SUPERVISOR DECLARATION

'I admit that had read this thesis and in my opinion this thesis was satisfied from the aspect of scope and quality for the purpose to be awarded Bachelor of Mechanical Engineering (Thermal Fluids)'

Signature	: .....
Name of Supervisor	: PM Juhari Abd Razak
Date	: 22 April 2011

OPTIMIZATION OF RENEWABLE HYBRID SYSTEM USING HOMER

MOHD ZUL HILMI BIN BAHARUDIN

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CONFESSION

"I verify that this report is my own work except for the citation and quotation that the source has been clarified for each one of them"

Signature : ……..
Name of Author : ……..
Date : ……..

Especially to My Beloved Parent

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ABSTRACT

The application of renewable energy system has become an important alternative as power provider in rural electrification program when the price of oil is reaching the highest level and it is increasing. The using of standalone diesel generation system is not practical because there is a limitation in generator's operating hour and the lack of electricity will effect to the villagers' daily routine and educational system. In applying renewable energy hybrid system, we need to know the optimum combination of hybrid energy system to reduce excess energy in minimizing cost of energy (C.O.E). This is because; single source renewable leads to component over sizing, which increases the operating and life cycle cost, but the combination of one or more resources of renewable energy that we called hybrid will improve load factors and help saving on maintenance and replacement costs as the renewable can complement each other. This research will review the hybrid system which are include PV (Photovoltaic), Pico hydro turbine, wind turbine, and also diesel generator, battery and inverter as backup and storage. A real time system for optimization process using HOMER (Hybrid Optimization Model for Electric Renewable). This software will help us to find the combination of components that can serve a load at the lowest life cycle cost which mean the cost of a system over its useful life. All of the costs which mean the cost of owning, operating, maintaining, and also replacing component will be in today's Ringgit Malaysia. The data for remote area will get from Meteorology Department, so that, the comparison and options evaluation based on the demand load that exist in the remote area.

ABSTRAK

Aplikasi terhadap sistem tenaga yang boleh diperbaharui pada dewasa ini menjadi satu alternatif yang sangat penting sebagai salah satu sumber kuasa untuk penempatan di pedalaman di mana kadar kenaikan harga petrol dan diesel yang saban hari semakin meruncing. Penggunaan atau kebergantungn kepada penjana elektrik berasaskan diesel semata-mata adalah tidak praktikal sama sekali kerana sesebuah penjana elektrik mempunyai had masa untuk berfungsi menyumbang kepada kekurangan bekalan elektrik sekaligus mengganggu rutin harian dan juga aktiviti pembelajaran di kawasan pedalaman. Langkah untuk mengaplikasikan sistem hibrid daripada sumber yang boleh diperbaharui mestilah mengetahui apakah kombinasi komponen-komponen yang paling optimum untuk mengurangkan lebihan tenaga sekaligus mengurangkan kos tenaga. Hal ini kerana, penggunaan satu sumber yang boleh diperbaharui semata-mata tanpa hibrid dengan sumber-sumber yang lain akan menyebabkan peningkatan kos kitaran hidup, tetapi dengan cara menggabungkan beberapa sumber tenaga yang boleh diperbaharui ataupun dikenali sebagai hibrid, akan menyumbang kearah kecekapan sistem hibrid dan juga kos penukaran dan penjagaan boleh dikurangkan kerana komponen ini akan saling melengkapi antara satu sama lain di dalam menghasilkan tenaga elektrik. Kajian akan dilakukan terhadap beberapa kombinasi beberapa komponen iaitu Tubin air piko, tubin angin, panel suria, penjana elektrik diesel, bateri dan juga inverter yang bertindak sebagai simpanan dan juga untuk bantuan dalam penhgasilan tenaga elektrik. Satu sistem hibrid akan dihasilkan berdasarkan data-data yang sebenar dan dalam mencari kombinasi yang paling optimum, satu perisian yang dikhaskan untuk membantu kerja-kerja pengiraan iaitu HOMER akan digunakan. Perisian ini akan menbantu dalam mencari kombinasi komponen yang boleh menghasilkan

elektrik tetapi mempunyai kos kitaran hidup yang paling sedikit. Semua kos-kos yang terlibat seperti kos pembelian, operasi, penjagaan dan juga kos untuk menukar alat ganti atau komponen itu sendiri akan dikira didalam Ringgit Malaysia. HOMER akan membantu dalam membuat perbandingan dan menghuraikan pilihan-pilihan yang munasabah berdasarkan keperluan tenaga elektrik yang diperlukan di kawasan pedalaman.

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P pv	=	Array Size
EL	=	Daily Energy Requirement
D	=	Required Number of Storage Days
C	=	Charge Recovery of the Battery Days
BE	=	Watt-Hour Efficiency of the Battery
X	=	Annual Average Equivalent Peak Hours/Day (Sunshine Period)
Vs	=	System Voltage
CD	=	Maximum Permissible
Ph	=	Hydro Power
Pw	=	Wind Power
Ppv	=	Photovoltaic Power

CHAPTER I

INTRODUCTION

1.0 INTRODUCTION

The high level of oil consuming nowadays meet the critical situation. All of people around the world must know that world's oil stock is reaching the end. So, the best solution to avoid or in best word, to reduce oil consuming is renewable energy. In this research, there are not about reduce oil consuming but this is all about using the renewable energy in the remote and isolated areas far from the grid. So, in this research, the use of renewable energy will be a main solution in reducing oil consuming in a way to appreciate the free resources that exist in the universe. At off-grid area we should know that there is such a problem to reach because its distance from urban area is too far and this will affect for transportation cost. When this is happen, the shipping / transportation process to this area need higher cost. So that, everything include, food, oil / diesel, education and etc will nearly hard to find at this place and almost separate with outside world. The most important now is electrical supply because it can fix most of the problem because everyday routine for people at this rural area will be more systematic. And our main purpose is to reduce oil consuming with create a hybrid system in generate electrical energy. This is because the generator set can't operate 24 hours per day and for this system the generator set is only used as backup and storage system so that this low operating hour can save cost for oil / diesel price. The education process also can be easier. It is also impossible to meet the small power load either through

long-distance distribution network or by the conventional generation. This is due to the high cost of transmission lines and higher transmission losses that accompany distribution of centrally generated power to remote areas. The power-supply for these areas mainly depends on "stand alone" diesel or hybrid generation systems, which are now a possible economical alternative to running the grid all the way to remote area. This research is will be done in West-Malaysia at off-grid area which is to create an energy system with combine one or more renewable energy, called hybrid system. In designing a hybrid system would require correct components selection and sizing with appropriate operation strategy. Initial optimization and component sizing methods are based on worst month scenario leads to non-optimal design with excess capacity. Hybrid Optimization Model for Electric Renewable (HOMER) is software that invented for optimizing the hybrid system that we create where it can make the calculation for which combination of renewable energy we need to use and its application is wide range includes the cost, emission, and so on. Many literatures discussed how to determine the optimum combination of a hybrid energy system from the meteorological data for small loads (range from 10 W to 1 kW) in a given location. These systems are all designed to yield a high reliability of power supply. The results obviously show that, renewable energy-based off-grid hybrid generation systems can compete with power from the grid in remote locations, where the grid is either not feasible or nonexistent. For example, hybrid systems such as wind / photovoltaic (PV), wind / diesel are now proven technologies and an option for the supply of small electrical loads at remote location. This research will review the hybrid system which are include PV, diesel generator, Pico hydro turbine, and also battery and converter as backup and storage for off-grid area in Malaysia. This hybrid system is suitable for domestic climate. Besides, to know that what combination of hybrid system is the best to reduce excess energy in minimizing cost of energy (COE) for the hybrid system created.

1.1 PROBLEM STATEMENT

Previous research has found that there are some problem involved in creating a hybrid generation system which are divided in some major situation. First of all, the climate condition is the most important part in this research because we are deal with renewable energy resources which are different for certain area. The geological features of the place of work must be suitable for hybrid system that we want to create. The data from Meteorology Department shown there is only some renewable energy available for our chosen remote area in West-Malaysia. The combination of photovoltaic (PV), Pico hydro turbine and wind turbine will be our renewable hybrid system we can create because of high daily radiation for Malaysia climate and consistent water stream. A perfect selection of component specification and sizing is important in created a hybrid system for reduces excess energy in minimizing cost of energy (COE). The demand load that involve must be suitable with the size of hydro turbine and PV to avoid excess energy and high cost in build a hybrid system. So that, we need to focus on specification selection of those component and this action must be referred to the previous created hybrid system which is successfully match with exist load and beside that we can compare the best result in optimization of renewable energy in hybrid system. Different specification of those components will be tested using Hybrid Optimization Model for Electric Renewable (HOMER) with constant data of renewable energy resources. This software is invented to do the calculation for optimization hybrid system which is include many output result that important in comparing the best combination of component, renewable energy and COE involve in this research. This high technology software also can show accurately the emission result, electrical energy data, and also cost that spent in the system. System cost and the cost of energy are two main indicators for economic assessment of the off-grid hybrid generation systems. Following the Electric Power Research Institute Technical Assessment Guide (EPRI TAG methodology), estimates of the system costs is made and the costs of energy for the various system configurations were calculated. The off-grid hybrid generation systems require a large initial investment, which results in the high cost of energy. So that, the

best way is to simulate first the system using the software and we can estimate how much cost will be spent. We have estimate the demand load that exist for ten houses which are only use three units of bulb and two units of 42" ceiling fan for each house and divided into three different cases to create an effective hybrid system in all condition.

1.1.1 Objective

This research is based on the optimization methodology of renewable hybrid system which is too important in create an environment that not only use oil resources and produce less emission in generate the energy for living. Hybrid energy system is an excellent solution for electrification of remote areas where the grid extension is difficult and not economical. Such system incorporates a combination of one or several renewable energy sources such as solar photovoltaic (PV), wind energy, Pico hydro and may be conventional generators for backup. In order to decide which hybrid system is more efficient we need such a medium to simulate the result of the optimization for each combination that we create. In other word, we use the optimization software to optimize the system and it called Hybrid Optimization Model for Electric Renewable (HOMER). Using this software, we will discuss about different system components of hybrid energy system and develop a general model to find an optimal combination of energy components for a typical rural community minimizing the life cycle cost. The developed model will help in sizing hybrid energy system hardware and in selecting the operating options. The proposed system in this optimization methodology involves Pico hydro turbine, PV array, wind turbine and also battery and inverter as part of backup and storage system.

1.1.2 Scope

The scope of work is to study the optimization process using HOMER. There are a few steps that involved in this software until the result come out. First of all is about simulation whereas we need to make the cost estimation and determine the feasibility of a system design over 8760 hours per year. Then, the optimization process will show a simulation of each system configuration and display list of system sorted by net present cost (NPC) based on our input. Lastly, the sensitivity analysis, this part is to perform an optimization for each sensitivity variable which means to make the result is more accurate when there are some changes in input data as example price diesel per liter, scaled annual average for solar radiation, wind speed and so on. Our scope is also to develop a real time system for optimization process using HOMER. This project is about to generate electric energy for off-grid remote area in West Malaysia. Ten houses with some electrical device will be a model in developing a suitable hybrid system for that purpose. Each house consist three units of 100 Watts light bulb and two units of 24 Watts 42" ceiling fan. The electrical consuming is divided into three demand load which are for standard usage, rainy day, and sunny day. This will be shown in graph for demand load and the purpose for these different demand loads is to know which situation consume or demand high electric energy and so that we will be know the maximum demand load and set the limit for hybrid system in generate electrical energy to avoid excess energy and also to save cost because it need large initial investment to develop hybrid system. Real cycle cost is the cost of a system over its useful life. It's consist of initial cost associated with equipment purchases and installation, costs of owning, operating and maintaining the system and lastly cost for replacing components. For NPC is the life cost expressed as a lump sum in "today's Ringgit Malaysia". Using this software, we also can model a single technology system or multiple-technology (hybrid) systems and after that we can compare multiple combinations of different technologies. Our scope is also about summarizing the advantages and disadvantages of using HOMER for optimization of renewable energy hybrid system. As an information HOMER is only a model and it does not provide the right answer to question but it only help us to consider important factors and evaluate and compare options. There is another

methods and control strategies in designing hybrid system such as classical optimization methods, Monte Carlo methods and Genetic Algorithms methods but we decided to use HOMER because it is easy to operate and only for small system.

CHAPTER II

LITERATURE REVIEW

2.0 LITERATURE REVIEW

Power supply to off-grid location is usually supplied by generator using diesel or petrol. It is often only available at night and for certain number of hours. Applications of renewable energy at this location are through solar energy via photovoltaic (PV) panels, wind turbines and small hydro turbines. Initially, the system is a single source system. However a single source renewable usually tends to be oversized to accommodate load demand. (Bagul, A.D et al, 1996). It leads to high wear and tear, thus increasing operating and life cycle costs. A combination of one or more resources of renewable energy such as solar, wind, hydropower and biomass with other technologies such as batteries and generator, defined as hybrid renewable is a better option. (Kaldellis, J.K et al, 2006). Hybrid system can complement each other and component capacities are better utilized, improve load factors of generators and better exploitation of renewable leads to saving on maintenance and replacement cost.

However the hybrid initial capital cost is high thus the needs for long-lasting, reliable and cost-effective system. (Kellog, W et al, 1996). While designing a hybrid system it is important to look into correct combination of components selection and sizing together with the operation strategy. (Borowy, B.S et al, 1994). Malaysia comprises Peninsular Malaysia, Sabah, and Sarawak (part of Borneo) and lies on latitude 1°22'N and longitude 103°55' E. Malaysia lies in the equatorial zone and the climate is governed by the regime of the Northeast and Southwest monsoons which blow alternately during the course of the year. The Northeast monsoon blows from approximately October until March, and the Southwest monsoon blows between May and September. (Niewott, S. 1996). The alternative energy sources are non-polluting, free in their availability, and continuous. (Borowy, B.S & Salameh, Z.M). Alternative and renewable sources of energy have real potential mainly beyond the year 2000. However, they are not likely to be a total answer to the world's energy requirements. All forms of renewable energy are regarded as carbon dioxide neutral. The main renewable energies are: Solar, Wind, Hydro, Tidal, Wave, Land fill, Sewage and other bio gas, incineration of waste (municipal, industrial, hospital etc.), Geothermal, and Bio & el (Wood). Some of these sources such as solar and wind are classified as intermittent renewable sources while some others like hydro and biomass are classified as no intermittent sources.

Environmental impacts of renewable energy are much smaller than those of fossil fuels and nuclear energy. Increasing public interest in renewable energy technology is creating both challenges and opportunities for the advent of renewable energy resources utilization worldwide especially in the USA and Europe. According to the European Wind Energy Association (BWBA), 10% of the European Union's electricity could realistically be generated by wind power by the year 2030, Zahedi, A. The small, off-grid stand-alone renewable energy systems represent an important option for narrowing the electricity gap in rural parts of the developing world, where progress in grid extension remains slower than population growth. (Zahedi, A). A reinforced exploitation of renewable resources is increasingly demanded by the public in order to

expand the durability of fossil energy reserves and resources and to decrease harmful energy-related gas emissions. (Nfah, A.M et al). Rural electrification initiatives have traditionally approached the electricity need by extending the power grid from central utilities or installing diesel mini grids but the costs of this approach become prohibitive sparsely populated area. (Castro, M.A et al). Solar photovoltaic (PV) are gaining acceptance for providing electricity to households and small businesses in rural areas. (Matthew, G.G). Hydropower is still the most widely used RES (Renewable energy sources) worldwide, (Sadrul Islam, A.K.M et al, 2006) contributing almost with 18.5% to the fulfillment of the planet electricity generation. (Paish, O). The rated power of a SHP (small hydro power) station is usually less than 10MW, while all stations with rated power less than 1MW are characterized as mini. For very small applications (rated power less than 50 kW) one may also use the expression ‘‘micro hydro power station’’. (IEA, 2006). Hybrid energy systems are recognized as a viable alternative to reticulated grid supply or conventional, fuel-based, remote area power supplies. (Kaldellis, J.K).

Life cycle cost (LCC) analysis is a tool used to compare the ultimate delivered costs of technologies with different cost structures. (Lopez, R.d & Agustin, J.B.L). Rather than comparing only the initial capital costs or operating costs, LCC analysis seeks to calculate the cost of delivering a service over the life of the project. The final cost per kWh is estimated independent of the technology used to deliver the electricity. Often competing power systems have different load capabilities and reliability. To compare the two types of systems using LCC analysis, their reliability must be made the same. This can be done by upgrading the design of the least reliable system to match the power availability.

In some cases, as in the HOMER, (Bhuiyan, M.H et al) program, it is possible to consider the pollutant emissions by economically valuating them, and therefore becoming a part of the costs objective function. This mapping of costs to emissions is subjective, and decisively influences the results of the design. The method that HOMER