UNIVERSITI TEKNIKAL MALAYSIA MELAKA

OPTIMAL POWER FLOW STUDY OF A NETWORKED MICROGRID IN SARAWAK RURAL AREAS

This report is submitted in accordance with the requirement of the Technical University Malaysia Malacca (UTeM) for the Bachelor of Electrical Engineering Technology (Industrial Power)

By

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I hereby, declared this report entitled “Optimal Power Flow Study of a Networked Micro-grid in Sarawak Rural Areas” is the results of my own research and found that it has comply the partial fulfilment for awarding the degree of Bachelor Electrical Engineering Technology (Industrial Power).

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APPROVAL

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Date: 25 Februari 2021

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Co- Supervisor's Name: Encik Wan Mohd Faizal Bin Che Wan Mohd Zalani

Date: 25 February 2021

ABSTRAK

Projek ini akan memberi tumpuan kepada sistem aliran kuasa yang optimum iaitu grid mikro berangkaian di kawasan luar bandar Sarawak. Setiap sistem kuasa di grid utama dari sumber semula jadi generasi yang dihubungkan ke saluran penghantaran dan dihantar ke permintaan dikenakan kosnya untuk penggunaan elektrik. Komuniti kawasan luar bandar adalah tempat di mana terdapat masalah mengenai penggunaan elektrik kerana kekurangan akses jaringan berbanding dengan kawasan bandar. Objektif prinsip projek ini adalah untuk memperbaiki dan meminimumkan kos elektrik elektrik pengguna di luar bandar Sarawak dengan pilihan tambahan grid mikro tunggal atau berbilang disambungkan ke grid utama. Dalam projek ini, bekalan grid mikro disambungkan ke grid utama di kawasan yang dipilih dengan beberapa jenis sambungan. Perisian Power-World Simulator akan digunakan dalam projek ini untuk mensimulasikan dan menganalisis data kos efektif antara pelbagai grid mikro di kawasan luar bandar Sarawak. Pada akhir projek ini, kos efektif dalam jaringan mikro jaringan berdasarkan kaedah aliran daya optimum akan dianalisis. Hasil simulasi termasuk penjana bebas bekalan kuasa gabungan dan penjana mahal seperti sistem solar, penjana diesel, simpanan bateri sama ada dalam mod bersambung grid atau dalam mod pulau. Permintaan beban adalah gabungan dari grid mikro berjaringan sekitar 69 kampung. Grid utiliti dan juga penjana diesel akan menampung kos setiap jam apabila permintaan beban meningkat. Minimumkan kos berlaku dalam grid mikro rangkaian yang mengandungi penjana percuma dan juga penjana yang mahal apabila kaedah aliran daya optimum diterapkan di kawasan luar bandar masyarakat di Sarawak. Oleh itu, penjanaan tenaga kepada permintaan memerlukan bekalan kestabilan dan permintaan untuk memastikan kos sistem kuasa yang disambungkan akan memperoleh faedah yang baik kepada pengguna.

ABSTRACT

This project will focus on the optimal power flow system a networked micro-grid in Sarawak rural areas. Every power system in the main grid from generation natural sources connected to the transmission lines and delivered to the demands have their cost charged for the use of electricity. The rural areas community is the place where have a problem about the electricity consumption because there have lack grid access compared to the urban areas. The principle objective of this project is to improve and minimize the cost-effective of the user electricity Sarawak rural areas with added option of single or multiple micro-grid is connected to the main grid. In this project, the micro-grid supply is connected to the main grid in the chosen areas with several type of the connection. The Power-World Simulator software will be used in this project to simulate and analyse data of the cost-effective between multiple micro-grid in Sarawak rural areas. At the end of this project, the cost-effective in networked micro-grid based on optimal power flow method will be analysed. The simulation result including combination power supply free generator and costly generator such as solar system, diesel generator, battery storage either in grid connected mode or in island mode. The loads demand are combination of the networked micro-grid approximately for 69 villages. The utility grid and also diesel generator will be containing the hourly cost when the loads demand increase. The cost minimize happened in a networked micro-grid that contained free generator and also costly generator when the optimal power flow method being applied in community rural areas in Sarawak. Therefore, the power generation to the demands needs stability supply and demand to make sure the cost of the power system networked will obtain a good benefits to the user.

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SDG	-	Sustainable Development Goal
UN	-	United Stated
SARES	-	Sarawak Alternative Rural Scheme
MGs	-	Multiple Microgrids
PV	-	Photovoltaic
DC	-	Direct Current
AC	-	Alternative Current
MV	-	Medium Voltage
LV	-	Low Voltage
RES	-	Renewable Energy System
MGCC	-	Microgrid Control Centre
CCU	-	Control Centre Unit
RES	-	Rural Electrification Scheme
OPF	-	Optimal Power flow

CHAPTER 1

INTRODUCTION

1.1 Research Background

Affordable and clean energy is a one from seventeen of the agenda the Sustainable Development Goals (SDGs) adopted by United Nation Members in 2015. The biggest objective of this agenda is to protect the world and ensure all countries enjoy peace and prosperity by 2030. SDGs of affordable and clean energy are focused on the energy sector such as renewable energy and etc. (UN 2018) stated that from 2000 to 2016, the proportion of the global population with access to electricity increased from 78 per cent to 87 per cent, with the number of people living without access to electricity dipping to just about 1 million. If the current scale continue, there would still be 674 million people living without access to electricity in 2030 (UN 2018). In order to achieve agenda of 2030, the access of electricity need increased within rated 0.8 per year.

For example, Sarawak that is states located in island Borneo and the largest Malaysian state at 124449.5 squares kilometres (Malaysia, 2017). Sarawak had a population about 2 million peoples. Approximately, 52% are living in rural areas (Cencus, 2015). In rural areas, there have certain community having a problem due to lack of facility working environment. While energy markets around of the world is increase, the fuel cost is increase, there is another method to design the cost-effective energy generation systems with the networked micro-grid.

There are many ways to improve the problem of electricity consumption with the cost-effective in power system in rural areas. Installation of a stand-alone micro-grid can reduce the cost consumption but it has limited capacity and it will cause a trouble to the demand on loads variation. Due to this problem, there is another option with networked micro-grid connected to the main grid (autonomous mode) with several type connection. The multiple micro-grid connected to the main grid can reduce the consumptions of usage electricity.

Installations of a networked micro-grid to the utility grid in rural areas region is either one of the initiative to maintain the cost-effective in power system. Micro-grid is the interconnected networked that can supply and store energy when the general capacity exceeds local demands or local demands exceeds general capacity. The micro-grid can supply power to the main grid or can import power from the main grid because the power system need to be optimize of the cost operation to make sure it will cause a good benefits to the consumers. The optimal power flow is the best way to instantaneously operate a power system and it will minimize the operating cost. The networked micro-grid design with the optimal power flow method analyse also can balance the power system flow because it not only can minimize the cost-effective, but it also can minimize of active power losses and voltage deviation. (Purpose)

1.2 Problem Statement

In Sarawak rural areas, Alternative Rural Electrification (SARES) that provided another alternative strategy due to take significant amount of time to extend the grid lines to interior part. The project concentrates on installation of generation renewable energy likes community solar and micro-hydro (Status, 2017). Under the Sarawak Alternative Rural Electrification (SARES) programme, based on another researches Fauzi Shahab and Syed Mohamad (2017) clarified there is 323 villages behind this project where is 50 villages are completed installed in phase 1 of 2016 and the rest is under planned until 2020. With this project, 97% of the villages in rural areas has electricity coverage but there are some issues of this problem that need improvement in the future such as:

I. There is stand-alone micro-grid installation that only provided for one household which it has limited capacity (2kWh/per household per day) just only for basics used likes a LED lamp, TV audio, small rice cooker and etc.

II. Unbalance populations community in certain rural areas that power supply cannot be connected each other due to the micro-grid stand-alone installation.

1.3 Objectives

After several information and data in Sarawak rural areas electrical system are combined, a few objectives with this project must be accomplished which are:

I. To modelling grid-connected of a networked micro-grid which is suitable in Sebauh rural areas in Sarawak.

II. To simulate grid-connected of a networked micro-grid using software Power-World Simulation.

III. To analyse the cost-effective and power delivery sharing of a networked micro-grid electrical system in Sebauh rural areas in Sarawak using Optimal Power Flow methods.

1.4 Scope of Research

The scope of work for the project include in main areas. In order to ensure of this project achieve the pointed objectives. The three main scopes of this project must be done within area:

I. The suitable design of grid-connected multiple micro-grid electrification system selected area which is Sebauh rural regions has been choosen with the serial MGs with the single feeder of distributed generation.

II. The electrical power flow system come out by design of grid-connected multiple micro-grid in rural areas has been analysed using the Power-World Simulator.

III. Optimal power flow method has been used to analyse the cost-effective and power delivery sharing with multiple micro-grid in rural region. Analysis in this project focuses on two different mode operation of topologies. The first mode concentrated with the both of micro-grid in islanded and the second is the both of micro-grid is grid-connected either individually or through each other.

1.5 Thesis Organization

There are five chapters in this project that consist of introduction, literature review, methodology, result and conclusion as well recommendation. The first chapter of introduction will be cover of the short explanation overall of the project with the research background, problem statement, objectives and scope of research. The second chapter of literature review will be cover exactly of theoretical background of project. The related of research networked micro-grid in rural areas and cost-effective is stated in this chapter. The related research comes from the origin of the international research's sources. Most of research comes from the country of Malaysia and overseas. The third chapter of methodology are completely explain how to design a model of networked micro-grids, create a flow chart and what method are used from the beginning to end. All the results that will be analyse stated in next chapter. In this chapter, the result of cost-effective are showed. Lastly, the conclusion and recommendation of this project will be conclude in this last chapter.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Literature review is part of process where the data and information is collect related in the field study. Data and information can be collected from several medium likes a journal, online database, books and etc. Basically, this chapter have two main section. The first section fully focused on previous related study on this project within several case study. The second section focused on theory currently of the related projects.

2.2 Overview On Previous Research

2.2.1 Networked Microgrid as Cost Effective

The networked micro-grid concept with the integrating of distribution energy resources within the utility grid. This implementing of this thing must be giving on economic beneficial to the customers. This planning system will decrease a cost while ensuring energy sharing balance. A networked micro-grid cost usually contribute on many criteria such as location, energy prices, DER cost, cost of emission, amount of outage due to period supply power to the loads. For every strategy in order to balance and optimal the cost consumption in networked micro-grid, framework need to be consider carefully within this scope study. The design of micro-grid conceptual need to be consider in several important elements such as resources selection, resources sizing and resources dispatch. According to a research study by example for the resource selection usually include the generation, storage and controlled load. Capacity and energy is for the resource sizing. Economic dispatch is fully on resource dispatch. This elements design are focused on economic impact especially in minimize the cost or environmental. Economic system are also to design constraint that may be physical, preferential or regulatory. The overall of economic networked micro-grid depends on variety of design itself.

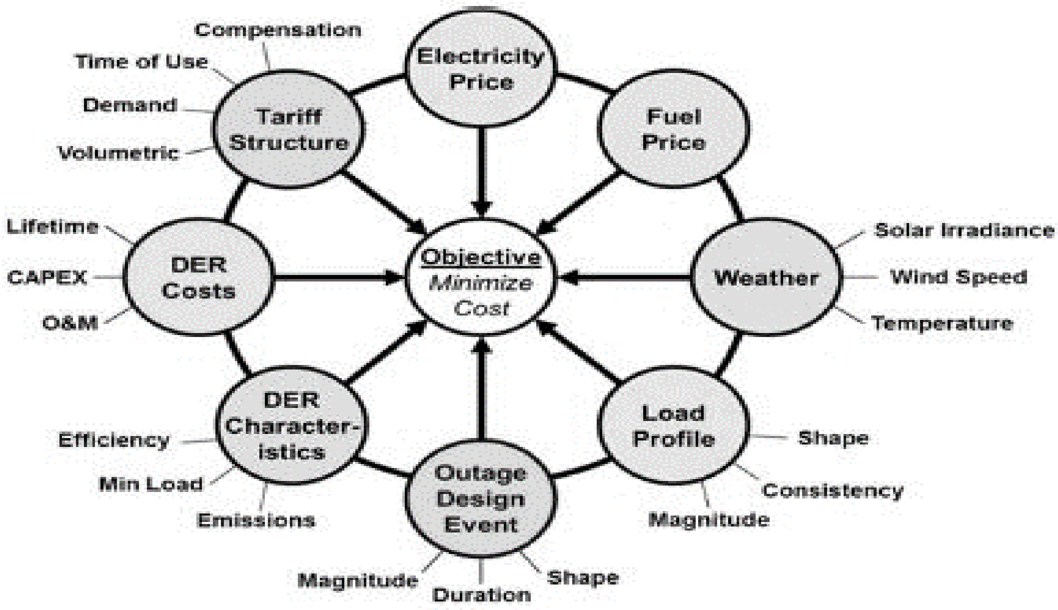

Figure 2.1: Factor that impact economic and design micro-grid

2.2.2 Study Case on Namibia Rural Areas

According to (Hamatwi et al. 2018) stated that Namibia is the one of the country that have a very high potential of renewable energy such as wind energy and solar energy due the landscape nearest coastal areas. Besides, Namibia is the place almost having a sun energy through the years. This is another reason that Namibia Country had a good solar energy generation. This research will be carried out and focusing about the cost-optimization of a networked micro-grid Solar PV, Wind energy and diesel generator with a backup battery bank for Oluundje village in Namibia rural areas. Namibia under the National Planning Commission with the Vision 2030 strategy include one of this project with are produced natural resources sector. The example of centralised solar energy in Namibia rural areas in expected figure 2.2 below.

Figure 2.2.: The micro-grid consist of solar energy in Namibia rural areas (Solar et al. 2020)

2.2.2.1 Demand Analysis and Assessment in Oluundje Namibia Rural Areas

In this case study in the total of load demand and total energy consumption will be obtained. For this load demand, the total number of households and shops 80 and 15 will be estimated due the survey through interviews and questionnaires in Namibia rural areas. The survey on Oluundje Villages on identifying current sources energy for 80 households and shops. Most of them are still depending on candles and kerosene lamps for lighting purpose that most possible cause the fires and loss valuable items. Some of them use the diesel generator for the big events like gathering or social events. The total load demand and the total of power consumption of 80 households and 15 shops had been analyse consist of basic load demand needed in daily lives such as LED light, TV, Phone charging, radio and etc. The total of load demand and total power consumption for 80 households are 84,600W and 54,3520Wh. For 15 shops, the data analyse with the total load demand and total power consumption are 4,650W and 72,735Wh. After getting the total of load and consumption, the average of total households and shops will be determined using the mathematically formula. The average of the total load demand and total power consumption will showed in table 2.1 and 2.2 below.