# MODELLING A FRAMEWORK OF MICROGRID HYBRID WITH ENERGY STORAGE SYSTEM (ESS) - REDUCE MAXIMUM DEMAND IN UNIVERSITI MALAYSIA SABAH

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**FACULTY OF ENGINEERING**

**UNIVERSITY MALAYSIA SABAH**

**2022**

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**NUR AINA ALWANI BINTI MOHAMAD**

**THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR DEGREE OF BACHELOR OF MECHANICAL ENGINEERING**

**FACULTY OF ENGINEERING**

**UNIVERSITI MALAYSIA SABAH**

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# CERTIFICATE

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| VIVA DATE | : | 26th JULY 2022 |

CERTIFIED BY;

MAIN SUPERVISOR

SIGNATURE

DR. MOHD KAMAL MOHD SHAH

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# DECLARATION

I will henceforth declare that this project progress report entitled "Modelling A Framework of Microgrid Hybrid with Energy Storage System (ESS) – Integration For Reduce Maximum Demand", submitted to Universiti Malaysia Sabah in an original and it is submitted as a partial fulfilment 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 the work described here is entirely mine, except for quotations and summaries of sources which have been duty acknowledged.

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1st JULY 2022

NUR AINA ALWANI BINTI MOHAMAD

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# ABSTRACT

In theory, a microgrid system generates electricity by utilizing renewable energy sources such as solar, wind, and biomass through distribution energy resources such as photovoltaic panels, wind turbines, and biomass gasifiers and supplying it to the load requirements of a specific group of consumers. Nowadays, Malaysia is one of the countries with a vast number of renewable energy sources derived from its geographical location, giving Malaysia a good potential to put the system in place in the country to replace nonrenewable energy sources such as fuel and coal, which are nearing the end of their useful life. As a result of the implementation, the nation and its citizens will reap significant benefits. Modeling a Framework of Hybrid Microgrid with Energy Storage System (ESS) - Reduce Maximum Demand at University Malaysia Sabah was carried out at the Faculty of Medicine and Health Science (FPSK). Initially, the simulation of a hybrid system includes the solar sources which include photovoltaic panels, then the addition of wind resources to examine the performance of the system, which include photovoltaic panels and wind generic turbines. Data such as electricity usage for the entire faculty, as well as the type of panel, turbine, and generator, was collected and studied. Several simulations were run in HOMER Pro software to determine the feasible model setup of the hybrid system. This project aims to produce a configuration that can meet the faculty's electricity usage; hence, technical and financial analyses were performed to determine the most optimal and best fit of the configuration that is consistent with the faculty's electrical consumption situation. Furthermore, this project aims to reduce the maximum demand faced by the faculty because this demand will incur additional costs for university management; thus, the analysis in terms of maximum demand obtained by the chosen modelling configuration is made to determine whether it can or cannot reduce the demand for the entire faculty.

# *ABSTRAK*

## *MODEL RANGKA KERJA MIKROGRID HIBRID DENGAN SISTEM PENYIMPANAN TENAGA (SPT) – MENGURANGKAN PERMINTAAN MAKSIMUM DI UNIVERSITI MALAYSIA SABAH*

Secara teorinya, sistem mikrogrid menjana tenaga elektrik dengan menggunakan sumber tenaga yang boleh diperbaharui seperti solar, angin dan biojisim melalui alat pengagihan sumber tenaga seperti panel fotovoltaik, turbin angin, dan pengegas biojisim dan membekalkannya kepada kumpulan pengguna tertentu untuk menampung beban keperluan seharian. Pada masa kini, Malaysia merupakan salah satu negara yang mempunyai sejumlah besar sumber tenaga yang boleh diperbaharui yang mana terhasil disebabkan oleh struktur geografi muka bumi di tanah Malaysia, memberikan Malaysia potensi yang baik untuk meletakkan sistem itu di negara ini bagi menggantikan sumber tenaga yang tidak boleh diperbaharui seperti bahan api dan arang batu, yang kini hampiri akhir hayat bagi penggunaan mereka. Hasil daripada pelaksanaan itu, negara dan rakyat akan mendapat faedah yang besar dan menguntungkan semua pihak. Model Rangka Kerja Mikrogrid Hibrid dengan Sistem Penyimpanan Tenaga (SPT) - Mengurangkan Permintaan Maksimum di Universiti Malaysia Sabah telah dijalankan di Fakulti Perubatan dan Sains Kesihatan (FPSK). Simulasi sistem hibrid yang menggunakan sumber suria melalui penggunaan panel fotovoltaik, dan seterusnya memasukkan sumber angin melalui penggunaan turbin generik angin untuk mengkaji prestasi system hibrid tersebut. Data seperti penggunaan elektrik untuk seluruh fakulti, serta jenis panel, turbin, dan penjana, telah dikumpul dan dikaji. Beberapa simulasi telah dijalankan dalam perisian HOMER Pro untuk menentukan persediaan model sistem hibrid yang boleh dilaksanakan dilokasi tersebut. Projek ini bertujuan untuk menghasilkan konfigurasi yang dapat memenuhi penggunaan elektrik di fakulti; oleh itu, analisis teknikal dan kewangan telah dilakukan untuk menentukan kesesuaian konfigurasi yang paling optimum dan

terbaik yang mampu mencapai tahap penggunaan elektrik terkini di fakulti tersebut. Tambahan pula, projek ini bertujuan untuk mengurangkan permintaan maksimum yang dihadapi oleh fakulti kerana permintaan maksimum ini akan mewujudkan kos tambahan yang perlu dibayar oleh pihak pengurusan universiti; oleh itu, analisis dari segi permintaan maksimum yang diperolehi oleh konfigurasi pemodelan yang dipilih, dibuat dan disemak untuk menentukan sama ada ia mampu atau tidak untuk mengurangkan permintaan maksimum bagi keseluruhan penggunaan elektrik do fakulti.

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| | |
|---|---|
| **AC** | Actual Current |
| **AH** | Ampere Hour |
| **BESS** | Batteries Energy Storage System |
| **CO2** | Carbon Dioxide |
| **COE** | Cost of Energy |
| **DC** | Direct Current |
| **DER** | Distribution Energy Resource |
| **EIS** | Energy Interconnection System |
| **ETIME** | Estimation Time |
| **EPA** | Environment Protection Agency |
| **ESS** | Energy Storage System |
| **EV** | Electric Vehicle |
| **FIT** | Feed Tariff |
| **FPSK** | Faculty of Medicine and Health Science |
| **FYP** | Final Year Project |
| **HESS** | Hybrid Energy Storage System |
| **HOMER** | Hybrid Optimization Multiple Energy Resource |
| **kWh** | Kilo-watt hour |
| **LI-Ion** | Lithium Ion |
| **LSS** | Large Scale Solar |
| **MD** | Maximum Demand |

| | |
|---|---|
| **MTs** | Micro-turbines |
| **NPC** | Net Present Cost |
| **O&M** | Operation and Management |
| **Pdem+** | Power Demand |
| **PCMs** | Phase Change Materials |
| **PECs** | Power Networks |
| **POWER** | Prediction of Worldwide Energy Resources |
| **PV** | Photovoltaics |
| **RE** | Renewable Energy |
| **RERs** | Renewable Energy Resources |
| **RM** | Ringgit Malaysia |
| **RMS** | Root Mean Square |
| **SESB** | Sabah Electricity Sdn. Bhd |
| **STC** | Standard Test Condition |
| **STR** | Sunday Tariff Rider Scheme |
| **TNB** | Tenaga Nasional Berhad |
| **UKM** | Universiti Kebangsaan Malaysia |
| **UMS** | Universiti Malaysia Sabah |
| **U.S.** | United State |
| **WTG** | Wind Turbine Generator |
| **WTs** | Wind Turbines |
| **WGS** | Wind Generator System |

# CHAPTER 1

# INTRODUCTION

## 1.1 Chapter Overview

This chapter provides an overview of the entire project. It also contains information about the project's background, the problem statement, project objectives, and scope of works, general methodology, research contribution, and research commercialization.

## 1.2 Introduction

Cambridge Dictionary described that energy can be defined as an ability to do work. Nowadays, in line with the development of civilization, people have been learned how to change the energy from one form to another to be used to do the work. There are many types of energy in this world such as mechanical energy, nuclear energy, kinetic energy, solar energy and many more. These energies can be used by a variety of equipment created using the latest technology. Furthermore, there are many types of energy source in this world. However, the two main source of energy is known as renewable energy and non-renewable energy. Renewable energy is defined as a source that can be renew, and can be used many times such as solar energy, wind energy, geothermal energy, hydropower energy and biomass energy. Non-renewable

energy is the energy that commonly used for work which comes from fossil fuels such as natural gas, coal and petroleum. Non-renewable energy known as an energy that cannot be renew and eventually can gone forever once it finishes. The application of renewable energy in economic system can conserve the ecosystem and preserve the environmental also can the pollution of the nature such as decompose the anthropogenic of the greenhouse effect (Amoatey *et al.,* 2022).

In the term of energy saving and conservation of nature and environment protection, the traditionally used of fossil fuel is not in the higher chart in demand in power industries. In recent years, the study related to the distributed energy resources (DERs) keep dragging the attention of the researcher and scientist to develop more technologies. Distributed energy resources (DERs) units may include several devices such photovoltaic (PV) panel, micro-turbines (MTs), energy storage systems (ESSs), wind turbines (WTs) and etc. Additionally, PV and WT are commonly used for the connection of the utility grid and always face the difficulty during the operation in the term of intermittent and variable outputs of the system (Liu *et al.,* 2016).

Microgrids are small-scale generation and distribution systems that include distributed energy resources (DER) units, energy storage systems, energy conversion devices, monitoring and protection equipment, and loads. This system is self-contained and capable of high adaptability, operation efficiency, self-control, self-protection, and self-management (Jiayi et *al.,* 2008). This idea (microgrid) was created with the intention of realizing the flexible and efficient deployment of dispersed energy resources (DERs). There are three common type of the microgrid which are AC microgrid, DC microgrid and AC/DC microgrid (Ahmed *et al.,* 2020).

A microgrid is a local energy production and transmission system. thus, microgrid are called a decentralized grid system where energy is produced locally and transmitted locally to its users in a specific area. Whereby a central power grid system produces energy and pushes it through long transmission cables around the nation. Transmission through this national power grid system is inefficient in a way where eight to fifteen percentage of energy will be lost in transmission. Moreover, a microgrid system overcome this inefficiency by producing electricity close to its end-

user like a solar panel on the roof top of its user. Through this method, a minimal amount of energy is lost in the transmission process.

In advance, microgrid consists of three-type of operation mode, known as islanded mode, grid-connected mode and transition mode (Jiayi *et al.,* 2008). A typical hybrid microgrid is purpose under the grid-connection mode as the application of this system is still under study and currently applied in a certain place. In Sabah, microgrid system have been currently applied at the local place to supply electricity. However, the existing microgrid system used is not a hybrid microgrid but it is a DC microgrid of photovoltaic (PV) system where they used the DC-based for the system, connected to the battery as the energy storage system.

Moreover, in recent year, a new developed software that have been introduced by United State (U.S) to determining the application of the microgrid with an easier way, called Hybrid Optimization Multiple Energy Resource (HOMER). Homer is a software program that is widely used to develop and evaluate various aspects of a system in terms of technical and financial aspects depending on the system's structure and control. The National Renewable Energy Laboratory in the United State created this application in 1993 (Kassam -Field & Manager, n.d.). Generally, this software provides the features to defining the site local for the system to be place and run an experiment on that place to determine whether it is suitable or not to build up a station for the system at that place. By using this software application, it can help many government organizations to analyze the related issue before they proceed to build or improving the further system without any cost provided.

## 1.3 Problem Statement

Renewable energy consists of many functions when combined with the latest technology in this era until it can even influence the demand of fossil fuel as the primary source before, to be the replacement for economic well-being. The role of distributed energy resources such as wind turbines, solar photovoltaic panel,

batteries, and etc. are created to be use with the renewable energy in a system for distribution purpose. Currently, the distribution energy is using large-scale transmission for the electrical distribution energy to the city and its surrounding.

Furthermore, the growing economy of Sabah has driven an increase in the electricity demand of the state. In 2018, the projected growth of peak demand was 0.7%. However, the actual demand supplied was far higher than the forecasted value. About 1235 MW of the dependable capacity of the electricity was supplied to the power grid with a 29% reserve margin. Between the year of 2030 and 2037, it is projected that the peak demand of Sabah will increase by 3.0% (Suruhanjaya tenaga). The demand, especially in the east coast region, is far more than what the power plants present on the east coast can generate. To balance this shortage, a maximum of 224 MW of electricity was supplied to the east coast from the powerplants in the west coast through the grid. With load demand increasing steadily, Sabah needs to produce more electricity to cater to its people's requirement.

Eventually, to achieve the balance in energy production and distribution throughout Sabah, there are several steps that can be considered by the authorities. An implementation of a microgrid in the region that require electricity generation can be one of the steps in the same time to save a vast portion of large number of expenditures

One faculty established in Universiti Malaysia Sabah is the Faculty of Medicine and Health Science (UMS). This faculty is also connected to the university's newly constructed hospital. Furthermore, during the five (5) years of education, medical students frequently have a full schedule of academic activities. The frequent uses of the room and electrical and electronics in the faculty continuously for clinical exams, anatomy lessons, and other classes and also usage for the university hospital, causing the increasing amount of load demand by the faculty, hence in the same time increase the electricity bills. Hence, in order to reduce the maximum demand causing by the increasing of the electrical usage by the faculty, implementation a microgrid at the faculty can be applied which can help the university to reduce the electricity bills charges by the electricity company.

## 1.4 Research Objectives

This research aims to create a model of framework for Microgrid Hybrid with Energy Storage System (ESS)- reduce maximum demand in Universiti Malaysia Sabah. The aims will be achieved through the following determination:

i. To identify the electrical usage pattern at Faculty of Medicine and Health Science in Universiti Malaysia Sabah (UMS)
ii. To identify the best architecture structure of the hybrid microgrid system in Universiti Malaysia Sabah (UMS)
iii. To determine the reduce maximum demand occur by the system for Faculty of Medicine and Health Science (UMS)

## 1.5 Scope of Works

The specific scope has been considered for this project in order to successfully accomplished the objectives according to the required time. The planned scope of work is as follow:

### 1.5.1 Preliminary Literature Review

A review and study on the existing project about the microgrid hybrid with the energy storage integration system will be conducted before proceeding to the simulation phase. Literature reviews is made as to gain more knowledge of existing research related to the Microgrid Photovoltaic system. This information will be extracted from many sources such as ScienceDirect, Google Scholar in the term of books, local and international research article, e-Books, textbooks and lecture notes.

### 1.5.2 Data collection of maximum demand and the structural analyzing

Data collection is the first thing that needed in this project to analyze the load demand of electricity used in the faculty. Besides, analyzing the processes and structures of the existing systems to gain more knowledge for the developing modelling structure. The experiment is done on the structural system of the microgrid hybrid with the energy storage integration system to determine the desire features when the load is supply using HOMER application. The result of the experiment will be used for further inspection for data analysis of the system.

### 1.5.3 Conducting the Simulation

The purpose of conducting the simulation is to construct the framework configuration of the system using software and also determining the best configuration of the framework that has been optimized by the software to be applied at the study's location. By using this step, the best framework modelling of the system can be determined.

### 1.5.4 Analyzing the performance of the system

After the simulation conducted, the performance of the system is analyzed to determine whether it is suitable or not if the system is applied on the actual location for the university used based on the simulation result.