UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Investigation of Energy and Cost Effectiveness between Electric Water Heater and Energy Harvested from 1.0 HP Air Conditioner

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Mechanical Engineering Technology (Maintenance Technology) with honours

by

MUHAMMAD RIDZUAN BIN ABDUL ZALI

B071410138

921005-14-6663

FACULTY OF ENGINEERING TECHNOLOGY

2017

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **Investigation of Energy and Cost Effectiveness between Electric Water Heater and Energy Harvested from 1.0 HP Air Conditioner**

SESI PENGAJIAN: **2017/18 Semester 1**

Saya **MUHAMMAD RIDZUAN BIN ABDUL ZALI**

mengaku membenarkan Laporan PSM ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. Laporan PSM adalah hak milik Universiti Teknikal Malaysia Melaka dan penulis.
2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja dengan izin penulis.
3. Perpustakaan dibenarkan membuat salinan laporan PSM ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. **Sila tandakan (✓)

☐	SULIT	(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia sebagaimana yang termaktub dalam AKTA RAHSIA RASMI 1972)
☐	TERHAD	(Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)
☐	TIDAK TERHAD	

Disahkan oleh:

_____ _____

Alamat Tetap: NO 2101, JLN 18/38,
TAMAN SRI SERDANG, 43300,
SERI KEMBANGAN, SELANGOR

Cop Rasmi:

Tarikh: _____

** Jika Laporan PSM ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh laporan PSM ini perlu dikelaskan sebagai

DECLARATION

I hereby, declared this report entitled "Investigation of Energy and Cost Effectiveness between Electric Water Heater and Energy Harvested from 1.0 HP Air Conditioner" is the results of my own research except as cited in references.

Signature : ……

Author's Name: **MUHAMMAD RIDZUAN BIN ABDUL ZALI**

Date : 14/12/2017

APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelors of Mechanical Engineering Technology (Maintenance Technology).The member of the supervisory is as follow:

……

(**AZMAN BIN IBRAHIM**)

ABSTRAK

Penggunaan pemanas air elektrik di bangunan kediaman dan komersial sudah menjadi kebiasaan disebabkan permintaan pengguna yang semakin meningkat. Walau bagaimanapun, penggunaan tenaga elektrik dan caj tenaga yang tinggi dalam menghasilkan air panas menggunakan pemanas air elektrik terus membebankan kebanyakan pihak kerana penggunaan pemanas air elektrik yang meluas terutamanya oleh sektor perumahan dan industri. Manakala, penghawa dingin terkenal sebagai pembekal udara sejuk ke kawasan yang disasarkan tetapi tidak semua orang tahu bahawa pada masa yang sama ia melepaskan udara panas ke atmosfera dari unit kondenser. Ini adalah pada dasarnya kitaran penyejuk tetapi tidak semua orang tahu hakikat bahawa tenaga haba buangan dari unit kondenser boleh memberi manfaat kepada aplikasi lain. Hasil daripada proses fabrikasi dan ujikaji dilakukan dalam projek ini menghasilkan sistem penghasilan air panas percuma menggunakan haba buangan dari unit luar penyaman udara. Keputusan ujikaji menunjukkan peningkatan pekali prestasi bagi unit diubahsuai dan lebih ekonomikal berbanding unit normal. Kesimpulannya, tenaga haba buangan dari unit luar telah membuktikan kemampuannya dalam menjana air panas secara ekonomi. Penggunaan haba buangan boleh menjadi dominan di masa depan di mana pemuliharaan tenaga telah digunakan sepenuhnya. Oleh itu, projek ini adalah mengenai penyiasatan penggunaan tenaga elektrik dan kadar caj tenaga antara pemanas air elektrik dan tenaga haba buangan daripada 1.0 HP penghawa dingin.

ABSTRACT

The application of electric water heater in residential and commercial buildings is quite familiar to be heard due to the increasing occupant's demands. However, the high consumption of energy and electricity charges on generating hot water through electric water heater is continuously burdening to the most people because of the application is widely used especially by the residential and industrial. In the other hand, air conditioner is well known as provider of cool air to the targeted region but not everyone know that it simultaneously release a hot air to the atmosphere from the outdoor unit. This is basically the refrigerant cycle but not everyone knows the fact that the waste heat energy harvested from the outdoor unit can be beneficial to other applications. The fabrication and testing done on this project leads to the production of free hot water in using harvested heat energy from outdoor unit of air-conditioner. The result shows the increment of COP of modified unit and even more economical than normal unit. The conclusion is harvested waste heat from outdoor unit had proved it capabilities in generating hot water in economical ways. The utilization of waste heat could be dominant in the future where the conservation of energy been fully applied. Therefore, this project is about investigation of energy and cost effectiveness between electric water heater and energy harvested from 1.0 HP air conditioner.

DEDICATION

To my beloved parents

To my kind lecturers

And no forgetting to all my fellow friends

For their

Love, Sacrifice, Encouragement, and Best Wishes

ACKNOWLEDGEMENT

Firstly, I would to express how grateful I am to Allah S.W.T. for giving a good health and space that necessary in completing this PSM report. I am also feeling very grateful in having these chances in order to successfully prepare this report. Even though, I am having tough time while preparing this report, guidance from Allah S.W.T. always there for me.

I also want to express my appreciation to my family that continuing supporting me through thick and thin in the process of completing this report. They keep motivating me while I am less motivated and needs support. Furthermore, I would like to deliver a special thanks to my supervisor Mr. Azman Bin Ibrahim and my co-supervisor Mr. Amir Abdullah Bin Muhamad Damanhuri for sharing their experiences, knowledge and visions to me in order to completing this report. Thank you for the consistent guidance throughout the making of this report.

I take this opportunity to express gratitude to the entire department faculty members for their guide and support. I also want to thank to my parents for the encouragement, support and attention. Their support always be my backbone during preparing this report

Lastly, I would like to thank to my entire friend for their encouragement and motivation especially during brainstorming process. Each single of them contribute very well in helping me.

TABLE OF CONTENT

CHAPTER 4 : RESULT AND DISCUSSION

CHAPTER 5 : CONCLUSION & FUTURE DEVELOPMENT

LIST OF FIGURES

LIST OF TABLE

LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURES

ACDHWS	Air Conditioners with a Domestic Hot Water Supply
CETDEM	Centre for Environment Technology and Development of Malaysia
COP	Coefficient of Performance
EER	Energy Efficient Ratio
EQ	Equation
EWH	Electric Water Heater
HP	Horse Power
HPWH	Heat Pump Water Heater
LPG	Liquefied Petroleum Gas
MACWW	Modified Air-Conditioner without Water
MACWFW	Modified Air-Conditioner with Filled Water
RACD	Room Air Conditioner Dryer
ST	Suruhanjaya Tenaga
TNB	Tenaga Nasional Berhad

CHAPTER 1
INTRODUCTION

1.1 Background of Study

Air conditioning system has become a necessity to the residential buildings, commercials and industrial sector especially in hot and high humidity climates. This is because air conditioning system is functioning to maintaining thermal comfort particularly in indoor area (Chua et al., 2012). Besides that, the air conditioning system comes in various types depending on the capacity and the usage. Usually in residential buildings, split-unit type is more than enough to sustain the thermal comfort in indoor area due to the lesser usage and small capacity. Meanwhile in the commercial buildings and industrial sector, the larger working capacity and high usage is the main working system which in this case, split-unit seems does not enough to sustain the demands. Therefore, the application of the centralized unit of air-conditioning which can fulfill the working and environment needed.

Basically, split-unit type and centralized unit have the same refrigerant cycle but have a different scope of application. Centralized unit comprised of an enormous high capacity compressor that able to deliver a huge amount of aerating and cooling to a larger area of the buildings. This is essential to the particular buildings because they need to ensure the comforts of the occupants, the working environment and the product they made is in the good state. Normally in the industrial sector, air conditioning is needed for every second's means it had a non-stop operations which explained why a larger capacity of air conditioning is essential to be applied to this sector.

In the other hand, split unit types are widely used especially in the residential buildings and small offices. The capability of slip unit type to deliver a cool air in

small area makes it a preferred choice to the consumer compared to centralized unit which more suitable for supply cool air to the entire building. Split unit type is more suitable for the residential area due to the capability of this type to supply cool air only to a limited region. This split unit type comes with 2 units for their operation, outdoor unit and indoor unit which could explain why it being called "*split unit*" type. Outdoor unit contain compressor, condenser and expansion valve while indoor unit contain evaporator.

In the time an occupant enjoying the cool air in indoor area, the people probably did not realize that condenser heat has been released to the atmosphere outside. This is one part of the refrigeration process when condenser fan is blowing the heat from a high pressure refrigerant gas that coming from compressor to release the heat before it passing through expansion valve (Wang, 2001) . That heat was called waste heat energy and not everybody knows that it could be very helpful in increasing energy efficiencies. The releasing condenser heat to the outdoor surrounding is not only induces energy wasting, but it leads to the phenomenon called yield thermal pollution (Jiang et al., 2005).

Based on observation, it can be stated that majority of the Malaysian loves the idea of using air conditioner for thermal comfort for their houses. The statistics of air conditioner ownership supposedly to be increase over the years as the growth of population and modern lifestyle changing. Besides using the air conditioner for comfort purposes, it is important for the Malaysian to be exposed to the idea of energy efficiency for future sake because the energy sources in the world will be depleted eventually.

Heat pumps were first discovered by the residences in 1950s and being used for thermal comfort in the indoor area and to generated domestic hot water. The application of heat pump in residences is widely used in country that had the cold weather but they discovered that the system is costing them much and it's not

reliable (Baldi et al., 2017). The costing is quite high due to the maintenance itself and the technologies is kind of new which leads to the lack of expertise and spare parts. Since then heat pumps had undergone a rapid improvisation and development to overcome the issue.

In this modern century, industrial sectors, commercials and residential buildings using electric boiler or electric water heater to generate hot water for daily usage. Commercial buildings such as hotel use electric water heater 24 hours in a day to fulfill the customer demand. The hot water is use for bathing and cleaning in this sector. Therefore, this sector required a consistent hot water supply which electric water heater can provide. In this case scenario, the generating of hot water is consuming highly in costing due to regularly used.

The biggest scared is Malaysia has been listed 26th out 30 top countries in top greenhouse emitters in the world (Suleiman et al., 2015). The fast grown in industrial sector and population of the Malaysian leads to the increasing of energy consumption over the last few decades. This is the bigger threat to the government as it will affect the credibility of Malaysia which in its way to the idea of developed country. Developed country must have the awareness of energy issue and energy management as their background to be an example to the other countries to be followed.

1.2 Problem Statement

The increasing energy consumption in residential area is the problems that had been growing up rapidly in recent years. This is happen because of the increment on load density for this sector which may come from the increasing of occupants and the usage of electrical appliances (Ahmed et al., 2016). The problem is probably not bigger enough because the general problem is we stuck with the society's mentality that scared to any kind of changes due to the lack of exposure about energy management and awareness of energy sources. Besides that, most of Malaysians are still preferred to use electric water heater to generate hot water compared to other appliances (Ali et al., 2009). The usage of electric water heater in

residential is high in costing and continuously increase the electrical monthly bill with increasing family size (Baldi et al., 2017). This is clearly state that generating hot water using electric water heater is burdening the consumer in terms of high bill payments and the maintenance itself. In the same time, the application of air-conditioner is currently releasing the waste heat from condenser unit and causing thermal pollution. However, energy harvested from split unit air conditioner is wasted to the surrounding (Jiang et al., 2005). The fact is heat energy harvested from condenser unit of air conditioner can go through a recovery process in order to optimize the energy for other usage such as to generating hot water. The fact is the application of air conditioner in daily life has not been fully optimized yet and the new inventions are supposed to increase the energy efficiency and performance of the units.

1.3 Objective

The direction of this project is based on the following objectives:

- To fabricate energy harvesting test rig using 1.0 HP air conditioner.
- To analyze the effectiveness of energy harvesting test rig.

1.4 Scope

The limitation of this project is based on the following scopes:

- Fabricate energy harvesting test rig using 1.0 HP air conditioner with back-to-back outdoor indoor unit and external customized hot water tank.
- Analyzing the effectiveness of energy harvesting rig in terms of electrical consumption and electricity charges against domestic electric water heater.
- Type of refrigerant gas used for 1.0 HP air conditioner is R22 (chlorofluorocarbon).
- Copper pipe used for refrigerant line is based on specification made by manufacturer as stated in Table 3.1.

CHAPTER 2
LITERATURE REVIEW

2.1 Air Conditioning Systems

In this modern era, most buildings are equipped with air conditioning system due to hot and humid climate especially in Malaysia. It became necessity for commercial buildings, residential and industrial process to have air conditioning comprising with cooling and dehumidification (Chua et al., 2013). With air conditioning system installed, it ensure the occupants in the building reach the level of thermal comfort which definitely leads to high productivity of working performance and a better indoor environment.

2.1.1 Types of Air Conditioner

Generally, building air-conditioning system can be classified into 3 types which is split-units, package units and centralized air-conditioning systems (Othman et al., 2013). Those 3 types use the same principles of refrigerant cycle but slightly different in cooling mechanism used.

Most common types been used in residential is the split unit type which certainly because of the inexpensive in price and cooling capacity factors. Split unit type had been recommended to the household because the application is not involved a huge spaces and easy to maintain. Split unit means the unit is being split into 2 set of system which is indoor unit and outdoor unit. Indoor unit is installed in the area which needs to be cooled and the unit comprises with evaporator and blower.

Furthermore, the indoor unit could be either a wall-attached or ceiling type depends to the demands of the household. Meanwhile, the outdoor unit is located at the outside of the building comprises with compressor, condenser and also blower.

In the other hands, package units is a system of cooling that can handle a high cooling capacity in a range between 3 to 15 tonnes in a area. Figure 2.1 shows a package unit that regularly spotted nearby the buildings. The operations are involving filtering, cooling and dehumidifying as well as air handling components either water-cooled or air-cooled condensers. The application of this type normally installed in medium size of area that has quite a number of cooling loads such as restaurants and halls.

Figure 2.1 Package Units (Goodman Manufacturing Company, 2017)

For centralized air-conditioning system, it can be either direct expansion system or indirect chilled water system. This system involved a huge space for the operation because it contains an air handling unit which must be place in one separated room and a set of cooling tower located outside of the building. This type of air conditioning can handle a huge number of cooling loads in tonnes which

explained why it become essential for a big in size of buildings preferred to use this kind of type compared to the other. The operation is crucial because the design of the systems must be precise in order to achieve a desired cooling comfort for the entire building.

2.1.2 Operations of Air Conditioner

The refrigerant cycle comprise with 4 major processes which are Evaporation, Compression, Condensation and Expansion. Those processes happen in different unit of air conditioning systems and the thermodynamic properties of the refrigerant are also in different physical state. Refrigerant process is all about stating the change of thermodynamic properties of the refrigerant including the energy transfer of the refrigerant to the surroundings (Wang, 2001).

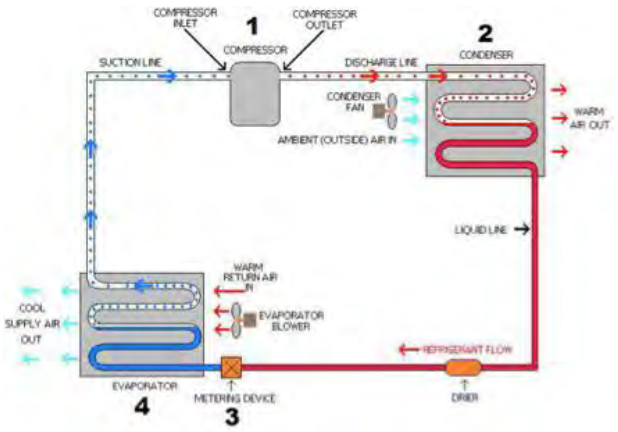

Figure 2.2 Refrigerant Cycles (Varghese, 2014)

The figure 2.2 above shows that the refrigerant cycles that happen in air conditioning systems and its basics components that undergo a series of processes in operating the systems. By referring to the figure above, it is all started at compressor where refrigerant gas was inserted there and the cycle just to start. Now days, most of the gas that filled in was a R134A due to the more environmental in terms of gas emitted compared to R22 gas (chlorofluorocarbon). In the compressor (1), refrigerant will eventually been compressed to trigger a high pressure.