UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DETERMINATION OF THE SUITABLE POWER DELIVERY METHOD TOWARDS COMPATIBLE LINE LOADABILITY IN MICROGRID USING POWERWORLD SOFTWARE.

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

by

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Electrical Engineering Technology (Industrial Power) with Honours. The member of the supervisory is as follow:

……

(Project Supervisor)

ABSTRAK

Sistem Microgid yang merupakan integrasi tenaga boleh diperbaharui (RE) sebagai penjanaan diedarkan (DG) ke dalam grid elektrik semakin meningkat dengan ketara disebabkan galakkan oleh dasar kerajaan. Dengan perkembangan Microgrid, syarikat utiliti harus menghantar kuasa yg cekap dari penjanaan kuasa kepada pengguna. Krisis kuasa adalah salah satu isu utama dan penghasilan kuasa haruslah cekap dan tidak berubah ubah. Jadi, objektif kajian ini adalah untuk memilih kaedah yang sesuai ke arah talian beban yang serasi dalam Microgrid. Microgrid mod operasi yang digunakan dalam projek ini ialah mod pulauan. Kaedah kuasa penghantaran telah dikenalpasti iaitu kaedah aliran kuasa, kaedah penghantaran yang ekonomi dan kaedah aliran kuasa optimum dalam Microgrid. Ketiga kaedah itu kemudiannya dianalisa dengan menggunakan keadaan pengurusan kuasa yang berbeza. Keadaan pengurusan kuasa yang terlibat dalam projek ini adalah kuasa semasa satu DG digunakan, jarak antara DG dengan beban dan berlainan jenis DG yang digunakan. Proses simulasi telah dijalankan untuk memilih kaedah yang sesuai untuk penghantaran kuasa ke arah talian beban yang serasi dalam Microgrid dengan menggunakan software PowerWorld.

ABSTRACT

Microgid system which is integration of RE resources as DG into electrical grid is increasing substantially due to encouraging government policy. With the development of Microgrid, it is necessary for utility company to deliver the efficient power from power generation to consumer. Power crisis is one of the major issues and the production of power should be efficient and reliable in power dispatch. So, the objective of this project is to select the suitable power dispatch method towards compatible line loadability in Microgrid. The operating mode of Microgrid used in this project is islanding mode. The method of power dispatch which is power flow, economic dispatch and optimal power flow was identified in Microgrid. Each of the three method was then analyze by using the different condition of power management The condition of power management that involve in this project are power during one DG is used, distance between DG and load and different type of DG. Simulation was conducted to choose the suitable method of power dispatch towards compatible line loadability in Microgrid by using PowerWorld software.

DEDICATION

I dedicate my dissertation work to my beloved family especially for my lovely parents with deepest gratitude 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.

ACKNOWLEDGEMENT

This final year project is research conducted on finding the suitable power dispatch method towards compatible line loadability in Microgrid. At the time preparing this paper, I am gone through IEEE publication paper, industrial and business website, TNB guideline, US Energy Information (EIA) and also Sustainable Energy Development Authority Malaysia (SEDA).which help me to get a lot of information with the new topics. It was almost five month I spend the time to complete this final year project. When I was started, I had to face some difficulties and a lot of challenges. As it turned out, I sure needed help and very grateful for the support that I had receive. First, I wish to express my sincere appreciation to my supervisor Mr. Adlan bin Ali for his guidance in carrying out this project. It was a great honour for me to pursue my research under his supervision. I sincerely thank to my family and members of University Teknikal Malaysia Melaka who rendered their help during the period of my project. I also thank the universities for providing me the opportunity to embark on this project.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

DG	-	Distributed Generator
RES	-	Renewable Energy Source
MT	-	Micro Turbine
DE	-	Diesel Engine
PV	-	Photovoltaic
WT	-	Wind Turbine
FC	-	Fuel Cell
CHP	-	Combined Heat Power
PM	-	Power Management
PCC	-	Point Common Coupling
HCPV	-	High Concentration Photovoltaic
VSC	-	Voltage Source Converter
PF	-	Power Flow
ED	-	Economic Dispatch
OPF	-	Optimal Power Flow
EES	-	Electrical Energy Storage
DSM	-	Demand Side Management
SSM	-	Supply Side Management
APAC	-	Asia-Pasific
FIT	-	Feed-in-Tariff
TNB	-	Tenaga Nasional Berhad
SESB	-	Sabah Electricity Sdn. Bhd.
SEB	-	Sarawak Energy Berhad
DSTATCOM	-	Distributed Static Compensator
MPQC	-	Microgrid Power Quality Conditioner
GA	-	Genetic Algorithm
PG	-	Programmable Generator
NPG	-	Nonprogrammable Generator
O&M	-	Operational and Maintenance

CHAPTER 1
INTRODUCTION

1.0 Project Overview

A Micro-grid is defined as a group of Distributed Generation (DG), energy storage devices and loads, serviced by a distribution system [1]-[3]. The capacities or sizes of Microgrid vary from few kilowatts up to Megawatts [1]-[4]. For the conventional DG usually used fuel and diesel as microsource. Nowadays, most DG used Renewable Energy which is photovoltaic (PV) high concentration photovoltaic (HCPV), wind turbine (WT), and hydro plants. For energy storage, batteries, super capacitors, and flywheels was used [1]-[4]. These types of sources and energy storage devices produce voltage in ac or dc with various amplitudes and frequencies. In order to convert source, power converter is needed for example VSC (voltage Source Converter) [3][15]. The Micro-grid have three operating mode. First is the grid-connected mode (non autonomous) that operate in parallel to the grid. Second is the islanded mode (autonomous) that operate without utility grid and providing uninterruptible power supply service. Third is ride- through between two modes [1]-[8]. The development of Micro-grid is based on the encouraging government policy and it was an attractive plans [4][5]. Malaysia is one of the country that develop a Microgrid system to deliver power at local demand especially for rural area [4][5][11]. Rural area at Peninsular Malaysia, (Perak) Sabah and Sarawak have their own Microgrid to supply power to local demand with the maximum capacity usually not more than 50 MW [11]. In recent years, with the development of Microgrid the power stability becomes a major issue and have to be solve properly [11]-[15]. In order to deliver a suitable power to consumer the method of power dispatch have to be identified.

In this project, three method has been approached which is power flow (PF), economic dispatch (ED) and optimal power flow (OPF). Power flow describe that a steady-state analysis whose target is to determine the voltages, currents, and real and reactive power

flows in a system under a load conditions.[16][17] Power is deliver by considering losses in line and maximizing the power generation output. The cost of operation and generation was neglected.[16]-[20]

For the Economic Dispatch is to determine the cost of power generating of DG and it will minimize that overall cost of fuel, PV and WT needed to serve the system load [18][19]. This method was also applies to economic scheduling of plants output without considering transmission losses in line. Then the output of each of the plant is have to achieve the total cost of generating in minimum [18][20].

For the optimal power flow is method actually combine the power flow and economic dispatch method [21]. The OPF problem aims to achieve an optimal solution of a specific power system objective such as fuel, PV and WT generation cost while maximizing the power transfer to consumer [21]-[23]. OPF also will minimize the total of active power losses and minimize the operating cost when has losses in line [21][23].

There are many such thing that have to be considered in order to evaluate the suitable method of power dispatch in Micro-grid. A condition of Power Management (PM) is required for sound operation of a Micro grid [24]. The PM used in this project is condition of power when one DG is used in certain value of load [25]. For the second PM is the distance between the DG with load because long, medium or short distance of transmission line will affect the power quality to consumer [10][26]. For the last PM is type of different DG used in Microgrid system. The different type of DG draw a different power output level for example is fuel type that draw a high power output as compared to PV and WT [27][28]. By considering the PM in Microgrid, the suitable method for power dispatch can easily be selected towards compatible line loadability.

1.1 Problem Statement

The existing government policy today is moving to development of Microgrid with some RE as DG source. The use of DG in Microgrid give the impact on power quality and stability during the process of power dispatch. The performance of power during islanding

mode cause a changes on power dispatch quality to consumer [11]-[15]. This is because, during islanding modes, the DG will continue to supply power to local demand and leads to issues of power quality.

1.2 Project Objectives

1. Identify the method of power dispatch used in Microgrid.
2. Analyse the method of power dispatch by using the different Power Management on Microgrid through PowerWorld software.
3. Evaluate the suitable method of power dispatch towards compatible line loadability on Microgrid.

1.3 Project Scopes

This project focuses on the finding the suitable power delivery method towards compatible line loadability The scope of this project is finding the suitable power delivery method on Microgrid starting from power generation to consumer. The mode of Microgrid used in this project is islanding mode.

CHAPTER 2
LITERATURE REVIEW

2.1 Microgrid Definition

Refer to Mohammed Yekini Suberu, Nouruddeen Bashir, Ogundola Matthew Adefemi and Umar Usman on 2013, authors state that with the development of DG nowadays based on renewable energy sources (RES) was increase the development of Microgrid in certain area. Microgrid can be define as combination, group or cluster of electricity generation, system electrical energy storage (EES) and load. The meaning of DG is a generation of electricity that supply a power close to power consumer via some distribution network. With the development of Microgrid, it give a lot of benefit especially for rural area. In a modern power sector, to supply the reliable power to consumer, demand side management (DSM) and supply side management (SSM) play an important role to supply an efficient power in low level of losses. In order to supply a reliable power to consumer, the implementation of DG have to be develop in distribution area. Figure 2.1 shows a typical of Microgrid with some RES .

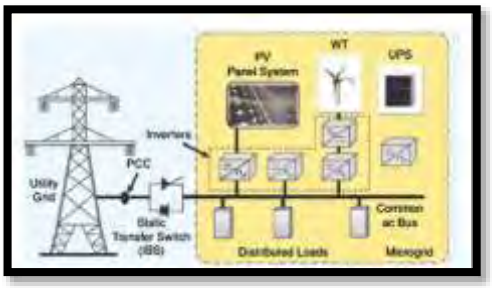


Figure 2.1: Typical of Microgrid with some RES .

Another meaning or definition of Microgrid by n Ping*, ZHOU Xiao Xin and wu Shou Yuan on 2011, Microgrid can be conclude as implementation of microsource and ESS complete with power electronic equipment to be installed in the system. It will provide

electricity with reliable power to consumer. The implementation of DG as Microgrid system will help to reduce losses and increase the system efficiency to deliver power as compared to main grid.

Besides that, based on Ritwik Majumder, Member IEEE 2013 state that Microgrid have three types area which is remote microgrid, facility grid and utility grid. A remote microgrid use decentralized control method as operation system and it never have connection between utility. For the power that use is maximum and limited for the customers. It power quality demand is high quality as compared to a facility Microgrid. The next type of Microgrid is Facility Microgrid. It connection is normally connected to host utility and usually a single business-entity Microgrid. For the last type of Microgrid is utility Microgrid. The utility Microgrid have the connection to the utility at one point (it could be also multiple connection points for grid connected reliability) of point common coupling (PCC). The PCC act as circuit breaker to connect and disconnect from the main grid. The area of utility grid is large (compared with facility Microgrid) and contains a lot of different types DG and load.

2.1.1 Development of Microgrid

Based on the Korea Smart Grid Association in 2015 they state that the development of Microgrid of 10 countries in Asia-Pacific (APAC) is expected to grow by four times in 2023 by remote Microgrid. Figure 2.2 below shows a project of Microgrid of 10 countries in APAC.

Based on Hossein Lotfi and Amin Khodaei, the capacity of Microgrid in United State, funded by many organization such as power industry, government labs and others investors. In 2015, it can seen that the total global of installed Microgird is 12,031 MW from 4,393 in 2014. The big difference between the value show can be conclude that the development of Microgrid is increase.

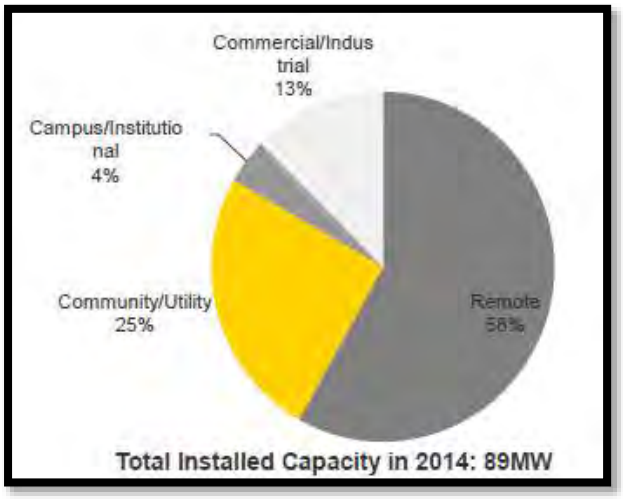


Figure 2.2 : Microgrid Project Type of top 10 countries in APAC

India, Philippines, and Malaysia are selected as target among 10 countries of this project considering its potential for remote Microgrid because high demand of remote island and have a great potential. India have a largest Microgrid market in APAC which is 22.9 MW followed by Philippines and Malaysia which is 12.6 MW and 11.6 MW respectively. For Malaysia renewable energy is targeted to be installed in capacity among 3GW by 2020, Feed-in-Tariff (FIT) . Three state-owned utilities, TNB, SESB and SEB, provide electricity to Peninsular Malaysia (Major projects: Kemar -850kW, Perhentian -300kW), Sabah (Major projects: Banggi-200kW, Kinabatangan-1.5MW) , Sarawak (Major projects: Mudung Abun-20kW, Long Lawen-15kW) and majority of Microgrid projects are located in Sabah and Sarawak because Microgrid have big potential towards rural area. The rural and remote areas in developing countries are the major victims to get the electricity. Selection criteria to develop remote Microgrid is economic analysis, distance from grid, load growth and capacity of RES.

Another development of Microgrid in Malaysia is written in Workshop Report Kuching, Malaysia 2015. It state that the development of Microgrid moretowards rural area which is area of less than 10,000 residents outside of local authority zones. In Table 2.1 shows the experience of TNB involvement in rural electrification.

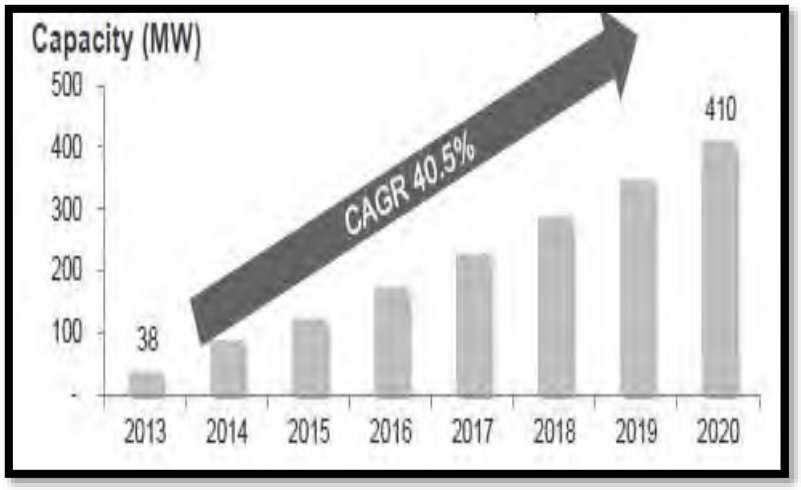
Project	Track Record	Total (Capacity)
Grid Connection	Since 1975	>1500 projects
Mini Hydro	Since 1980	35 project (18 MW)
Hybrid Wind/Diesel	Since 1995	1 project (150 kW - Wind) & (150 kW - Genset)
Solar Hybrid System - Solar/Diesel	Since 2001	70 projects (1.806 MW)
Biomass	Since 2004	1 project (2 MW)
Solar Hybrid System - Solar/Wind	Since 2007	1 project (2 x 100 kW - Wind) (100 kW - Solar) & (500 kW - Genset)

Table 2.1 : The experience of TNB involvement in rural electrification (adapted from http://www.slideshare.net/e4sv/kuching-112-tnb-micro-grid-renewable-for-rural-electrification-mohd-azhar-abdul-rahman)

For example project in Kemar Grik, Perak is equipped with solar generating capacity of 850 kW in 2012. In 2004 until 2008, solar hybrid was build at station at Kg. Pak Kaleh, in P. Pemanggil, Kg. Teluk Berhala in P. aur, Pulau Perhentian, Kg. Sinulihan in Kiulu, Pulau Banggi in Kudat Sabah at Pulau Perehentian.

2.1.2 Size of Microgrid

Based on the business paper by Korea Smart Grid Association on October 2015 shows a capacity of Microgrid in India, Philippines, and Malaysia are selected as target countries of the development Microgrid project considering its potential for remote Microgrid. By refer to Figure 2.3 it state that the capacity of Microgrid from 2013 until 2020 was estimate 38 MW up to 410 MW. The bigger in capacity causes by the development of technology that more intelligent.



Figures 2.3 : The capacity of Microgrid from 2013 until 2020 at APAC

2.1.3 Common type of Distributed Generation

For the common type of DG by Hartono RS, Budiyanto and Rudy Setiabudy in 2013, both author state that Microgrid is small-scale independent source that are placed near consumers, which is also compatibility to different condition of environment. Generally, DG type can be divided into two categories conventional type for example micro-turbine (MT), diesel engine (DE) and renewable type for example wind turbine (WT), photovoltaic (PV) microhydro turbine. Energy storage devices which can be battery, supercapacitor, superconducting energy storage and flywheel. DG can not only supply electric energy, but also can supply combined heat and power (CHP). Microgrid is a small power grid, which is composed by various DGs, energy storage, loads, monitoring system and protection system. Microgrid behaves as a dispatchable load to large power system, and it behaves as a independence power source to consumers.

Another explanation by Ping*, ZHOU Xiao Xin, wu Shou Yuan on 2011, author state that Microgrid contain microsource from renewable energy which is wind , solar , biomass, ocean and geothermal energy. The huge number of RES contained in Microgrid are very helpful for reducing dependence on conventional type of DG such as fuel and diesel. The use of RES will protect the ecological environment and reduce the producing of harmful carbon.

In Microgrid system, there are many combination of DG or in other name is DER. It was various DER technology such as dipatchable thermal generation, common renewable energy which is solar generation and but not least is DES. This is due to paper by Hossein Lotfi and Amin Khodaei on paper 2016.

2.1.4 Operating mode

Due to paper by C.E Jones and C. FItzer (undated) , both author explain that Microgrid can operate in connected to the main grid or islanded from utility grid. Grid operating mode means that Microgrid system supply the load with help by utility grid. But for the islanded operating mode, Microgrid will be separated from the utility grid if any fault develop on main grid. Therefore, the islanding mode is needed because it produce non interrupt supply. The Microgrid also can operate between two modes.

Another paper by Frank van Over, D Pudjianto and G Strbac in 2005, three of them state that Microgrid have two operating mode which is grid connected mode and islanding mode. In grid connected mode, microgrid operate with utility grid and islanding operating mode is when Microgrid operate independently without utility grid.

Besides that, based on Ritwik Majumder, Member, IEEE 2013, author state the common coupling (PCC) is point of a utility Microgrid connected to utility (there could be also multiple connection points for grid connected reliability). The function of that point is to connect or disconnect the Microgrid from utility. When the PCC circuit breaker is open, the Microgrid will change mode from the grid connected mode to islanding mode. Figure 2.4 shows the point of common coupling (PCC).

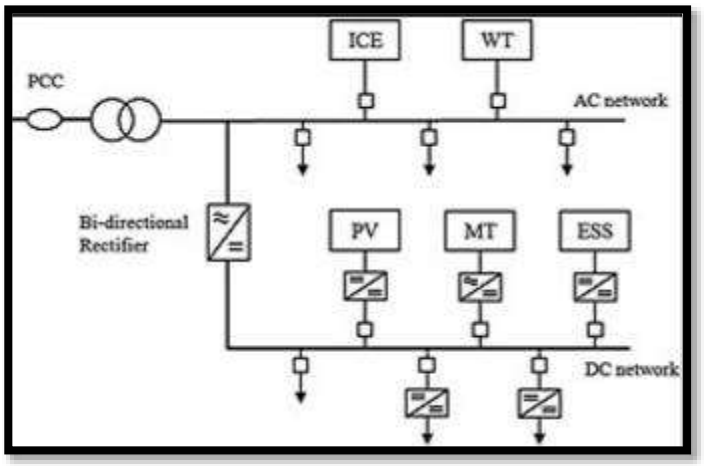


Figure 2.4 : PCC circuit breaker connected in Microgrid (adapted from https://www.researchgate.net/figure/264224520_fig7_Figure-1-Hybrid-AC-DC-microgrid-AC-alternating-current-DC-direct-current-ICE)

Based A. Solanki, A. Nasiri, V. Bhavaraju, *T.* Abdullah and D. Yu, Member, IEEE 2013, all the author states that Microgrid is a group of DGs that used renewables energy and local loads connected to the utility grid. Microgrid can operate in parallel to the grid or as an island. The most attractive feature of a microgrid is the ability to separate and isolate itself from the utility's distribution system in unintentionally during problem for example during faults, voltage collapses, black-outs. It may also intentionally disconnect during grid maintenance and also when the quality of power from the grid falls below certain standards. So the PCC circuit breaker will open and Microgrid start to operate itself without utility grid.

Based on the paper by Aida Khavatian, Masoud Barati and Gino J Lim, they state that Microgrid is a one team of loads and DER that act as controller with respect to national grid. They also state Microgrid system has an ability operating in parallel with national grid in islanded mode to increase the system reliability of the grid.

Last paper by Aida Khavatian, Masoud Barati and Gino J Lim, they mentioned that the PCC is used when having an interruption in main grid, the Microgrid is have ability to island from the main grid by open the switch at PCC.