



Faculty of Engineering

**OPTIMIZATION OF HYBRID RENEWABLE ENERGY IN
SARAWAK REMOTE RURAL AREA USING HOMER
SOFTWARE**

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OPTIMIZATION OF HYBRID RENEWABLE ENERGY IN
SARAWAK REMOTE RURAL AREA USING HOMER
SOFTWARE

NUR ANISAH AZIERA BINTI ABDUL HALIM

A final year project report submitted in partial fulfilment of
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ABSTRACT

In past few years, there has been a huge concern about decentralized electricity supply in Sarawak. Stand-alone diesel generator is used in remote rural area are considered as a technology-based limited level of supply to meet the basic needs and no reliability of energy planning to remote rural customers. Renewable energy resources can be seen as an alternative energy to capture the remote rural electrification's problems. Installing and operating a renewable energy generation is not difficult but it requires cautious step as to make sure maximum use of energy can improve the electrification. Therefore, the aim of this study is to critically analyse five types of optimized hybrid renewable energy systems in term of financial and power production using HOMER software. This paper approaches four renewable energy resources namely solar, hydro, wind and biomass in three remote rural areas located in Limbang, Kapit and Sri Aman regions. Different combination of solar PV system, micro-hydro generator, wind turbine and biomass generator together with battery storage and converter were studied in this paper. The optimization between these different sizes of system was built based on energy demand satisfaction, system cost and carbon emission. Comparison between operational of behaviours hybrid renewable energy systems with stand-alone diesel generator were carried out to elucidate the effects on investment cost and environment. The result of this study shows that hybrid hydro with battery system is seen to be the cheapest system and has the best technical performance in all locations. Solar PV and biomass generator system were combined with hydro generator as back-up power. The worst option to be chosen as hybrid renewable system in Sarawak is wind energy. This paper also discovered that hybrid renewable energy is more cost-effective and able to reduce of carbon emission compared to stand-alone diesel generator.

ABSTRAK

Dalam beberapa tahun yang lepas, bekalan elektrik tidak berpusat telah menjadi kebimbangan terbesar buat negeri Sarawak. Penjanakuasaan berdiri sendiri berasaskan petrol diesel telah digunakan dalam penempatan terasing yang dikatakan berteknologi terhad untuk mencapai keperluan dan tidak boleh dipercayai kepada penduduk kampung. Sumber boleh diperbaharui boleh dilihat sebagai pilihan untuk permasalahan elektrik di penempatan terasing ini. Pemasangan dan operasi sesuatu penjanakuasaan tidak sukar tetapi ia memerlukan langkah yang cermat dalam memastikan penggunaan tenaga yang maksima untuk menambah baik elektrifikasi. Oleh itu, tujuan thesis ini ditulis adalah untuk menganalisa secara kritikal lima jenis optimum sistem tenaga boleh diperbaharui dari segi kewangan dan penjanaan tenaga menggunakan perisian HOMER. Thesis ini menggunakan pendekatan empat jenis tenaga boleh diperbaharui iaitu cahaya matahari, hidro, angin dan biomas dalam tiga penempatan terasing yang terletak di daerah Limbang, Kapit dan Sri Aman. Pelbagai gabungan di antara sistem PV, penjana micro-hydro, kincir angin dan penjana biomas bersama dengan bateri dan converter telah dikaji dalam thesis ini. Optimisasi di antara berlainan saiz sistem telah dibina berdasarkan tenaga kepuasan tuntutan, kos sesebuah system dan perlepasan karbon. Perbandingan kelima-lima kelakuan semasa beroperasi dengan penjanakuasaan berdiri sendiri berasaskan petrol diesel juga dijalankan untuk mengenalpasti kesan terhadap kos pelaburan dan persekitaran. Hasil daripada pembelajaran ini mendapati bahawa hybrid sistem hidro bersama bateri dan converter adalah sistem paling murah dan mempunyai prestasi teknikal yang terbaik untuk semua lokasi. Penjana solar PV dan biomas boleh dijadikan sistem sokongan apabila bergabung dengan penjana hidro. Pilihan yang paling teruk untuk menggunakan sistem tenaga diperbaharui di Sarawak adalah kuasa angin. Thesis ini juga telah menemui tenaga diperbaharui lebih kos efektif dan dapat mengurangkan perlepasan karbon berbanding penjanakuasaan berdiri sendiri berasaskan petrol diesel.

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LIST OF ABBREVIATIONS

BioGen	-	Biomass Power Generation and Demonstration
BOS	-	Balance of System
DFBG	-	Downdraft Fixed Bed Gasifier
DNI	-	Direct Normal Irradiance
DOD	-	Depth of Discharge
EFB	-	Empty Fruit Bunch
Genset	-	Generator set
GHG	-	Greenhouse Gases
GHI	-	Global Horizontal Irradiation
HOMER	-	Hybrid Optimization of Multiple Electric Renewable
IPCC	-	Intergovernmental Panel on Climate Change
MoU	-	Ministry of Utility
NASA	-	National Aeronautics and Space Administration
NFPE	-	Non-Financial Public Enterprises
NKRA	-	National Key Result Area
NPC	-	Net Price Cost
NREL	-	National Renewable Energy Laboratory
O&M	-	Operating and Maintenance
POME	-	Palm Oil Mill Effluent
PV	-	Photovoltaic
R&D	-	Research and Development
RE	-	Renewable Energy
RES	-	Renewable Energy Sources
RES	-	Rural Electrification Scheme
RM	-	Ringgit Malaysia
RPSS	-	Rural Power Supply Scheme
SARES	-	Sarawak Alternative Rural Electrification Scheme
SCORE	-	Sarawak Corridor of Renewable Energy
SEB	-	Sarawak Energy Berhad

- SREP - Small Renewable Energy Program
- TMY - Typical Metrology Year

CHAPTER 1

INTRODUCTION

1.1 Project background

Electricity energy has been one of backbones of supporting socio-economic development to a modernize country. Growing financial in industries and development in the standards of living is the reason of rising in energy consumption [1]. The degree of people's residential, economic development, transportation and agricultural sectors in the world are completely related to the fossil fuels energy. Fossil fuels energy such as coal and natural gas has been the main power plant in Malaysia. However, Malaysia are acknowledged the disadvantages of convectional energy to green house and start to appreciate natural resources in order to help electrification in some inaccessible rural areas. In this paper, the potential renewable energy resources and the effects of renewable resources to country's economic are studied using HOMER software.

1.1.1 Hybrid renewable energy

International Energy Agency has predicted almost 30% of power demand in 2023 is provided by the renewables and it will have the rapid expansion of electricity, up from 24% in 2017 [2]. During this length of time, renewable has predicted to meet 70% of global electricity generation growth. In 2013, the hydropower is remains as the largest renewable energy with distribution of 16% of world electricity need, followed by wind (6%), solar PV (4%), and bioenergy (3%) [2].

The world is however, facing the limited and fast depleting sources of conventional energy that use to generate power electricity. The conventional sources like

coal, natural gas, crude oil are threatening the balance of energy demand for future generation.

Furthermore, the emission gases from production of energy by conventional sources in increasing and might lead to greenhouse effect and global warming [3].

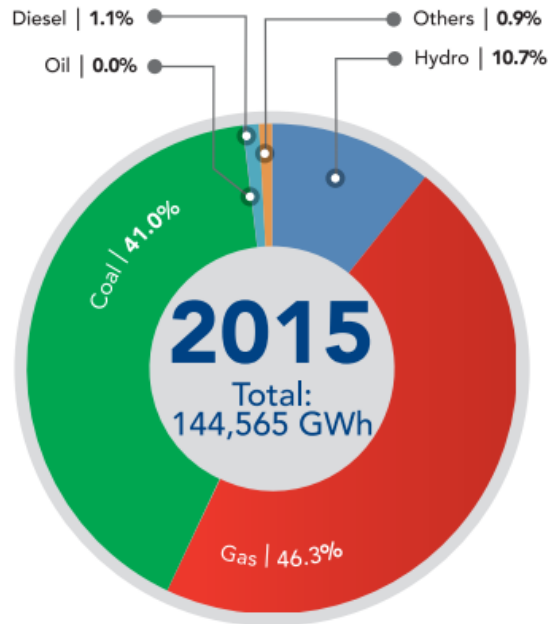


Figure 1.1: Distribution of primary energy supply by fuel variety [4]

Figure 1.1 shows the pie chart of distribution of power supply in Malaysia. According to Malaysia Energy Commission’s statistic in 2016, the electricity generation in Malaysia is dominantly powered by gas power plant and followed by coal power plant. The hydro is the resource that monopoly the renewable energy in power generation system. Meanwhile, the other power plants like biomass power plant are not widely used in Malaysia.

Based on the current rising trend of fuel prices in the world market, the Malaysia government perceived the potential of renewable energy as an alternative option to make sure the sustainability of energy resources [5]. Besides hydro, another renewable resources like solar, wind and biomass are not fully utilized as Malaysia is on the lookout to strengthen the advancement of natural energy and small number in renewable expertise.

1.1.2 Sarawak electrification

Sarawak is one of Malaysia's state located at the north of Borneo island. Sarawak electrification is monopoly by Sarawak Energy Berhad (SEB), which is fully owning by the state government. Therefore, SEB is vertically integrated electric utility has responsible for generation, transmission and distribution in the state of Sarawak [6].

The statistic in 2013 has stated that the Malaysia's electricity access rate had reached to 96.86%. The percentage contribution of electricity in Peninsular Malaysia, Sabah and Sarawak are 99.72%, 92.92% and 88.01% respectively [7]. Sarawak has the biggest rate of poor electrification access in Malaysia which most of them are living in unreachable electric grid of rural areas.

The lack of electricity intensifies the poverty where the developing countries have high demand for electricity. One of the most significant current discussion in legal and moral philosophy is the off-grid hybrid renewable energy focusing in rural area is to reduce the poverty rate.

In past few years, there has been an increasing concern in the decentralized electricity supply that considered as a technology-based limited level of supply to meet the basic needs, which is the reliability of energy planning to rural customers is not taking into consideration [8]. Hybrid renewable energy system has been in deeply research to enhance the sustainable energy worldwide distribution. The combination of two or more hybrid renewable energy eventually give advantages in supporting the shortcoming of electrical energy and give strength to unpredictable renewable energy resources [9].

However, a major problem with this kind of application is the to find the optimum hybrid energy that can satisfy customers' demand with minimum cost. This problem can be overcome by doing a deep research on the potential of renewable energy system.

1.2 Problem statement

Sarawak has a centralized power system planning under SEB. Energy supplied in Sarawak are affiliated by conventional energy resources energy such as diesel generator and natural gas power plant. However, Sarawak is the greenest state in Malaysia, with 75% of electricity production is from renewable energy which is mainly from hydro energy power plant. From SEB presentation, about a 1.2 million people living in rural setting with 6235 villages with about more than 200,000 homes [6]. In 2016, SEB has identified 4316 villages that consist of 40,000 homes in rural area have not received 24-hour electricity yet. However, the government state and villagers are expected to have positive social economic impacts in the future such as increased employment and business opportunities, increased development for affected areas and increased in infrastructure to improving their quality of life. In order to proceed this planning, the electrification must be covered the whole Sarawak.

As Sarawak is the biggest state in Malaysia with geographical area of 124,450km² [6], SEB has difficult times to access electricity to all community with national grid. Some of the rural areas are remote and inaccessible to national grid. Those people used diesel generator (genset) to produce electricity as it is cheap stand-alone system. However, the genset itself might not achieved the sustainability of rural electrification since it has limited capacity and expensive to electrify many households in a village. In this case, the solution is to introduce an initiative of building stand-alone hybrid renewable power generation systems as a mission to support community's activities.

The renewable energy resources is an alternative energy to capture the remote rural electrification's problems. However, installing and operating a renewable energy generation is not difficult but it requires cautious step as to make sure maximum use of energy can improve the electrification. Therefore, this study use a software to analyse and evaluate the economic cost of optimized renewable energy. Renewable energy resources such as solar, biomass, wind and hydro are taken into consideration.

1.3 Objectives

Aware of the issues confronting the hybrid renewable energy systems, the objectives of this paper are as follow:

1. To simulate hybrid renewable energy, namely solar PV system, micro-hydro, wind turbine and biomass generator for Limbang, Kapit and Sri Aman.
2. To analyse the performance of five cheapest hybrid renewable energy systems as to meet the reliable and sustainable electricity demand.
3. To compare hybrid renewable energy with stand-alone diesel generator in term of financial and carbon emission.

1.4 Project scope

This project is about simulating an optimization of hybrid renewable energy sources in a remote rural area using HOMER software. The renewable energy data, electrical appliances used for typical remote rural area data, the price fuel in world market are acquired from official websites on internet. The performance of renewable energy and conventional energy and the combination of both as a hybrid energy system are obtained from researcher's past journals. Variant type of data needed a particular method to analyse the economic issues are extracted officially from Sarawak Energy Berhad and Malaysia Energy Commission reports.

The type of hybrid renewable being simulated in this project are solar PV system, micro-hydro system, wind system, biomass generator and diesel generator systems. The targeted remote rural area to be investigated is in Sri Aman, Kapit and Limbang with estimated to have 100 houses in that division as these regions still have no on-grid electric connection. Five optimal stand-alone hybrid renewable energy system are analysed and compared with the diesel generator. Effective policies and incentive on the renewable energy sources (RES) is stressed to promote low carbon economy for the future.

1.5 Project outlines

Chapter one of this paper is an introduction about the whole project which includes the project background, problem statement, objectives, project scope and project outline. A general information about electrification and hybrid renewable energy in a remote rural area are explain in chapter one. This chapter also brief on the idea of simulation an optimization of hybrid renewable energy using software.

Next, chapter two is the literature review of the past research. The literature review is corresponding to the study potential renewable energy in Malaysia including solar, hydro, wind and biomass energy. In addition, the optimization of hybrid renewable energy in a remote rural area using HOMER also studied in this chapter. There are an overview of hybrid renewable energy using HOMER that have been discussed on the past researches such as PV-wind turbine-diesel system, PV-hydro-diesel, PV-diesel system and many more. On the other hand, this chapter includes the understanding of cost of electricity, initial cost, operation cost and also emission of carbons.

Besides that, chapter three explains the methodology of the project. The explanation is including the process of simulation and analysing the hybrid model. This chapter contains the project flowchart, the simulation flowchart, simulation tools, and calculation on sizing components and other related information.

Chapter four is for result and discussion of the project. The results from five optimized hybrid renewable systems simulation are record and analyse in detail. The discussion is assisted by graph and pie charts to give more explanation in this chapter. And then, the comparison between hybrid renewable systems and stan-alone diesel generator is also discussed in this chapter

Lastly, chapter five is the conclusion about the whole project. There are some recommendation for improvement in the future use.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The electrical energy is become a crucial utility in development of modern rural area as electricity lighted up community houses, commercial and industrial buildings, hospitals, schools, universities, street lightings, agricultural sites, and telecommunication networks. The growth of community is the factor of economic development. The availability of energy can increase job opportunities, improve healthy service and rural evolution.

Malaysia's electrical generations are mainly depending on convectional energy such as oil and gas. However, in past 15 years, Malaysia has started to realize the importance to have sustainable energy supply and green country. Renewable energy is adopted in energy mix in accordance with energy renewable energy policies as to insure the continuing of energy supply and security.

This chapter is divided into four parts. The first part begins with Malaysia renewable energy policies followed by introduction of Sarawak electrification programs. This chapter also reviews the literature concerning the availability of renewable energy resources in Sarawak are critically discuss. Next, this chapter gives an overview of HOMER software and address past researches and studies in optimizing and analysing renewable energy resources. Lastly, this paper evaluates economic benefits and carbon emission reduction using renewable energy resources.

2.2 Government policies and rural electrification programs on renewable energy resources

2.2.1 Malaysia policy and plan

Renewable energy has been mentioned in the 8th Malaysia Plan (2001 to 2005) with introduction of Small Renewable Energy Program (SREP). The main idea is to promote renewable energy implementation such as solar, mini-hydroelectric, wind and biomass. Malaysia Federal Government and Non-Financial Public Enterprises (NFPE) are responsible agency that invested a firm amount of money to provide electricity for the country. In 8th Malaysia Plan, Malaysia has spent about RM 27.9 billion for power electricity system including rural electrification[10].

After that, Malaysia focused on development of solar energy or photovoltaic in the 9th Malaysia Plan (2006 to 2010), with expectation of increasing RM 30 billion from 8th Malaysia Plan [10]. The 9th Malaysia Plan also has set 5% of renewable energy is in country's energy Malaysia. However, energy mix technique that used to generate electricity for the country is still depending on conventional energy. As to secure country's health air and environment, the 10th Malaysia Plan (2011 to 2015) emphasized the target of lowering the greenhouse gases (GHGs) emission until achieved 33% by 2013[11].

On 2nd April 2010, a policy of renewable energy called Malaysian National Renewable Energy Policy and Action Plan has been approved by the cabinet. The policy is aimed to improve the application of renewable energy resources concerning the contribution of electricity security and development of renewable economic. There are five strategic thrusts of National Renewable Energy policy shown in Figure 2.1.

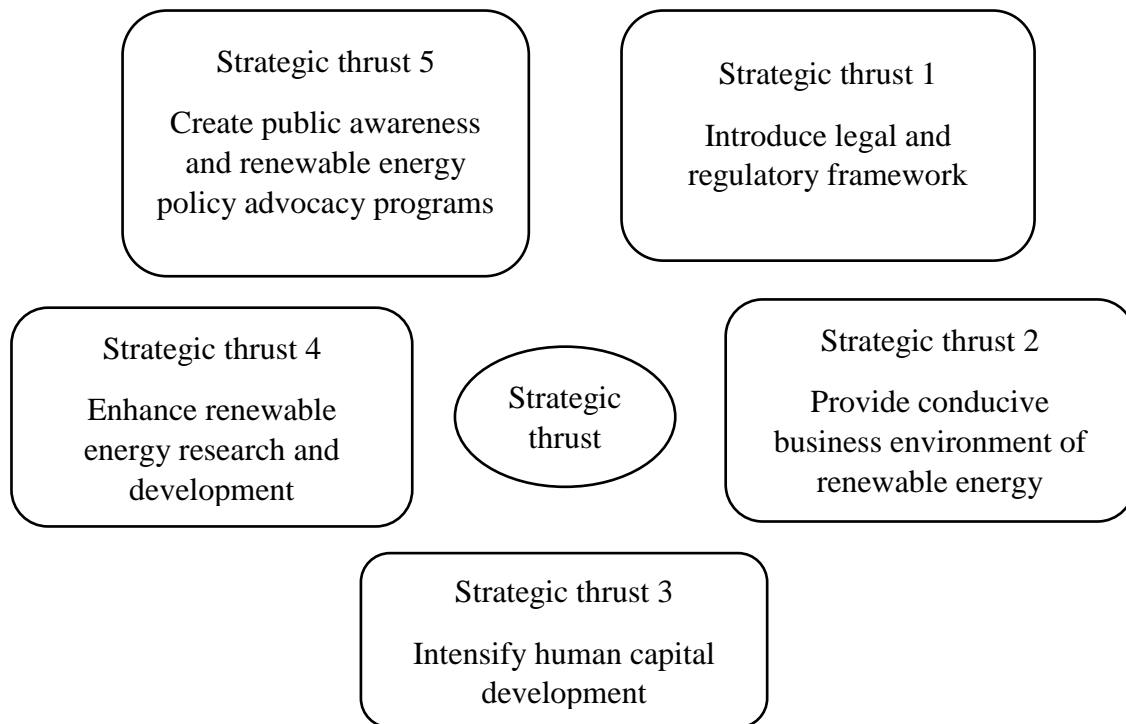


Figure 2.1: Five strategic thrust of National Renewable Energy policies [12]

In conjunction of the policy, Sarawak Corridor of Renewable Energy (SCORE) is introduced by Federal Government of Malaysia as one of five economic development corridors [13]. The aim is to simulate a fresh quality of revenue and growth of the Sarawak. The main objective is to produce a bulk of electricity by harnessing Sarawak’s sustainable strategic advantage at globally market to attract investment to the State [6].

As of today, the 11th Malaysia Plan (2016-2020) is introduced is to preserve green growth in socio-economy development by adjusting of enabling environment specifically in term of policy, human capital, green technology investment and financial method.

2.2.2 Rural electrification programs in Sarawak

SEB reported the overall state rural coverage is drastically increase to 90% in 2015 compared to 56% in 2009 [6]. The rapid growth of electricity is because of cooperation and commitment of Sarawak in providing sufficient electricity to the community. Table 2.1 shows rural achievements of Sarawak electricity from 2009 to 2016.