UNIVERSITI TEKNIKAL MALAYSIA MELAKA

POWER FLOW ANALYSIS OF A NETWORKED MICROGRID IN ISLANDED MODE

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electrical Engineering Technology (Industrial Power) with Honours.

by

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APPROVAL

This report is submitted to the Faculty of Mechanical and Manufacturing Engineering Technology of Universiti Teknikal Malaysia Melaka (UTeM) as a partial fulfilment of the requirements for the degree of Bachelor of Electrical Engineering Technology (Industrial Power) with Honours. The member of the supervisory is as follow:

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ABSTRAK

Pada masa ini, banyak mikrogrid telah digunakan untuk membekalkan elektrik. Sebilangan besar mikrogrid yang dipasang berkaitan dengan mod pulau dan terhubung ke grid untuk menyokong komuniti. Sebilangan besar mikrogrid Asia digunakan dari jarak jauh untuk menghasilkan tenaga boleh diperbaharui yang tersedia untuk sistem kuasa yang boleh dipercayai dan Malaysia adalah salah satu negara Asia yang menerapkan sistem mikrogrid. Sarawak Alternatives Rural Electrification Scheme (SARES) adalah program di bawah Sarawak Energy yang bertujuan untuk menyediakan bekalan elektrik 24 jam kepada masyarakat luar bandar di mana ia tidak dapat dilaksanakan untuk disambungkan ke grid. Rangkaian mikrogrid baru-baru ini menjadi inovasi seni bina grid yang popular dan dapat menawarkan pelbagai manfaat kepada rangkaian pengedaran tempatan dan pengguna, di antaranya pengoptimuman ekonomi, kestabilan, ketahanan, dan pemulihan. Oleh itu, tujuan penyelidikan ini adalah untuk menganalisis aliran daya rangkaian mikrogrid dalam mod pulau dalam aspek profil voltan, jumlah aliran daya , dan kehilangan kuasa. Objektif projek ini adalah untuk memodelkan ramgkaian mikrogrid menggunakan Power World Simulator di Song dan Nanga Merit yang terdiri daripada Solar PV, penyimpanan bateri, dan penjana diesel, untuk mensimulasikan rangkaian mikrogrid dalam mod pulau berdasarkan empat kajian kes dan menganalisis aliran daya rangkaian mikrogrid semasa gangguan / pemadaman elektrik di grid utama. Simulasi dan analisis mengenai jumlah aliran daya, kehilangan

kuasa, profil voltan sistem kuasa mikro jaringan untuk kawasan desa Song dan Nanga Merit telah dilakukan dalam penyelidikan projek ini. Hasil kajian menunjukkan bahawa sistem rangkaian mikrogrid mempunyai kebolehpercayaan yang baik untuk menampung keperluan elektrik di kawasan luar bandar di Sarawak. Oleh itu, projek ini berpotensi tinggi untuk menyumbang kepada mereka yang terlibat dalam peningkatan sistem elektrik di kawasan luar bandar sama ada di semenanjung atau Sabah dan Sarawak.

ABSTRACT

Nowadays, a lot of microgrids have already been deployed to provide electricity. Most of the microgrids installed are related to islanded and grid-connected mode to support communities. Most Asian microgrids are used remotely to generate any renewable energy available for a reliable power system and Malaysia is one of the Asian countries that implement microgrids system. Sarawak Alternatives Rural Electrification Schemes (SARES) is a programme under Sarawak Energy that aims to provide 24-hour electricity supply to rural communities where it is not feasible for connection to the grid. Networked micro-grids have recently become a popular grid architecture innovation and can offer a range of benefits to local distribution networks and consumers, among which economic optimisation, stability, durability, and recovery. Therefore, the purpose of this research is to analyse the power flow of the networked microgrid in islanded mode in term of voltage profile, total power flow, and power losses. The objectives of this project are to model networked microgrid using Power World Simulator at Song and Nanga Merit consisting of Solar PV, battery storage, and diesel generator, to simulate the networked microgrid in islanded mode based on four case studies and analyse the power flow of the networked microgrid during interruption/power outage at the main grid. Simulation and analysis on the total power flow, power losses, voltage profile of the networked microgrid power system for Song and Nanga Merit rural region has been done in this project research. The results showed that the networked microgrid systems have the good reliability to

accommodate the electricity need of the rural region in Sarawak. Therefore, this project has high potential to contribute with those who involved in the upgrading of the electrical system in rural areas either in peninsula or Sabah and Sarawak.

DEDICATION

I dedicate my dissertation work to my beloved family especially for my lovely parents with deepest gratitude for giving me all inspiration and support I need because without their encouragement I was not able to complete this final year project and their prayers have always been a source of strength for me.

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LIST OF SYMBOLS

hr	-	hours
kV	-	kilovolt
kW	-	kilowatts
kWh	-	kilowatts hour
L	-	Load
MW	-	Megawatts
MWh	-	Megawatts hour
MWp	-	Megawatts peak
P	-	Active Power
pu	-	Per unit
Q	-	Reactive Power
R	-	Resistance
V	-	Voltage
X	-	Reactance
δ	-	degree

LIST OF ABBREVIATIONS

AC	Alternate Current
AI	Artificial Intelligence
CCHP	Combine Cooling Heat and Power
CERTS	Consortium for Electric Reliability Technology Situations
CHP	Combine Heat Power
COE	Cost of Energy
DC	Direct Current
DG	Distributed Generation
DMS	Distribution Management System
EHV	Extra High Voltage
ES	Energy Storage
ESS	Energy Storage System
IoT	Internet of Things
O&M	Operation and Maintenance
PCC	Point of Common Coupling
PV	Photovoltaic
RES	Renewable Energy Sources
RPSS	Rural Power Supply Scheme
SARES	Sarawak Alternative Rural Electrification Schemes
SDG	Sustainable Development Goal
SEB	Sarawak Energy Berhad

CHAPTER 1

INTRODUCTION

1.1 Research Background

A lot of microgrids have already been deployed to provide electricity or have been installed in laboratories worldwide to carry out work on the function of microgrids in depth. Most of the microgrids installed are related to islanded and grid-connected mode to support communities (Hossain et al., 2014). In North America region, the Consortium for Electric Reliability Technology Situations (CERTS) is the most renowned of U.S. microgrids. The project was planned to make it simpler for the micro-generators to work together to power the main grid. The European Union (EU) also implemented the system microgrid to overcome the global warming and climate change. Apart from North America and European country, microgrids system also been implemented in Asian country. Most Asian microgrids are used remotely in order to generate any renewable energy available for a reliable power system.

As mention earlier, microgrid can operate in two mode which is grid-connected or islanded mode. The grid connected mode is further divided into power matching activity and power mismatched activity by power exchange. In grid mode the microgrid is attached to the main grid and shares the electricity. When the microgrid connected to the main grid it will facilitate stable operation if the main grid acts as a main source of the microgrid (Fusheng, Ruisheng and Fengquan, 2016).

Islanded mode means the microgrid is disconnected from the main grid distribution system by grid failure, with loads running independently in the microgrid. The electricity is generated by the microgrid itself in island mode. Generally, the electricity produced is small and insufficient to support the demand loads, so the loads must be prioritise based on their importance and ensure uninterrupted supply to important loads (Fusheng, Ruisheng and Fengquan, 2016).

Malaysia is also one of the Asian countries that implement microgrids system. Sarawak Alternatives Rural Electrification Schemes (SARES) is a programme under Sarawak Energy that aims to provide 24-hour electricity supply to remote/rural communities where it is not feasible for connection to the grid (Status, 2017). Sarawak Energy main target is to electrify 20, 000 more households by 2020. Rural coverage increases to 97% (state-wide 99%). By 2025, the target to electrify households is 100% (Ajan and Electrification, 2017).

Networked micro-grids have recently become a popular grid architecture innovation and can offer a range of benefits to local distribution networks and consumers, among which economic optimisation, stability, durability, and recovery. The interconnection of two or more microgrids with the ability to connect to the distribution network to share the power between microgrids and/or the distribution system at the point of common coupling (PCC) is the Networked Microgrid.(Wang, Member, Chen, et al., 2015). One of the alternative solutions to using distributed energy sources is by running microgrid clusters in the context of networked microgrids. Networked microgrids will share loads in both regular and emergency scenarios with optimum and efficiency.

1.2 Statement of the Purpose

The purpose of the research is to investigate the effect of fiber treatment on the mechanical properties such as tensile, flexural and impact properties and water absorption of kenaf/polyester composite.

1.3 Problem Statement

A study of power flow in a modern power system is an important analysis. Sarawak Alternatives Rural Electrification Schemes (SARES) had installed single microgrid at each rural/remote area in Kapit. For example, community solar had been installed individually at Song and Nanga Merit. The problem of single microgrid is it cannot share and support the energy for the load demand during power outage from the main grid. To overcome this problem the single microgrid will be connected to the nearest microgrid to form a networked microgrid. There are several problems or interruption when the natural disaster occurs such as flood at the main grid that is link/connected to the microgrid. For example, in Sarawak, the number of floods occur in the year of 2017 is around 60 and above which is the highest cases starting from the year of 2013 until 2017. So, when the natural disaster occurs at the main grid that is link or connected to the networked microgrid it will disconnected due to the power outage.

The reason of networked microgrid is to share the energy from the renewable resource such as solar if one of this area has surplus energy in case of interruption or power outage from the main grid. The power flow analysis will determine either the networked microgrid will support the microgrid that is disconnected from main grid. Apart from that, the power flow analysis of networked microgrid is very important for