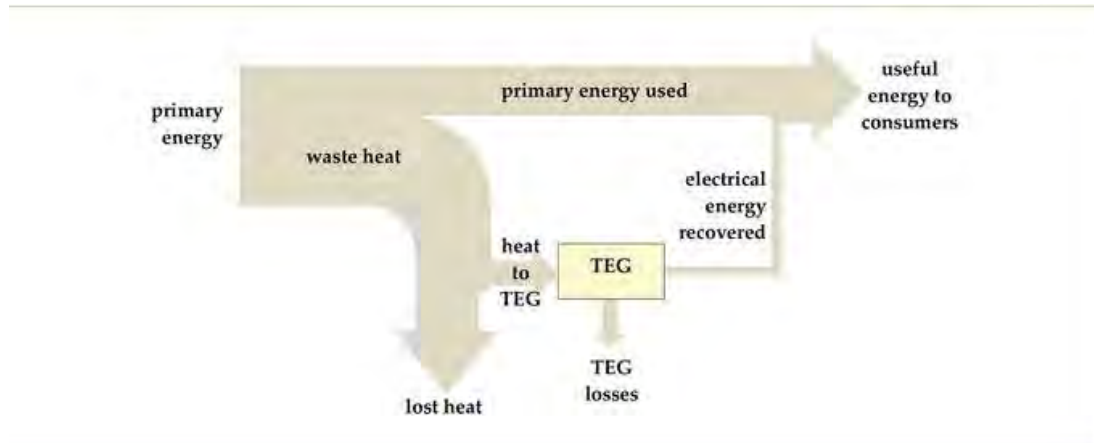
. Thermoelectric energy harvesting utilized the waste heat energy from the electric kettle as a heat source to supply heat after reached boiling point. This technique is used to create alternative energy to power the small application and electronics devices by using the thermoelectric concept to provide electricity. Different types of waste energy had been harvested by using different energy harvesting materials. However, it is quite challenging for the green technology to power up small applications. The condition to power up the small application by using the energy harvesting circuit is to harvest heat from harvested materials and boosted to the desired output in the circuit[1]. It required an energy storage to store the energy and provide a steady current flow to supply the small application & electronic device.

## 1.1 Project Background

In the modern globalization, most of the electronic devices and systems are utilized electrical source and batteries to power up the electronic system. It had the shortest life span of batteries and provide limited charging to electronic devices. When the battery depleted and finished usage, it needs to replace the another battery and found the electrical socket to recharge the electronic devices. The energy harvesting technique represented an external energy to replace the batteries and electrical socket to create free electricity in order to power up the small application. It created the environmentally friendly to replace the traditional source of multifunction wood stove and gases and solve the depletion resources in our planet.

Energy harvesting system generated the free electricity from the unused energy sources such as radio waves, solar power, kinetic energy, and temperature gradients to charge up the application such as wearable electronic devices, Wireless Sensor Nodes (WSN), long term low power sensor and electronic devices[2]. In the innovation technology, the researcher found the various way to replace the electrical source to power the devices such as mobile computers, smartphone, tablet, USB fan, and other electronic gadgets.

The thermal energy harvesting is the selected type from the energy harvesting system and is also known as energy searching technique. The module known as thermoelectric generator (TEG) to convert heat directly to free electricity from the surface electric kettle. TEG is the one type of Peltier module to create the thermoelectric energy harvester system and provides power generation from hundreds of microwatts to milliwatt in different sensor and transmitter.



**Figure 1.1: Electrical energy recovered from waste heat energy**

Figure 1.1 shows the primary energy to represent electric kettle to supply waste heat energy and converted to electrical energy in seeback effect. The consumers used electricity to power up electronic devices and WSN from TEG module[3]. The TEG is a low-cost device project to produce energy without using fossil fuels and greenhouse effect gases emission to surrounding environment. Furthermore, the energy storage is to represent the useful energy such as rechargeable battery and supercapacitor to store the energy and provide steady current flow to power up the electronic device to consumers in energy harvesting system [4].

The thermal energy harvesting provides various advantages such as high reliability and high efficiency produced from waste heat elements. The waste heat elements must applied with electric kettle to improve the thermal process in stable condition to create temperature gradient. The operation of temperature can reached to maximum temperature until 250°C after applied primary energy and heat source such as electric kettle. The condition of heat source must have in high temperature

## 1.2 Problem Statement

Nowadays, there are a lot of researchers found the various ways to charge up the small application & electronic devices due to electrical source can produce high power consumption in the usage and short lifespan for process battery charging. But when having battery depletion, it needs to replace another battery to continue charging. Furthermore, the low power produced from thermoelectric generator (TEG) is unable to power up the application after absorbed heat supply. Different temperature gradient produces different output power of TEG in seeback effect mechanism and the result is analyzed to prove the work of TEG.

An energy harvesting is required to step up the voltage to power the small application. Furthermore, the heat source needs to achieve in higher temperature and it required taking a long time to get the heat easily from heat source. Due to the TEG must achieve in high-temperature gradient to produce high voltage gradient. The low temperature gradient of waste heat produced, the low power produced from TEG in theory and knowledge. The suitable condition to provide heat conversion is required a high stable temperature and taking a short time heating process to achieve high temperature. After done some experiment from other heat sources, the electric kettle can solve the problem in a long time heating process and provides the stable in heat conduction between TEG and surface electric kettle. Next, the electric kettle was unable to dissipate heat easily from the surface area to surroundings area after done the boiling process.