INVESTIGATION ON LOAD DEMAND OF MICROGRID ENERGY MANAGEMENT SYSTEM IN KG. SUKANG TELIDUSUN AND PULAU SEPINONG

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DECLARATION

I hereby declare that this project progress report entitled "Investigation On Load Demand Of Microgrid Energy Management System in Kg. Sukang Telidusun And Pulau Sepinong", submitted to Universiti Malaysia Sabah is an original work under the supervision of Dr. Mohd Kamal Bin Mohd Shah, and it is submitted as a partial fulfillmen of the requirement for the degree of Bachelor of Mechanical Engineering, which has not been submitted to any other university for a degree. I also certify that the work described here is entirely mine, except for quotations and summaries of sources which have been duly acknowledged.

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ABSTRACT

The revolution to a more sustainable future has started in recent years, and it is important that this trend continues. The penetration of renewable energy systems (RES) in various locations and sizes has been encouraged by increasing energy demand from a growing population, as well as increasing greenhouse gas (GHG) emissions and depletion of fossil resources. As a result, the energy sector is undergoing a revolution from a centralised network of major, controlled power plants to a decentralised grid based on renewable energy resources (RER)s. Microgrids (MG)s are a fundamental component of this system for combining RES, controlled energy sources, flexible loads, and storage systems, whether grid-connected or island-connected.

This study is regarding on the investigation on load demand of MG energy management system (EMS) at the rural area and the chosen site locations were Kg. Sukang Telidusun and Pulau Sepinong. Besides, the main objectives are to identify and evaluate the maximum energy supply to fulfil the load demand in current condition using Solar Hybrid and Rural Stations by conducting an analysis of data and to study on the volatility and intermittency of hybrid solar energy source based on the analytical data. The analysis was carried out by gathering relevant data and information from previous research, as well as visits to relevant places and areas. Several simulations were carried out in the HOMER Pro software, and a feasible MG system was designed and analysed to meet the residential's and commercial's load requirements. As a result, System A was selected as the ideal configuration because it fits all of the component criteria and is close to the real-world circumstance at the site, allowing the research to achieve its aim of meeting load demand while remaining simple. In addition, the potential of solar power's intermittent renewables to meet demand was discussed.

ABSTRAK

KAJIAN MENGENAI PERMINTAAN BEBAN SISTEM PENGURUSAN TENAGA MICROGRID DI KG. SUKANG TELIDUSUN DAN PULAU SEPINONG

Revolusi ke arah masa depan yang lebih lestari telah bermula sejak beberapa tahun kebelakangan ini, dan trend ini penting untuk diteruskan. Penembusan sistem tenaga boleh diperbaharui (RES) di pelbagai lokasi dan saiz telah digalakkan dengan meningkatkan permintaan tenaga daripada populasi yang semakin meningkat, serta meningkatkan pelepasan gas rumah hijau (GHG) dan kehabisan sumber fosil. Akibatnya, sektor tenaga sedang mengalami revolusi daripada rangkaian terpusat loji janakuasa utama terkawal kepada grid terdesentralisasi berdasarkan sumber tenaga boleh diperbaharui (RER). Microgrids (MG)s ialah komponen asas sistem ini untuk menggabungkan sumber tenaga boleh diperbaharui, sumber tenaga terkawal, beban fleksibel dan sistem storan, sama ada bersambung grid atau bersambung pulau.

Kajian ini adalah mengenai penyiasatan permintaan beban sistem pengurusan tenaga MG di kawasan luar bandar dan lokasi tapak yang dipilih ialah Kg. Sukang Telidusun dan Pulau Sepinong. Selain itu, objektif utama adalah untuk mengenal pasti dan menilai bekalan tenaga maksimum untuk memenuhi permintaan beban dalam keadaan semasa menggunakan Stesen Solar dan Hibrid Luar Bandar dengan menjalankan analisis data dan mengkaji turun naik dan ketidakstabilan (putus-putus) sumber tenaga solar hibrid berdasarkan data analisis. Analisis dijalankan dengan mengumpul data dan maklumat yang berkaitan daripada penyelidikan terdahulu, serta lawatan ke tempat dan kawasan yang berkaitan. Beberapa simulasi telah dijalankan dalam perisian HOMER Pro, dan sistem MG yang boleh digunakan telah direka dan dianalisis untuk memenuhi keperluan beban kediaman dan komersial. Hasilnya, Sistem A dipilih sebagai konfigurasi yang ideal kerana ia sesuai dengan semua kriteria komponen dan hampir dengan keadaan dunia sebenar di tapak, membolehkan penyelidikan mencapai matlamatnya untuk memenuhi permintaan beban sambil kekal mudah. Di samping itu, potensi tenaga suria boleh diperbaharui yang kurang stabil untuk memenuhi permintaan telah dibincangkan.

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LIST OF ABBREVIATIONS

BDI	-	Bidirectional Inverter
CHP	-	Combined Heat And Power
CI	-	Clearness Index
DER	-	Distributed Energy Resources
DES	-	Distributed Energy Storage
DG	-	Distributed Generation
DR	-	Demand Response
EMS	-	Energy Management System
ESS	-	Energy Storage System
GCI	-	Grid Connect Inverter
GHG	-	Greenhouse Gas
GHI	-	Global Horizontal Irradiance
GTP	-	Grid Tie Power Inverter
HS	-	Hybrid System
MG	-	Microgrid
MTP	-	Maximum Tracking Point Inverter
NASA	-	National Aeronautics and Space Administration
NPC	-	Net Price Cost
O&M	-	Operation & Maintenance
PV	-	Photovoltaic
RE	-	Renewable Energy
RER	-	Renewable Energy Resource
RES	-	Renewable Energy System

SCC - Solar Charge Controller

SCM - Solar Charge Module

SESB - Sabah Electricity SDN BHD

SOC - State of Charge

LIST OF SYMBOLS

AC	-	Alternating current
DC	-	Direct current
hr	-	Usage hours of appliance
kW	-	Kilowatt
kWh	-	Kilowatt hour
kWh/day	-	Kilowatt hour per day
kWh/m^2	-	Kilowatt hour per meter square
kWp	-	Kilowatt peak
L/day	-	Liter per day
L/hr	-	Liter per hour
MJ/m^2	-	Mega joule per meter square
MW	-	Megawatt

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CHAPTER 1

INTRODUCTION

1.1 Project Background

With 60% of the world's population expected to live in cities by 2030, and demand on regional and national power networks expected to increase, a number of cities are looking to localized energy production for new constructions. Sabah, often known as the Land Below the Wind, is the northernmost state of Borneo, sharing land borders with Sarawak, Malaysia, and Kalimantan, Indonesia. Sabah, Malaysia's second-largest state, is home to several mountain ranges, as well as numerous national parks. Microgrids (MG)s are small-scale electrical systems that may operate alone or in parallel with generating stations as the economy and safety of MG operation are challenged by the unpredictability of renewable distributed energy such as photovoltaic (PV), wind power, etc. and load demand in the MG (Eklas Hossain, 2014).

This has caused thousands of households, especially in remote areas, to not have the privilege of getting electricity through the national power grid. The use of distributed energy resources (DER), energy storage, and demand response (DR) programmes is increasing as the world's population grows, environmental concerns grow, and energy consumption rises. Furthermore, RES play an essential part in the generation of clean energy (Seyed Amir *et al.*, 2021).

A MG, according to Wang *et al.* (2018), is an assemblage of integrated electricity consumers, distributed generation (DG), and distributed energy storage (DES) at a distribution grid voltage level with set electrical tolerances. DG can include diesel generators, microturbines, fuel cells, and other gasoline dispatchable power supplies, as well as other related energy sources. It provides services to a large number of people in a community such as a town, neighbourhood, rural community, hospital complex, or university campus. Generally, one or more DERs, such as solar panels, wind turbines, hydroelectric power, diesel engines, or other conventional generators, support microgrids. They have energy storage mechanisms like batteries. Through a smart control mechanism, MGs deliver electricity to surrounding buildings in a specific region.

Grid-connected MG has the ability to export and receive electric power from a bigger power network. Traditionally, the energy interchange with the main energy network was done at a fixed price. It is now possible to properly assess power generation and demand in real time because to the recent development of smart sensor items and technology. DG has significant incentives to reduce emissions of GHG, enhance power system efficiency and reliability, implement competitive energy policies, and postpone transmission and distribution system upgrades (Wang, 2018).

RES are now being implemented on a large scale to meet the demands of expanding energy usage, decrease pollution, and bring long-term socio-economic benefits. The integration of DER into the utility grid allows for MGs. Throughout grid disruptions, the MG concept is being used to define a self-contained system made up of DER that can function in an islanded mode (Hamidreza, 2018). In order to make the most use of these scattered energy resources in an intelligent, secure, trustworthy, and coordinated way, MGs require an energy management system (EMS).

A step-wise DR programme is also addressed in energy management in order to ensure cost-effective operation. The MG is a programmable system that may be utilised as a programmable load or an upstream power grid source. In grid-connected mode, grid-connected microgrids send and receive electricity from the main grid and other MGs in the system. Situations like as a significant outage on the main grid, a fall in the main grid's power quality below particular specifications, or maintenance programmes, on the other hand, might result in the MG being separated from the main grid (Rahman, 2017).

According to Zhiyi Li *et al.* (2019), the MGs are linked as a networked structure to take use of major advantages of networked MGs, which improves system reliability and performance. As a result, MG operators may be able to reduce their operating costs, while customers get access to a more cost-effective and stable power supply. In terms of economic dispatch and islanding control, networked MGs outperform single MGs. One of the most successful techniques for reducing the risks of these uncertainties on electricity delivery to consumers is to use electrical energy storage systems (ESS) near renewable resources. Electrical ESS can store excess renewable energy (RE) output during off-peak hours and then release the stored energy to help with load supply to customers.

1.2 Problem Statement

Microturbines, wind systems, solar systems, ESS, and loads must all be managed by the aggregating agent, who is also dealing with load uncertainty and additional uncertainties owing to the utilization of RERs and participation in the day-ahead market. Since these uncertainties cannot be eliminated from decision-making, correct formulation is required, and the suggested method customizes a stochastic programming problem for this task (Javadi, 2021). These improvements are the result of improved bidding in the day-ahead market and shifting energy use during times when market pricing for exporting energy are favorable.

Furthermore, DR systems reduce demand during peak hours by altering the load peak and moving a portion of the load from peak to off-peak hours, increasing system reliability and lowering operation costs. It is worth noting that while transferring load from peak to off-peak hours, the customers' comfort index should always be taken into account, as the customers' comfort index is one of the most essential elements in distribution system scheduling (Yang & Wang, 2012).

Rural regions, including certain Sabah islands with some economic activity like Kampung Sukang Telidusun in Beluran, and Pulau Sepinong in Sandakan, are also seeing an increase in energy usage. According to Jose *et al.* (2021), data show that in 2018, almost 860 million people globally lacked access to power. Aside from that, Sabah is continuously dealing with the issue of widespread power outages. This is mostly due to disruptions at gas terminals and outages at gas plants, as gas is Sabah's principal energy source for electrical generation. Due to such occurrences, operating reserves, which had a target of 215MW, were less than 100MW for about 70 days in 2018 (Suruhanjaya Tenaga (Energy Commission), 2019). The prevalence of supply and demand gaps between the west and east coast areas also has a significant impact in the frequency of power outages. This serious issue must be solved since frequent power outages will have a significant impact on the region's economy.

Besides, the increasing value of peak demand in the region directly affecting the consumers' pockets as the cost of energy in the particular region increased for the west coast region. However, due to a deficiency in energy output and rising demand on the east coast, much electricity is provided to the region via the Kolopis-Segaliud 275kV transmission lines. This west coast-east coast power transfer is becoming a big concern since the east coast region is totally dependent on the west coast for its electrical needs, while the west coast region itself has regular energy interruptions. As a result, balanced energy generation and distribution are required to balance economic growth in all regions.

Based on the problem statement above, MG management system that a power supply to the target region is constant, since certain industry need to ensure that all the productions will continue running which sometimes experience blackout or no electricity for several hours. By constructing the implementation of microgrids, the funds required to construct networks for the purpose of generating power in specific locations, particularly rural areas, can be decreased by utilizing RE more efficiently.

1.3 Research Objectives

i. To identify and evaluate the maximum energy supply to fulfil the load demand in current condition using Solar Hybrid and Rural Stations by conducting an analysis of data.
ii. To analyze on the volatility and intermittency of hybrid solar energy source based on the analytical data.

1.4 Scope Of Works

The scope of this project covers the following:

1.4.1 Literature Review

Literature reviews are conducted in order to gain knowledge in all aspects related to MGs. The aspects are including the RER, electrical energy storage, effective strategies to minimize the risks, demand response and any relevant fields. Many sources such as local and international research articles, textbooks, lecture notes and eBooks are being referred and extracted. Specific focus will be given to previous researches that were related to RERs and DR since they are the main objective of this project.

1.4.2 Data Analysis/Performing Technical Analysis

The technical components of the MG system were examined in the technical analysis. First, a location within Sabah was chosen as the site research area and goes with RERs were identified, and data on the sources was gathered. The load demand of the chosen location was then determined. The components were then identified. Virtual analysis will be conducted using HOMER Pro software that related to this project. The software used is a simulation model at its core. It will try to simulate a working system for all potential combinations of the equipment that is wanted to think about.

1.4.3 Simulation

The simulation was carried out by entering data on RERs, load demand, component specifications, and the current tariff structure. The optimisation algorithm was chosen to acquire data on various sizing of various configurations that could be suitable for the MG system. The HOMER Pro programme was used to run the simulation.

1.4.4 Result Analysis

Finally, the simulation results were examined. The output data was analysed to determine the quantity of power generated, the amount of load demand that could be met, and the amount of extra energy stored. After that, the discussion was made to meet the criteria of the objectives.

1.5 Research Methodology

First of all, this project need a very deep knowledge in order to make this project success. Thorough examination of literature review is very important to gain and get information from other references such as journal and eBooks. The main contributions in order to determine the number of DERs by considering other aspect which can affect the contributions such as economy of the project and the supply adequacy of critical loads under the uncertain formation of sub-MGs.

As this project is done by interpreting data collected from the specific company which is Sabah Electricity Sdn Bhd (SESB), the data will be collected before being inserted to the software. The design and development of the actual MG is processed by considering all the related values and factors. From this, the MG EMS tactics is varied from economic dispatch and unit commitment with the integration of RERs, ESSs, electric vehicles, and DR. Other solutions include DERs and load scheduling, system losses and outages avoidance, RERs intermittency and volatility control, and MG operation that is cost-effective, long-term, and dependable. Figure 1.1 illustrates the MG EMS strategies.

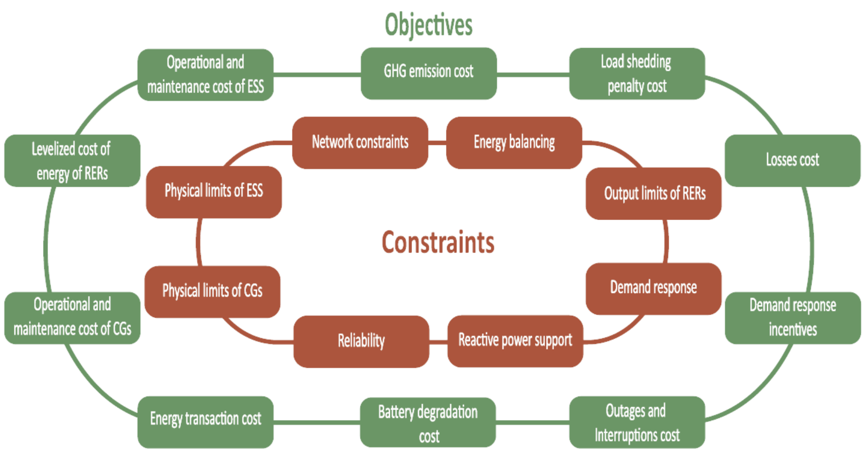

Figure 1.1 : Energy Management Strategies of microgrid.

Source : (Jéssica Alice, 2021)

As to summarize the flow of the methodology, Figure 1.2 below shows the flow chart which will set as a guidance to completing this project paper.

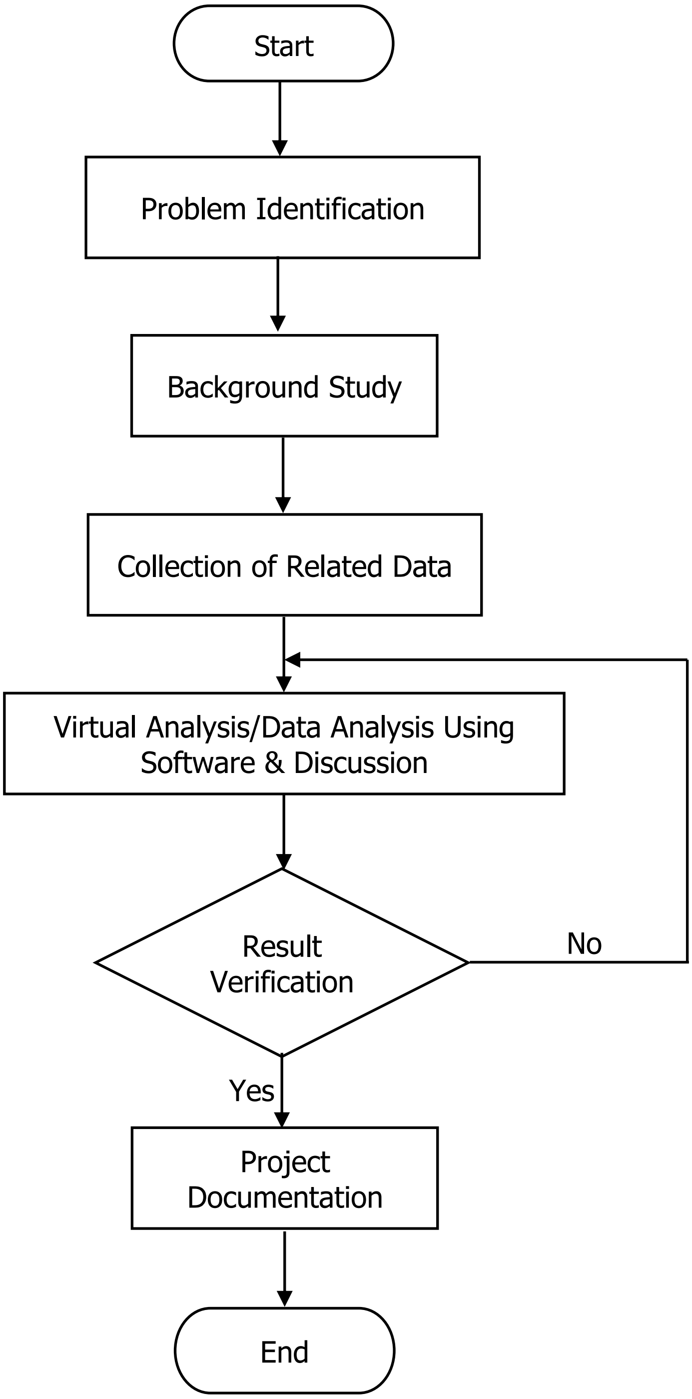

Figure 1.2 : Flow Chart Project

1.6 Research Contributions

This project is to investigate the load demand of the MG EMSs as the power and energy are very demanding in the future due to the increasing number of growth in industrial marketing. This in-depth analysis looks at solutions, opportunities, and chances for achieving energy management goals using various efficient approaches. These approaches were chosen for optimal MG operation based on their compatibility, practicability, and flexibility. This research will aid in the installation of microgrid systems in Sabah in the future. Smart MG systems have a number of advantages and contributions to society and the state in Sabah. The installation of a MG system in Sabah boosts the state's electricity generation. As a result, MG EMS is a comprehensive topic that addresses technological, economic, and environmental concerns.

1.7 Research Commercialisation

The goal of commercialization is to make a profit from this research project. The project's outcome will benefit the production of certain industries. Advancements in technology have improved the efficiency of electricity and power in order to meet load demand, with an emphasis on how to control the use of RE to prevent wastage. The numerous benefits provided by the MG system to society and the country will play a significant role in the system's commercialization value. Many places in Sabah, such as rural villages and communities without power, require MG energy solutions. Areas with power outages, minimal local electricity generation, high load demand, and high energy prices are good candidates for installing this system. Furthermore, as people's knowledge of environmental issues grows, this product will attract a lot of attention in the industry, making it easier for it to reach the market in the future.