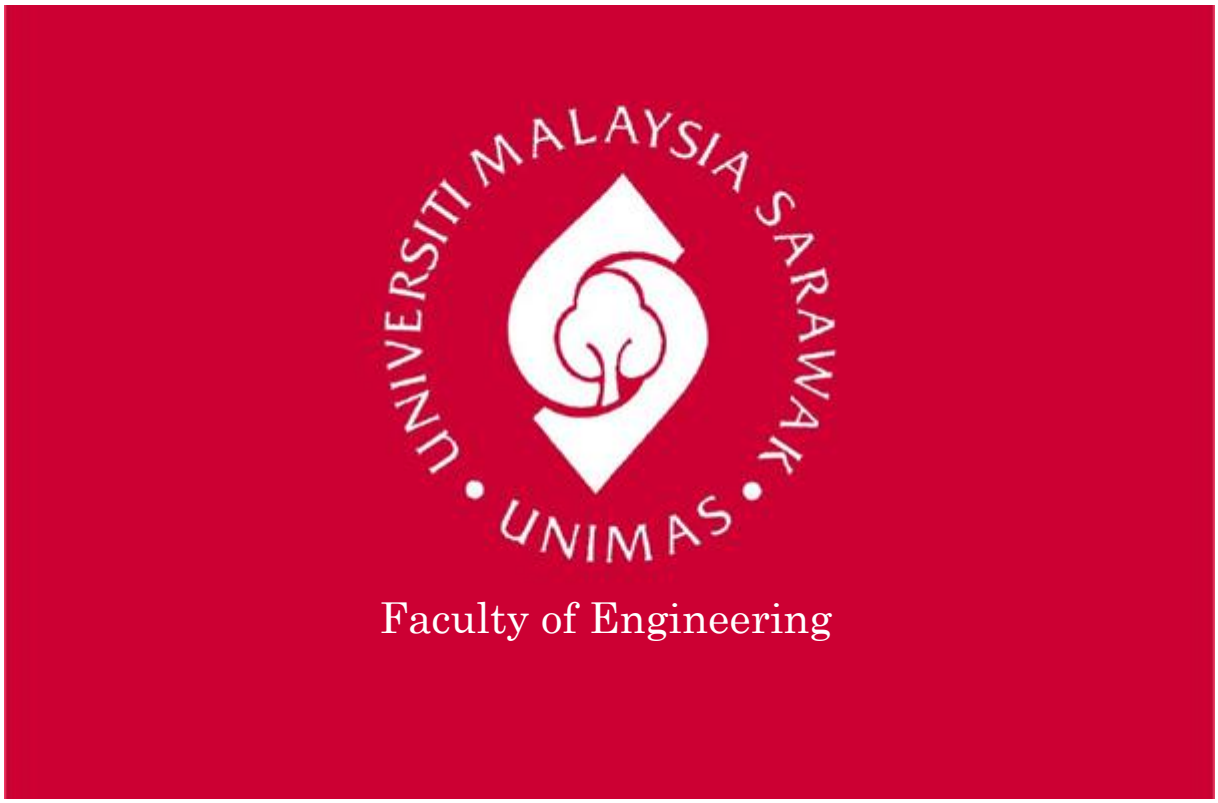

OPTIMIZATION OF HYBRID RENEWABLE ENERGY FOR TELECOMMUNICATION TOWER ENERGY SUPPLY

Mohd Farid Asyraaf Bin Ismail

Bachelor of Engineering

Electrical and Electronics Engineering with Honours

2023

UNIVERSITI MALAYSIA SARAWAK

Grade: _____

Please tick (√)

Final Year Project Report	√
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OPTIMIZATION OF HYBRID RENEWABLE ENERGY FOR TELECOMMUNICATION TOWER ENERGY SUPPLY

MOHD FARID ASYRAAF BIN ISMAIL

A dissertation submitted in partial fulfilment
of the requirement for the degree of
Bachelor of Engineering
Electrical and Electronics Engineering with Honours

Faculty of Engineering

Universiti Malaysia Sarawak

2023

ACKNOWLEDGEMENT

Firstly, I would like to express a thankful gratitude to my God, Allah SWT for giving me strength and courage to complete this study successfully despites of facing a lot of difficulties and challenges, whom with His willing giving me the opportunity to complete this Final Year Project which is title Optimization of Hybrid Renewable Energy for Telecommunication Tower Energy Supply. This final year project report was prepared for Electrical and Electronic Engineering, University Malaysia Sarawak (UNIMAS). This report is based on the methods given by the university.

I am deeply grateful to my research supervisor, Ts. Dr. Yanuar Zulardiyansyah Arief, for his invaluable time and energy, as well as his unwavering support in guiding me through this until the end of my study. I appreciate his dedication to helping me succeed and his guidance throughout this project. I really appreciate his afford and dedication to guide me in my final year project journey. Without his assistance, this paper would have never been accomplished. I also want to thank the lecturers and staffs of Engineering Faculty UNIMAS for their cooperation during my degree's life that had given valuable information, knowledge, and guidance in the completing my study.

Furthermore, I would like to express my heartfelt appreciation to my parents, Ismail bin Paee and Minah binti Padupai, for their unwavering financial and moral support throughout my journey. I also want to thank my siblings and big family for their encouragement and support in completing this study.

Last but not least, I want to express gratitude to myself for all of my hard work, for never taking a day off, for never quitting, for always striving to give more than I receive, for trying to do what is right, and for simply being myself.

ABSTRACT

The use of hybrid renewable energy systems for telecommunications towers has gained increasing attention in recent years to reduce reliance on fossil fuels, lower operating costs, and increase the reliability of the power supply. This paper provides a comprehensive review of research on hybrid renewable energy systems for telecommunications towers. These systems utilize solar panels, wind turbines, and other renewable sources, along with backup generators or storage batteries, ensuring reliable power supply. Existing studies demonstrate that hybrid systems are a promising alternative to fossil fuel-based systems. The paper covers design considerations, implementation challenges, and performance evaluation of these systems. It also discusses their potential benefits and limitations while outlining future research directions. This study focuses on solar, hydro, wind, and biomass resources in Lundu, Bintulu, and Limbang by evaluating their potential in remote areas.

The aim of this paper is to use the HOMER software to analyse the financial and power production potential of hybrid renewable energy systems in three rural areas. The study considers a range of combinations of solar PV systems, micro-hydro generators, wind turbines, biomass generator, diesel generator, battery storage, and converters, and evaluates their performance based on energy demand satisfaction, system cost, and carbon emissions. The paper also compares the operational behaviour and investment costs of hybrid renewable energy systems with stand-alone diesel generators to assess their environmental impacts. The goal is to optimize the size and configuration of the hybrid systems to maximize their financial and power production potential.

The result for this study emphasizes the potential of solar energy as the primary source of electricity for telecommunication towers in remote rural areas of Sarawak. Additionally, biomass energy as a backup power source. However, wind energy is not a viable option in Sarawak due to low average wind speeds. This study also discovered that renewable energy systems like solar and biomass are cost-effective and environmentally friendly alternatives to diesel generators, although not yet cost-competitive at present.

ABSTRAK

Penggunaan sistem tenaga boleh diperbaharui hibrid untuk menara telekomunikasi telah mendapat perhatian yang semakin meningkat dalam beberapa tahun terakhir untuk mengurangkan bergantungan pada bahan api fosil, menurunkan kos operasi, dan meningkatkan kebolehpercayaan bekalan tenaga. Kertas ini menyediakan kajian menyeluruh mengenai sistem tenaga boleh diperbaharui hibrid bagi menara telekomunikasi. Sistem ini menggunakan panel solar, turbin angin, dan sumber tenaga yang boleh diperbaharui, bersama dengan penjana sandaran atau bateri simpanan, bagi memastikan bekalan tenaga yang boleh diandalkan. Kajian menunjukkan bahawa sistem hibrid adalah alternatif yang menjanjikan kepada sistem berasaskan bahan api fosil. Kertas ini merangkumi pertimbangan reka bentuk, cabaran pelaksanaan, dan penilaian prestasi sistem ini. Ia juga membincangkan manfaat dan had-had potensi sistem ini sambil menggariskan arah penyelidikan masa depan. Kajian ini memberi tumpuan kepada sumber tenaga solar, hidro, dan angin di kawasan Lundu, Bintulu, dan Limbang, menilai potensi penggunaannya di kawasan terpencil.

Tujuan kertas ini adalah untuk menggunakan perisian HOMER untuk menganalisis potensi pengeluaran kuasa dan kewangan sistem tenaga boleh diperbaharui hibrid di tiga kawasan luar bandar. Kajian ini mempertimbangkan pelbagai kombinasi sistem solar PV, penjana mikro-hidro, turbin angin, penjana biojisim, penjana diesel, penyimpanan bateri, dan pengubah tenaga, dan menilai prestasi mereka berdasarkan kepuasan permintaan tenaga, kos sistem, dan emisi karbon. Kertas ini juga membandingkan operasi dan kos pelaburan sistem tenaga boleh diperbaharui hibrid dengan penjana diesel berdiri sendiri untuk menilai impak alam sekitar. Matlamatnya adalah untuk mengoptimumkan saiz dan konfigurasi sistem hibrid untuk memaksimumkan potensi pengeluaran kuasa dan kewangan.

Hasil kajian ini menekankan potensi tenaga solar sebagai sumber utama elektrik untuk menara telekomunikasi di kawasan terpencil di Sarawak. Tambahan pula, tenaga biojisim sebagai sumber kuasa sandaran. Walau bagaimanapun, tenaga angin bukan pilihan yang sesuai di Sarawak disebabkan kelajuan angin purata yang rendah. Kajian ini juga mendapati bahawa sistem tenaga boleh diperbaharui seperti solar dan biojisim adalah alternatif yang berkos efektif dan mesra alam kepada penjana diesel, walaupun masih belum bersaing dari segi kos pada masa ini.

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ABBREVIATIONS

BTS	-	Based Transceiver Station
BOS	-	Balance of System
DFBG	-	Downdraft Fixed Bed Gasifier
DOD	-	Depth of Discharge
RTT	-	Rooftop Towers
GBT	-	Ground-Based Towers
RTP	-	Rooftop Poles
FCU	-	Fan Coil Units
SMPS	-	Switched Mode Power Supply
Genset	-	Generator set
GHGs	-	Greenhouse Gases
HOMER	-	Hybrid 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
COE	-	Cost of Electricity
NREL	-	National Renewable Energy Laboratory
O&M	-	Operating and Maintenance
PV	-	Photovoltaic
DFBG	-	The Downdraft Fixed Bed Gasifier
EFB	-	Empty Fruit Bunch
FFB	-	Fresh Fruit Brunch
MPOB	-	Malaysia Palm Oil Board
R&D	-	Research and Development
LHV	-	Lower Heating Value
DRI	-	Demand Response Inverter
HOMER	-	Hybrid Optimization of Multiple Energy Resources

RE	-	Renewable Energy
RES	-	Renewable Energy Sources
RES	-	Rural Electrification Scheme
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 has played a crucial role in supporting and providing electrification in various sectors such as industrial, commercial, and residential areas, contributing to the modernization of countries [1]. The prosperity and development of a country's residential, commercial, industrial, transportation, and community sectors are often tied to the use of fossil fuel energy sources like coal and natural gas. However, the use of these fossil fuels can contribute to environmental issues, such as carbon emissions. This study aims to explore the potential of renewable energy systems and the economic impact they can have on a country using HOMER software.

A hybrid solar PV system combines solar panels with another source of energy, such as a diesel generator, to provide a reliable and consistent source of power. This can be a useful solution for telecommunication towers in remote locations or in areas where the power grid is unreliable. The development of telecommunications networks has changed the way people live, work, and play on their daily. This is because mobile networks connect so many people around the world which the telecom operators must tackle the challenge of providing reliable and cost-effective power solutions to these expanding and remote networks. Due to the non-availability of grid power supply, the electric power infrastructure is having a negative influence on the growth of mobile telecommunications in terms of network coverage and has a significant impact on the operation cost of operating the system[2]. As a result, the rural population has very limited and no cell network coverage.

For powering these mobile tower sites, standard diesel generators with backup batteries were used (BTS). These off-grid systems, which are usually located in difficult-to-access places that require regular maintenance and are differentiated by high fuel consumption as well as high transportation and operational costs[2]. Telecom companies are under pressure to find alternative options for powering these facilities as the demand for clean energy technology to reduce greenhouse gas emissions rises. As a result, alternative energy

sources must be combined to provide the continuous typical load requirement of a mobile base station under a variety of environmental factors[2]. Due to the increasing demand for off-grid electricity in rural areas, renewable energy is best suited to implement Sarawak rural area telecom tower sites using renewable energy technology. The project's objective is to develop a Base Transceiver Station (BTS) off-grid hybrid renewable energy system that can generate and supply cost effective electric power to meet the BTS's electrical load requirements.

1.2 Hybrid Renewable Energy

Hybrid energy systems are interconnected systems that combine wind power, solar power, fuel cells, and micro-turbine generators to generate power for local loads and connect to the grid or micro-grids, reducing dependency on fossil fuels [3]. In the future, hybrid systems are considered a more viable option for building modern electrical grids due to their economic, environmental, and social benefits [3].

However due to population growth, suburbanization, and industrial expansion all contribute to the daily growth of energy demand. When energy consumption exceeds the available supply from energy sources, it results in an energy shortage due to the insufficient energy to meet the demand. [3].

Conventional energy sources, such as coal, oil, and gas, are rapidly being depleted and their use has a significant impact on the environment in the form of rising CO2 levels, contributing to global warming. The main challenge with renewable energy sources is their reliance on weather conditions such as wind speed and solar irradiance. These sources cannot consistently provide power to meet demand due to their unpredictable and intermittent nature [3].

Wind, solar, hydro, biogas, and fuel cells are examples of renewable energy sources that can be combined to create a hybrid system that is more dependable and environmentally friendly. The goal of Malaysia's electricity supply development is to ensure a secure, reliable, and cost-effective energy supply, with the aim of boosting the economy's competitiveness and resilience.

1.3 Sarawak electrification

Sarawak is a state in Malaysia located on the northern part of Borneo Island. The electricity sector in Sarawak is monopolized by Sarawak Energy Berhad (SEB), a company fully owned by the state government. The focus of Malaysia's electricity supply development is to ensure a secure, reliable, and affordable energy supply, with the intention of improving the competitiveness and resilience of the economy. [4]. Peninsular Malaysia has almost 100% electrification; the picture differs in east Malaysia. Sabah and Sarawak electrification rates are decidedly lower, at 77% and 67% respectively [4].

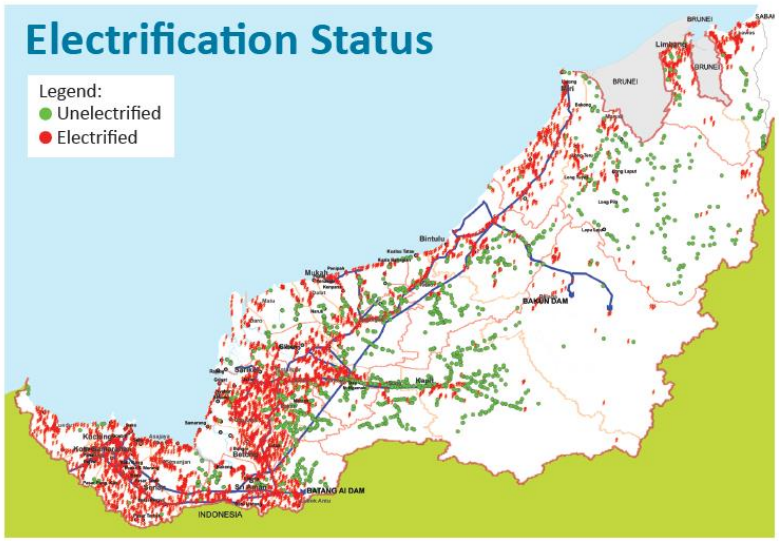

Figure 1.1: Sarawak electrification status [5].

Figure 1.1 shows the status of Sarawak electrification including urban and rural area. In past few years, which is 2009, the overall domestic coverage in the state was 79%, but only 56% of the rural population had electricity availability. [5]. These days, roughly 90% of the rural population has a source of electricity, increasing the overall coverage to about 95%. [5].

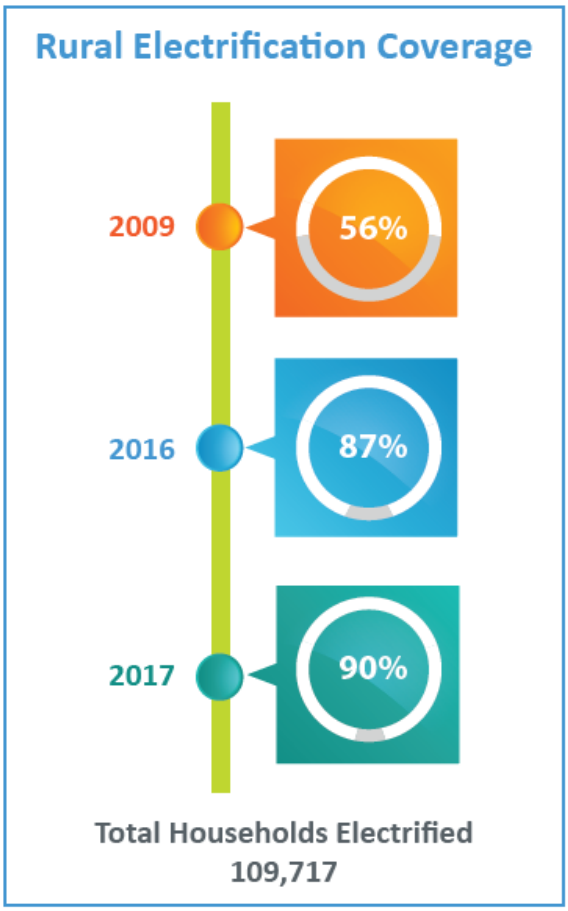

Figure 1.2: Rural electrification coverage [5].

Figure 1.2 shows the percentage of the rural electrification coverage in Malaysia. According to the figure, rural electrification started to advance in 2009 when the Federal Government made it a National Key Result Area (NKRA). The Rural Electrification Scheme (RES) in Sarawak spent RM3.5 billion to electrify around 102,000 homes by 2016 and 110,000 households in nearly 4,000 dispersed villages by September 2017 [5]**.**

1.4 Characteristic of Rural Sarawak

The research was conducted in 11 rural villages in the state of Sarawak, and it showed that only 36% of residents in these areas have access to the internet, compared to 56% of Malaysians overall [6]. This highlights that Sarawak lags in terms of internet availability and digital transformation. The government has implemented various welfare schemes to assist

those in need, such as benefits for children, the elderly, those with disabilities, and poverty aid.[6].

The study revealed that a majority of 61% of rural residents received government benefits. Additionally, a small percentage of 18% of rural residents do not possess any device that can access the internet [6]. The characteristics of Rural Sarawak as shown in Table 1.1.

Table 1.1: The characteristics of Rural Sarawak [7]

Characteristics of Rural Sarawak	Amount
Number of populations in 2019 (million)	2.81
Area (km2)	124,449.51
Rate of rural resident accessed to the internet (%)	36
Rate of rural resident received support of welfare schemes from Government (%)	61
Rate of rural resident did not own any Internet support device (%)	18

1.5 Problem Statement

Sarawak is the largest state in Malaysia, covering an area of 124,449.51 km2. Located on the island of Borneo [7], Sarawak is home to a few isolated, hard-to-reach communities that have historically been difficult for Sarawak Energy Berhad (SEB), the main provider of electricity in the state, to serve. The terrain in Sarawak, which includes hills, mountains, and other challenging landscapes, has made it difficult for SEB to reach all parts of the population. Some areas do have diesel generators (gensets) that produce electricity but these gensets are not reliable 24/7 sources of electricity and require diesel fuel, which requires a significant distance to obtain [7].

In rural Sarawak, the internet accessibility is low due to unreliable power grids to support telecommunication network and large geographical area[7]. As energy demand in rural areas rises because of agricultural activities and home usage, especially in the Borneo region, rural electrification in Malaysia is receiving more attention[8]. Rural areas typically lack access to the electricity utility grid due to geographic and economic factors[8]. Unsurprisingly, many telecommunications towers are placed on mountains in remote areas to improve signal reception[8]. The tower is often powered by a diesel generator system, which needs frequent refuelling and maintenance. Introducing renewable energy into diesel

generators has the potential to minimize the dependence on fossil fuels. Alternative energy sources, such as renewable energy sources, can help with remote rural electrification problems. Although setting up and maintaining a renewable energy generator is not difficult, it is important to take cautious precautions to ensure that electrification can be enhanced by maximum energy consumption. In order to analyse the performance and evaluate the economic aspects of the hybrid system to supply power for telecommunication tower, the Homer software utilized in this research was developed and implemented. Consideration is given to renewable energy sources like solar, biomass, wind, and hydro.

One problem that may arise in the to optimize hybrid renewable energy system for telecommunication tower supply is to optimize the use of various power sources by finding the balance that maximizes efficiency and minimizes expenses. For example, it may be more cost-effective to use grid-tied power during periods of high demand, while using solar power during periods of low demand. However, accurately predicting and managing the use of different power sources can be challenging, as it requires real-time monitoring and control of the energy usage of the telecom tower.

Another problem that may arise in the optimization of hybrid solar PV for telecommunications tower energy supply is the need to ensure that the power supply is reliable and able to meet the energy always needs of the telecom equipment. This can be challenging in locations where there are frequent power outages or where the availability of solar or wind power is unpredictable.

Finally, the optimization of hybrid solar PV for telecommunications tower energy supply may also involve the need to manage the maintenance and repair of the various power sources, which can be time-consuming and costly. This may include tasks such as cleaning and servicing photovoltaic panels, replacing batteries or generators, and maintaining wind turbines. Overall, the optimization of hybrid solar PV for telecommunications tower energy supply involves a few challenges that must be carefully managed to ensure a reliable, efficient, and cost-effective power supply for telecom towers.

1.6 Objectives

1. To model, simulate and optimize hybrid renewable energy system for telecommunication tower supply for Lundu, Bintulu and Limbang.
2. To analyse the performance and evaluate the economic aspects of the hybrid system to supply power for telecommunication tower.
3. To compare the financial and carbon emission aspects of hybrid renewable energy with stand-alone diesel generators.

1.7 Project Scope

In this project, HOMER software will be used to simulate the optimization of hybrid renewable energy for telecommunication towers energy supply in remote rural area. In some of Sarawak's outlying areas, there is no grid-connected energy supply. This alternative strategy for utilising renewable energy is beneficial for supplying power to the communications tower. In terms of operating costs, transportation costs, maintenance costs, as well as environmental problems for gas emissions, fuel is becoming more expensive on the global market. The effectiveness and performance of conventional energy, renewable energy, and a hybrid energy system are discussed in the research literature journals. Prices that require for a specific method for economic analysis are officially obtained from reports by Sarawak Energy Berhad and the Malaysian Energy Commission.

Solar PV systems, micro-hydro systems, wind systems, and diesel generator systems are the hybrid renewables being modelled in this study. The remote rural location to be researched is in Lundu, Bintulu and Limbang with an expected 1 tower in each division because these areas currently lack on-grid power connection. The diesel generator is compared to five ideal stand-alone hybrid renewable energy systems. Effective regulations and incentives for renewable energy sources (RES) are a challenge in promoting a low-carbon economy for the future. Sarawak Alternative Rural Electrification Scheme (SARES) has developed a rapid solution by supplying renewable energy such as solar and micro hydro systems to power up rural areas.

A project to optimize the use of hybrid renewable energy for telecommunications towers energy supply in remote rural area using Homer Pro software would involve several

key elements to ensure a reliable, efficient, and cost-effective power supply for the towers. These elements may include identifying and evaluating potential renewable energy sources, analysing energy usage patterns, modelling the performance and cost of different renewable energy systems, sizing and specifying the components of the hybrid system, implementing, and commissioning the system, monitoring, and evaluating the performance of the system over time, and providing training and support to the tower operators. The specific scope of the project may vary depending on the specific needs and requirements of the telecommunications tower and the available renewable energy sources in the area. The goal of the project would be to optimize the use of hybrid renewable energy sources for the telecommunications tower to provide a reliable, efficient, and cost-effective power supply.

1.8 Project Outlines

Chapter one of this paper presents an overview of the project, including its context, research question, goals, scope, and structure. This chapter also provides a comprehensive overview of the use of electricity and hybrid renewable energy systems in remote rural areas A brief discussion of software-based simulation and hybrid renewable energy optimization is included in this chapter.

Chapter two presents a literature review of previous research on the optimization of hybrid renewable energy systems for telecommunication towers in remote rural areas using HOMER. This chapter discusses various hybrid renewable energy configurations and electrification program in rural area Sarawak. Other than that, this chapter also present about the type of telecom tower, load profile, specification, nominal power, size, and speed.

In chapter three, the methodology employed in the project is outlined. It covers the simulation procedure and analysis of the hybrid renewable energy system model. The chapter comprises of a project flowchart, simulation flowchart and relevant information on the simulation tools used.

The results of the project, including data from simulations of optimized hybrid renewable energy systems, are presented in chapter four. The data is analysed and represented using pie charts and graphs.

Lastly, the final chapter presents the conclusions from the project, including any suggestions for further developments or enhancements. This chapter also summarizes the