COMPARISON OF ELECTRIFICATION OPTION FOR RURAL VILLAGE

MUHAMMAD HAFIZI BIN ABU

BACHELOR OF ELECTRICAL ENGINEERING WITH HONOURS
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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MUHAMMAD HAFIZI BIN ABU

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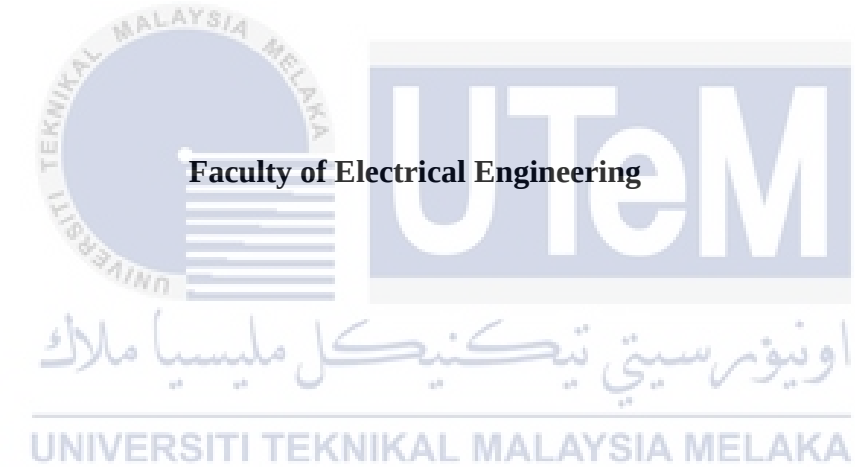

Faculty of Electrical Engineering

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DECLARATION

I declare that this thesis entitled “COMPARISON OF ELECTRIFICATION OPTION FOR RURAL VILLAGE” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : 

Name : MUHAMMAD HAFIZI BIN ABU

Date : 5 JULAI 2021

APPROVAL

I hereby declare that I have checked this report entitled "COMPARISON OF ELECTRIFICATION OPTION FOR RURAL VILLAGE" and in my opinion, this thesis it complies the partial fulfillment for awarding the award of the degree of Bachelor of Electrical Engineering with Honours

Signature : .....

Supervisor Name : PROF. MADYA IR. DR. GAN CHIN KIM
TIMBALAN DEKAN (PENYELIDIKAN & PENGAJIAN SISWAZAH)
Fakulti Kejuruteraan Elektrik
Universiti Teknikal Malaysia Melaka

Date : 5 July 2021

DEDICATIONS

I dedicate my research work to all my family member. My loving parents, Abu Bin Hassan and Norishah Binti Jamil whose give me encouragement to complete this Final Year Project report. Also to my brother and sisters that always with me when i ask favor. I am grateful to all my family members.

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ABSTRACT

This report presents a possible electrification option for rural areas in Sarawak, Malaysia. Among the electrical options that can be used in remote locations are off-grid electricity, on-grid electricity and a hybrid integrated renewable energy system. Off-grid electricity is the grid that is not connected to the grid extension and it allows buildings and households to be self-sufficient, while on-grid electricity works in conjunction with the national grid. Between these two options, off-grid electricity is a suitable solution for rural areas because this remote location is far from the grid extension, but off-grid electricity based on a single source is not suitable and efficient. So, the hybrid renewable energy system is the solution to the stand-alone energy system. The hybrid renewable energy system typically consists of two or more sources of renewable energy that are used together to ensure the performance of the system. When compared to stand-alone energy systems, an off-grid hybrid renewable energy system is a more effective solution..

ABSTRAK

Laporan ini menunjukkan kemungkinan pilihan elektrik untuk kawasan luar bandar di Sarawak, Malaysia. Antara pilihan elektrik yang boleh digunakan di lokasi terpencil adalah elektrik di luar grid, elektrik di grid dan sistem tenaga boleh diperbaharui bersepadu hibrid. Tenaga elektrik di luar grid adalah grid yang tidak dihubungkan ke sambungan grid dan ia membolehkan bangunan dan isi rumah menjadi mandiri, sementara elektrik di grid berfungsi bersama dengan grid nasional. Di antara dua pilihan ini, elektrik di luar talian adalah penyelesaian yang sesuai untuk kawasan luar bandar kerana lokasi terpencil ini jauh dari sambungan grid, tetapi elektrik di luar grid berdasarkan satu sumber tidak sesuai dan efisien. Jadi, sistem tenaga boleh diperbaharui hibrid adalah penyelesaian kepada sistem tenaga yang berdiri sendiri. Sistem tenaga boleh diperbaharui hibrid biasanya terdiri daripada dua atau lebih sumber tenaga boleh diperbaharui yang digunakan bersama untuk memastikan prestasi sistem. Jika dibandingkan dengan sistem tenaga yang berdiri sendiri, sistem tenaga boleh diperbaharui hibrid luar grid adalah penyelesaian yang lebih berkesan.

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LIST OF ABBREVIATIONS

RE	-	Renewable Energy
SDG	-	Sustainable Development Goal
PV	-	Photovoltaic
AM	-	Ante Meridiem (Before Noon)
PM	-	Post Meridiem (After Noon)
TNB	-	Tenaga Nasional Berhad
HOMER	-	Hybrid Optimization of Multiple Electric Resources
US	-	United States
NREL	-	National Renewable Energy Laboratory
NPC	-	Net Present Cost
COE	-	Cost Of Energy
IRES	-	Integrated Renewable Energy System
NASA	-	National Aeronautics and Space Administration
AC	-	Alternating Current
DC	-	Direct Current
GHI	-	Global Horizontal Irradiation
HRES	-	Hybrid Renewable Energy System
CO2	-	Carbon Dioxide
GHG	-	Green House Gases
DG	-	Diesel Generator
LF	-	Load Following
CC	-	Cycle Charging
O&M	-	Operating and Maintenance
USD	-	United State Dollar

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CHAPTER 1

INTRODUCTION

1.1 Background

The population of Malaysia is estimated to be 32.7 million in 2020, compared to 32.5 million in 2019 [1]. According to current data, 99.7 percent of the population in peninsular Malaysia has access to electricity, however the rate of electrification in Sabah and Sarawak is lower than in Peninsular Malaysia [2]. The percentage of the population in Malaysia that live in poverty line is about 3.8% and most of them live in rural areas [3]. In poor states, electricity coverage is around 79 percent, compared to 99.62 percent in Peninsular Malaysia [3]. The best solution to reduce energy poverty in rural areas is renewable energy sources (RE). It is impossible to extend the grid over challenging terrain and dense jungle or reducing economic poverty. Off-grid electricity can increase rural electricity capability and provide distinct community benefits as an economical and reliable source of energy [3].

Rural electrification based on a single energy source is a possible, but not an efficient alternative due to its intermittent existence [4],[5]. An integrated renewable energy system consists of two or more renewable energy sources to meet demand [4]. The combination of two or more RE sources and a storage unit is a stable and economical solution. One power source can be used to compensate for the other's weakness [5]. Goal 7 (SDG 7 or Global Goal 7) is one of the 17 targets set by the United Nation General Assembly in 2015 for sustainable development. The goal is to "Ensure that everyone has access to affordable, reliable, sustainable and modern energy for all" [6].

1.2 Problem Statement

For developing countries like Malaysia, the problem electrification in rural areas is to get connected to the grid system due to the location of rural areas that far from national grid [2]. The availability of grid power in rural areas is not cost-effective due to high delivery costs and the associated lack of transmission. However, grid extension through difficult areas

and dense jungle to sustain a small village are not feasible and economically [3]. It is challenging to transport traditional energy resources such as oil, coal, natural gas, etc. The transmission grid's usual expansion is also highly capital intensive due to the uneven and challenging terrain [4]. Due to primary renewable energy sources' erratic characteristics, rural areas cannot be effective and economical using one source of energy [5]. The grid extension in rural areas is facing huge problems because of the low population and energy needs. Models for demand and cost forecasts represent the complexity of energy demand and equipment costs in various regions over time [7]. Grid extension options for remote areas or submarine cables are typically costly for remote islands [8].

1.3 Objectives

1. To identify possible electrification options for rural villages.
2. To compare the Net Present Cost (NPC) and benefits between identified options.

1.4 Scope

To achieve the objective, three scope is been listed which is (i) identify possible electrification options for rural villages in Kapit, Sarawak at coordinate (1°59.7’0"N 112°56'0"E), (ii) this project work will use Homer Software to get a realistic projection of the capital, operating cost and (iii) Compare Net Present Cost (NPC) between the electrification option, off-grid solar system and diesel generator using Homer Software.

CHAPTER 2

LITERATURE REVIEW

2.1 Electrification Options

Five primary sources that supply energy in Malaysia is hydro, natural gas, coal, oil and renewable energy [3]. Renewables energy can be the right option to electrify certain remote areas to meet community needs [4]. Table 2.1 show the production of electricity sources in Malaysia.

Table 2.1 The sources of Malaysia's generated electricity [3]

Source	**Electricity (GWh)**
Gasses	61,910
Coal	26,177
Hydro	7459
Oil	1845
Solar PV	1
Tidal Energy	0
Solar Thermal	0
Nuclear	0
Biomass	0
Wind	0
Geothermal	0
Other Sources	0
Waste	0
Total of Production	97 392

2.1.1 Off Grid Electricity

Off-grid refers to not being connected to the grid system. The ability to apply alternative energy as an off grid system at remote location is also inexpensive than conventional energy sources, because such isolated location have limited connection to the national grid [2]. Off-grid power generated from hydro, solar and wind technology offers the potential to enhance capacity in remote areas in a cost-effective and reliable way, with distinct Community benefits [3]. Due to inaccuracy in operations from the main source of renewable energy, rural electrification cannot be cost-effective or efficient using a single source of renewable energy [5]. The village does not have access to grid electricity, which provides the village with a potential for off-grid electrification [9]. The off-grid method provides an effective solution [10].

2.1.2 On Grid Electricity

On-grid electricity is the electricity that working in conjunction with the national grid but due to geography and economics in the isolated locations so there are typically not connected to the national grid system [2]. Options for grid extension to isolated locations or delivery of submarine cables to the isolated islands are generally very costly [8].

The geographical conditions of remote areas, as well as the low population demand for electricity, make the expansion of grid electricity networks uneconomical [10]. Installation & maintenance costs are largely primary issues in extending the grid to rural areas [11]. Since most areas are very far from the national grid, the government failed to provide rural areas with grid electricity [12].

2.1.3 Renewable Energy Sources

Malaysia has the potential to use hydropower, solar, biomass, wind and tidal sources for energy resources. In Malaysia the potential to use PV and wind as renewable sources is in rural areas and island which is not linked to the national grid. One of the best options for rural areas to have electricity is renewable energy [3]. For the electrification of such isolated areas, renewable energy sources may be a good option to meet the energy needs of the city [4].

Renewable energy (RE) sources can be beneficial at a significant level in mitigating environmental problems and helping to sustain fossil fuels [5]. The issues is when these resources are used as a single supply for a specific load, it have a number of disadvantages, including high investment costs and a 24 hour supply limitation due to their intermittent and unpredictable nature [13]. It is found that the Solar irradiation, temperature resource, wind speed, and biomass residue quantities all have an impact on renewable energy potential [14].

Renewable energy technology is known as a common choice for alternative technologies to grid electricity networks and solar PV systems [10]. In recent decades, the use of stand-alone RE systems has steadily increased as an effective rural solution [15]. Solar energy has been found to be the most prospective of all RE sources in Malaysia [16]. Renewable energy is seen as a promising alternative to provide these remote settlements with sustainable energy. The use of RE in both developed and developing countries has greatly increased in recent years [12]. Table 2.2 illustrated some of the factors and problems that have an impact on the development of RE in Malaysia [17].

Table 2.2 Challenges that affect the development of RE in Malaysia [17]

Type of energy	Challenges that affect popularity of renewable energy in Malaysia				
Solar energy	Cost	The average of cloudy day and rainy is two month per year.	Ambient temperature is really high	land required for harvesting solar energy	Battery short lifespan due to overused without recharging
Wind energy	Low average speed of wind	Pollution of noise	Ecosystem disturbance and destruction	Affect the fauna, especially birds	Space (land) is being wasted for the installation of wind turbines.
Biomass	Difficult to transport	Difficulty in collecting, harvesting and processing	Equipment used to generate energy has a low efficiency.	The biomass energy market has a small number of companies.	Requires financial assistance and technological support
HRES	Cost	Finding the ideal hybrid system combination is difficult because there are so many variables to consider.	Highly dependent on meteorological condition	Highly dependent on energy sources available	lack of properly trained personnel

2.2 Rural Electrification

Rural electrification is the government, the private sector, an institution or organization's operation, plans, programs or initiatives that carry electricity to rural areas where there is no 24-hour electricity link. Geographical conditions and the low energy demand from the other electrical areas have unreasonably and in certain parts made network development unreasonable [10]. Rural electrification is a crucial and difficult challenge due to the geographical characteristics of the country and the substantial rural population [18]**.** In rural locations, electrification is highly related to poverty and growth. Consequently, rural electrification can be regarded as the front line of energy access and growth, which involves many of the country's sustainability and resources [19].

2.2.1 Rural Areas

The population lives in urban areas in Malaysia is around 71.3% while the other 28.7% is live in rural areas. Figure 1 shows Malaysia's pace of state urbanization in 2010. The urbanisation of Kelantan, as compared with the urbanized Kuala Lumpur and Putrajaya, is just 42,4 per cent lower. 8.4% of rural residents are estimated to living below the line of poverty, while in urban areas just 1.7% living below the line of poverty [3]. The under-served communities of Malaysia can generally be referred to as societies in isolated areas without power, water or basic public services [11].

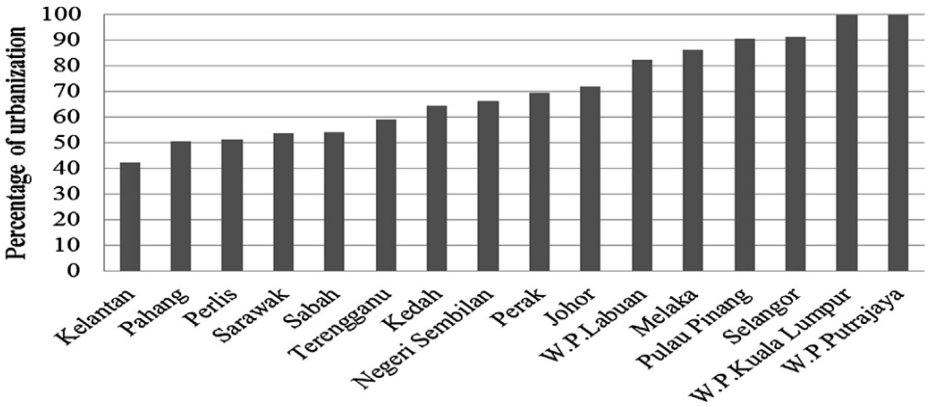

Figure 2.1 Malaysian State Urbanization Rate, 2010 [3]

Table 2.3 Shows the state energy supply in urban and rural Malaysia in 2000. The lowest electricity rate in 2000 in rural areas are Sabah and Sarawak, 67.05 percent and 66.91 percent, respectively [3].

Table 2.3 Power supply in urban and rural areas in 2000 [3]

State	Urban	Rural
Kuala Lumpur	99.76 %	-
Perlis	99.63 %	99.17 %
Pulau Pinang	99.84 %	99.16 %
Kedah	99.84 %	98.58 %
Johor	99.53 %	98.22 %
Perak	99.64 %	96.11 %
Pahang	99.63 %	93.96 %
N. Sembilan	99.61 %	98.60 %
Melaka	99.90 %	99.28 %
Kelantan	99.52 %	97.50 %
Selangor	99.39 %	97.92 %
Terengganu	99.65 %	98.24 %
Sarawak	93.96 %	66.91 %
Sabah	89.65 %	67.05 %

Table 2.4 shows that in Sabah and Sarawak, electrification levels are very low (by 82.51% and 78.74% respectively) compared with Malaysia, with 99.62% in 2010 [3]. Sarawak has the lowest electrification rate in Malaysia, with the majority of residents living in rural areas have no access to the electric grid [20].

Table 2.4 Electrification level in Malaysia in 2010 [3]

Regions	Total number of houses	Number of houses connected with 24hour supply	Coverage
Sabah	311,780 unit	257,780 unit	82.51 %
Sarawak	278,110 unit	218,992 unit	78.74 %
Peninsular Malaysia	1,656,800 unit	1,650,492 unit	99.62 %

Rural electrification of remote areas will play a significant role in the society's social and economic development [4]. In rural areas, the electrification rate is particularly low and only about 16 percent of rural household have access to electricity [7]. The government of Malaysia is committed to expanding modernization to rural areas [10].

Table 2.5 indicates the rural electrification effort carried out by Tenaga Nasional Berhad (TNB). Since 1975. Tenaga Nasional Berhad has significant experience and facility in supplies of rural electricity [21].

Table 2.5 TNB involvement in rural electrification since 1975 [21]

Project	Track Record	Total (Capacity)
Hybrid PV System – Solar and Wind	Since 2007	1 Project (2 x 100 kWatt – Wind) (100 kWatt – Solar) & (500kWatt - Genset)
Biomass	Since 2004	1 Project (2 MWatt)
Hybrid PV System – Solar and Diesel	Since 2001	70 Projects (1,806 MWatt)
Hybrid Wind and Diesel	Since 1995	1 project (150 kWatt – Wind) & (150 kWatt – Genset)
Mini Hydro	Since 1980	35 Project (18MWatt)
Grid Connection	Since 1975	>1500 Projects

In 2015, the Rural Power Master Plan by Sarawak Energy developed a program to electrify rural households. The plan aims to continuous improvement rural electrification through a variety of government-funded programs. Sarawak Energy aims to link more than 30,000 other rural households into the full electricity system by 2025 [22].

2.3 Comparison Electrification Option

Electrification option in rural area is been observed based on the location and the weather forecast. There are few options that have been observed which is solar photovoltaic, wind, hydropower, generator and hybrid renewable energy system. Solar photovoltaic is one of renewable energy that has advantage to use in Malaysia due to its location in the equatorial zone while wind turbine is not suitable due to mean annual speed in Malaysia is 1.8 m/s and the wind does not blow uniformly throughout Malaysia. The system consists of solar photovoltaic modules for the primary generator, batteries for energy storage, diesel engines for supporting an inverter to convert DC and AC voltage in both directions [10].

Most villages in rural Malaysia currently are powered by a typical diesel generator. Maintenance & installation costs are the main problems in the extension of the grid to rural areas. High transport and difficulty in carrying fuel to isolated villages, which causes the system fail to generate power consistently. PV systems have advantages as small-scale electricity sources in rural locations., but conventional solar panels are costly because the production technology of solar panels is still in its infancy and high material cost for solar cells [11]. Small hydropower will provide more opportunities to promote the expansion of rural electrification and also contribute to grid support for energy and capacity. The potential for small hydropower in Malaysia is immense, but the energy available from the rivers is already making a substantial contribution to the supply of electricity in rural areas [23].

2.3.1 Solar Photovoltaic (PV)

Solar photovoltaic (PV) energy technology is widely considered to be the most effective method for electrifying off grid rural areas. This is because of its potential to generate electricity based on several projects have been successfully implemented globally. Solar photovoltaic (PV) technology emits no greenhouse gases (GHG) and generates no