UNIVERSITI TEKNIKAL MALAYSIA MELAKA

ASSESSMENT ON ISLANDING MODE PERFORMANCE TOWARDS BETTER POWER UTILIZATION IN SMART GRID USING POWERWORLD SOFTWARE

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Engineering Technology (Electrical) (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:

………………………………

(EN. ADLAN BIN ALI)

ABSTRAK

Pada masa ini, elektrik grid menjadi salah satu isu utama di banyak negara. Ini kerana, apabila tiada bekalan kuasa di sesetengah kawasan, kawasan ini akan mengambil masa untuk kembali bekalan kuasa yang disebabkan oleh penyelenggaraan pembaikan sedang dijalankan. Oleh itu, grid pintar telah ditubuhkan. Grid pintar memenuhi semua keperluan untuk membuat rangkaian elektrik menjadi lebih bijak. Tetapi terdapat beberapa cabaran apabila pelaksanaan grid pintar ini. Kertas kerja ini juga dilengkapi dengan kelebihan grid pintar dan perbandingan antara kedua-dua grid iaitu grid pintar dan elektrik grid. Apabila beban dan sistem penjanaan diedarkan dimana elektrik diasingkan daripada baki sistem utiliti dan ia akan mengesan pulauan mod dalam grid pintar. Terdapat 2 jenis pulauan yang merupakan pulau sengaja dan pulau yang tidak disengajakan. Ciri utama dari penjanaan diedarkan adalah ia boleh membekalkan kuasa semasa pulauan mod. Pelaksanaan pulau sengaja penjanaan diedarkan meningkatkan kesinambungan bekalan dan kebolehpercayaan sistem kuasa. Dalam pulaun mod prestasi kuasa akan berlaku seperti kekerapan, voltan, arus atau faktor kuasa. Fokus utama kertas kerja ini adalah untuk menganalisa kehilangan faktor kuasa semasa grid pintar dan selepas menjadi pulau sengaja khususnya pada sistem 5 bus. Ia adalah sangat penting untuk mengesan pulaun mod dengan cepat sebelum ia akan merosakkan peralatan apabila kesalahan berlaku.

ABSTRACT

Currently, electrical grid becomes of one main issue in many countries. This is because when some areas are blackouts these areas will take time to get back the power supply caused ongoing repair by maintenance. Therefore, the smart grid was established. The smart grid meets all requirements to make the electricity network become smarter. But there are some challenges when implementation of the smart grid. This paper also comes with the benefits of smart grid and differentiation for both smart grid and electrical grid. The islanding mode will detect in the smart grid when a load and a distributed generation (DG) system are electrically isolated from the remainder of the utility system. The islanding mode will separated into two which is intentional island and unintentional island. The main feature of DG is it can supply the power during islanding mode. Implementation of intentional islanding of DG improves the continuity of supply and reliability of power system. The performance of power will occurs such as on frequency, voltage, current or power factor during the intentional islanding mode. The main focus of this paper is to analyse the losses of power factor during smart grid and after the intentional islanding especially at 5 system buses. When the fault occurs it is very essential to detect the islanding mode rapidly before it will damage the equipment on the system.

DEDICATION

My dedication is especially to my lovely both of my parents. For my mother that strong person who taught me to trust in Allah, believe in my hard work, always be my side whenever feel down and always prayer for my success in my life. For my father who is willing to earn an honest living for us, supporting me in whatever things and encouraging me to believe myself.

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Along to finish my report, I had taken a lot of efforts from start until the end to submit this report. However, it is not success without the kind support and help of many individuals and organizations. Therefore, thanks to all of them from the deep of my heart.

I am heavily indebted to my supervisor for the guidance and continuous supervision as well as for providing necessary information regarding to my project and also for the motivation in completing the project.

Besides that, very thankful toward fellow friends for their kind collaboration and impulse in helping me during completing my project.

Last but not least, the references from the value of TNB of grid system in Peninsular Malaysia and very thanks and appreciations also to certain lecturers in developing my project and people who had willingly helped me out of their abilities.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

DG	-	Distributed Generation
TNB	-	Tenaga Nasional Berhad
HV	-	High Voltage
PCC	-	Point of Common Coupling
CLPSO	-	Comprehensive Learning Particle Swarm Optimization
FACT	-	Flexible AC Transmission System
CB	-	Circuit Breaker
RES	-	Renewable energy sources
EV	-	Electrical Vehicle
VSC	-	Voltage Source Converters

CHAPTER 1

INTRODUCTION

1.0 Introduction

This chapter basically about the overall what is going in my project. First is about the background of project. This part will explain more about what is my project all about. Then, will come out with the problem statements in the project. The problem occurs currently related with our worldwide issue. After that, the objectives about my project. This objective must related with problem statements. Last but not least, the scope that of my project. The scope is the main part that will be focus only in my project.

1.1 Background of project

The electrical grid had been designed during the 19-20th centuries and it was mainly radial and had centralized generation [8]. Nowadays, national grid becomes one of the main issues in many countries such as in India. India has a weak grid but flourish energy needs to reinforce the electric network along with communication technology towards the future vision of electricity system which is to make electricity network become smarter [1]. To meet the needs of flourish economy like providing reliable, qualitative and economic power there are a lot of faces challenge that had been through [2]. Therefore, the smart grid will use to distribute electricity in grid system which is upgrade through two-way communications for make better reliability, control, safety and efficiency, [3]. The main contrast between smart grid and utility grid will be the generation and demand is kept in balance. The electric grid consists of generation plant, transmission lines, transformers and distribution substation that used to deliver the electricity from generation plant to home or factory or etc.

The system that produces power for the buildings which the systems are connecting to like solar panels to home was the condition of DG. The main anxiety of DG is to flourish power demand. High energy efficiency, environmentally, friendly and use of renewable energy was an advantages of the DG on distribution system [4]. To improve quality of power and minimize peak loads will make a contribution by a DG [5]. As a main part that to focus on is when during islanding mode the ability of the DG is it can supply the power. The part of power system that consist of one or more power sources and load for certain time that separated from the rest of the system was the words island mentioned [6]. While when the situation of distribution system becomes electrically isolated from the grid system then will be continuing energized by connected the DG was islanding mode [5]. In case of islanding through the current practice are almost all utilities need DG to be disconnected from the grid as soon as possible [5].

1.2 Problem statements

During islanding mode the performance of power utilization is the main problem that occurs in the electricity grid. Power outages in substantially interconnected power framework can make harm equipment of force plants, an intrusion of generation cycles, and awesome financial misfortunes [23]. Hence, most of the researchers make research to know the performance of power utilization during the islanding mode. During maintenance service is on the utility of the grid system must shutdown, there are many effect during this intentional islanding. As a verdict of voltage and frequency shift there are many risks resulting from this include the damage of the electric components. It is very essential to detect the islanding immediately and accurately due to that causes [7]. With the evolution through smart grid, distributed generation will be widely used. The main feature of DG is it can supply the power during the islanding mode [8]. There are many performances that can be know towards better power utilization during intentional islanding mode such as on current, frequency, voltage and power factor. But as my project, the performance of power factor will be the main focus. The performance of power factor due to the reactive power in the grid. Reactive power means the losses occur in the grid. Regarding to the theoretical, when the losses increase, the power factor will decrease.

1.3 Objective

There are 3 objectives in my project are to:

1) Model a smart grid with power factor and using PowerWorld software.
2) Investigate the effect on power factor during intentional islanding in smart grid system.
3) Recommend the possible improvement method on power factor correction during intentional islanding towards better power utilization in smart grid system.

1.4 Scope

As my project, my scope that will be focus is on smart grid system in islanding mode. But at the islanding mode my focus will be on intentional islanding. Then, circuit will be constructed on PowerWorld software to know the performance of power factor for both conditions during smart grid and after becoming intentional islanding mode. After that, improvement method on power factor correction during intentional islanding.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

This chapter is about the literature review as a reference that helps my project based on reading of journal or conference paper which that from there will get some knowledge and idea for my project. The journal will go through read from 5years past. It will come out with the results and summarize of each of the paper.

2.1 Electricity grid and Smart grid

An electricity grid is known as extension network for delivering from suppliers to consumers. An electricity system that will support all or a number of the following four operations: electricity generation, electricity transmission, electricity distribution and electricity control are the term of grid. One of the future electric system developments is the higher penetration of DG mention in distribution network to that the most expansion generation is connected. Thus, the system network must be able to accept and manage the generation in a flexible way and intelligent way which are it must to be a smart grid system [9]. The transmission voltage networks at Malaysia are 500kV, 275kV and 132kV while the distribution voltages are 33kV, 11kV and 400/230 Volts. However, Johor and Perak are the special case which is the distribution voltages may include 22kV and 6.6 kV [21]. According to newspaper MYNEWSHUB they said TNB Station among largest in Malaysia faces a natural disturbance. A turbine used to generate electricity using coal technology in Lekir, Manjung here reported experiencing technical problems [22].

By Mohd Yusof Rakob, Figure 2.1a below shows the general profile of power utilities in Malaysia. TNB is operated in Peninsular Malaysia, SEB is operated in Sarawak and SESB is operated in Sabah.

TNB (P. Malaysia)	SEB (Sarawak)	SESB (Sabah)
• Operates in Peninsular Malaysia • Total generation capacity is 21,051 MW (2010) • Customer is 7,593,684 • Max demand: 15,072MW • Gen mix (2010): – 54% gas – 40% coal – 5.2% hydro – 0.2% distillate	• Operates in Sarawak • Total generation capacity: 1230 MW (2009) • Customer is 499,618 • Max demand : 1036 MW • Gen mix (2009): –53% gas – 34% coal –8% hydro –5% diesel	• Operates in Sabah • Total generation capacity is 866.4 MW (2010) • Customer is 413,983 • Max demand :760 MW • Gen mix (2009): – 57% oil – 31% gas – 9% hydro – 3% biomass.

Figure 2.1a: The general profile of power utilities in Malaysia

When becoming a smart grid system, it mention to as smart electrical or power grid, intelligent grid, intelligrid, future grid, intergrid, or intragrid is an improvement of the 20th century power grid. A power generation devices that connect to the traditional grid and steady condition to supply electricity to the load in case of major failure mention as islanding mode [10]. Such that it can operate with the utility grid or in an isolated grid the smart grid was designed. Efficient in transmission and distribution system in electric power and quickly restore power after power failure due to faults are some of the advantages of smart grid.

Research paper by Raja Masood Larik, Mohd Wazir Mustafa and Sajid Hussain Qazi, to control and generate power the prior electromechanical grids have been based on vertical integrated utility structure. The consumers always suffered by the voltage instability, demand quality and preferable. To overcome contrasting challenges needs transform the electrical grids into smart devices, electronic and computational algorithms into high reliable and efficient smart grid. Recently, by rise the demand for power transfer over long distance the significance of stability in the power grid was emphasized. Stability refers to the ability of the grid to withstand disturbances and through the nature the disturbance of interest was classified. For improve reliability, control, safety and efficiency the smart grid had been used to distribute the electricity and upgrade through two-ways communication and widespread computing capabilities. To save energy and rise efficiency, reliability and transparency the smart grid was delivers electricity network between suppliers and consumers and control digital appliances. For interconnected elements it will provides protecting and monitoring automatically. Figure 2.1b shows that the conceptual model of smart grid. By the department of energy the primary objective of smart grid was identified.

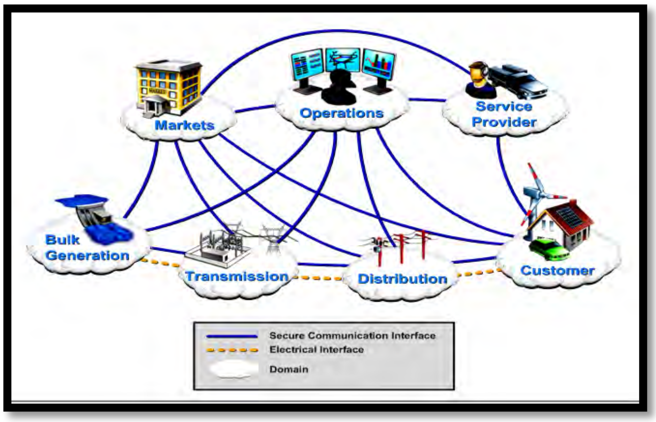

Figure 2.1b: The conceptual model of smart grid

2.1.1 Comparison of Both grids

Islanding mode can be divided into 2 types which are intentional islands and unintentional islands. An intentional islanding means that during maintenance service is on the utility of the grid system must shutdown. An unintentional island was caused by accidentally shut down of the grid system like fault occur in the grid [5]. North America, China and Europe are the example of the developed countries that adopted effectual and advanced power system techniques. Earliest and largest project of the smart grid was 'Telegestore' and from smart cities some of the countries already took their benefits. This project was applied in Italy in 2005, where the company designed their own meters and system software. Other than that, since 2003 the city of Austin, USA, Texas had been employed on smart grid. From the point of view in smart grid for modern power systems smart grid technologies are effective and beneficial in term of technical solutions and economical. Hence, this paper by

Raja Masood Larik, Mohd Wazir Mustafa and Sajid Hussain Qazi had conclude and summarize the comparison of existing grid and smart grid and shown by Table 2.1a.

Existing grid	Smart grid
Electromechanical	Digital
Centralized communication	Distributed communication
On-way communication	Two-way communication
Limited sensors	No limit
Manual restoration	Self-healing

Table 2.1a: Comparison of existing grid and smart grid

The smart energy subsystem, information subsystem and communication subsystem are the smart grid infrastructure. The traditional or utility grid is unidirectional and electricity generates with limit central power plants. The generated electric power further was passed to transmission grid and will move forwards. Furthermore, through solar plants and wind turbines the flow pattern of energy generation in smart grid is more flexible due to distribution grid capability comparing to utility or traditional grid. Based on passive distribution were the traditional or utility grid power systems with one way communication. Being changed by the flow between consumers and suppliers the role of the consumer was automatically changing into active distribution. With a two way flow of communication between consumer and suppliers the future electricity systems are the smart grids.

2.1.2 Challenges in Smart grid

During the implementation in smart grid systems there are various challenges occur. By the paper of Raja Masood Larik, Mohd Wazir Mustafa and Sajid Hussain Qazi Table 2.1b shows summarize of the challenges in smart grid.

Challenge	Description
Complexity (Cristaldi *et al.*, 2002; Choi and Chan, 2004, Dougal *et al.*, 2006; Dougal and Monti, 2007; Ponci *et al.*, 2009)	Smart grid communication system is complex due to infrastructure of systems of systems.
Efficiency (Amin, 2005; Dollen, 2008; Krebs *et al.*, 2008; Wen *et al.*, 2010)	Smart grid has many challenges by harnessing modern communication and IT for grid wide coordinated monitoring capabilities.
Reliability (Mets *et al.*, 2010; Moslehi and Kumar, 2010a, 2010b)	Need a framework for cohesive integration with reliability technologies with standards, protocols and analytical capabilities.
Security (Ericsson *et al.*, 2007; Ericsson, 2010)	There are many issues are exist related to cyber security for power system communication infrastructure in smart grid.

Table 2.1b: Summary and literature of challenges in smart grid

Hence, this paper had concludes even though there are many challenges occurs in smart grid system the smart grid technology is a beneficial technology for power system stability, customer's satisfaction, load distribution and all types of grid operations. The approach of smart grid technologies will give friendlier environment for future and better power supplies services.

By paper of P. Mukhopadhyay and H.K. Chawla since the ratification of the Electricity Act in 2003, Indian power sector had grown significantly. However, providing reliable, qualitative and economical power to all & meet the growing needs of the company was still faces the challenges. Through Grid Optimization, power quality and advanced consumer service there are some drivers for the smart grid which are growing energy demand, network reliability & security, energy independence & security, integration of renewable energy, economic growth and rise efficiency. Figure 2.1c indicates the basic system architecture of smart grid.

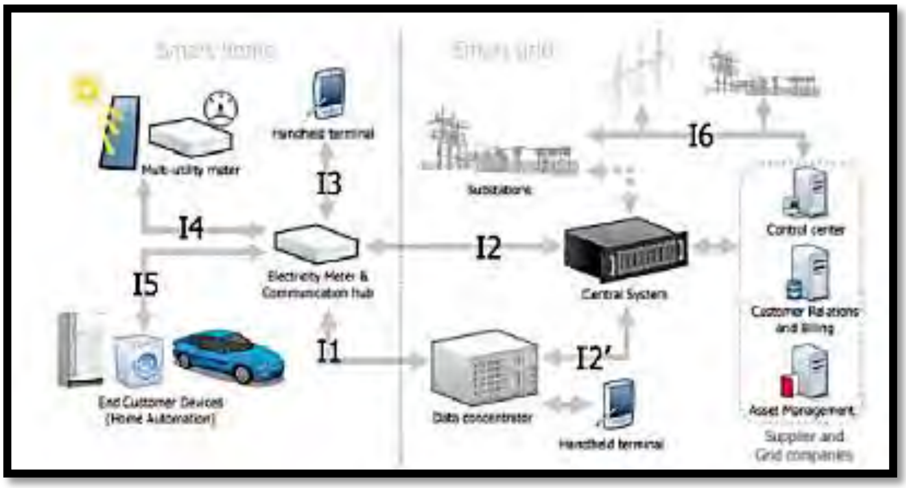

Figure 2.1c: Smart grid system architecture

Therefore, this paper conclude by meets the growing electricity demand with security, reliability, resilience, stability and quality power while reduce the electricity costs the smart grid shall bring efficiency and sustainability in the country.

The largest electric power utility in Malaysia is TNB. To increase efficiency TNB developing of a smart grid was in development plan. The TNB smart grid program was beginning in 2009 with four areas of focus which are operational efficiency (T&D) and energy efficiency, allow power to customers, reducing CO_2 liberation and support electric vehicles. TNB's smart grid was development plan has three phases between 2011 and 2015. Figure 2.2d shows the implementation initiatives of smart grid in Malaysia.

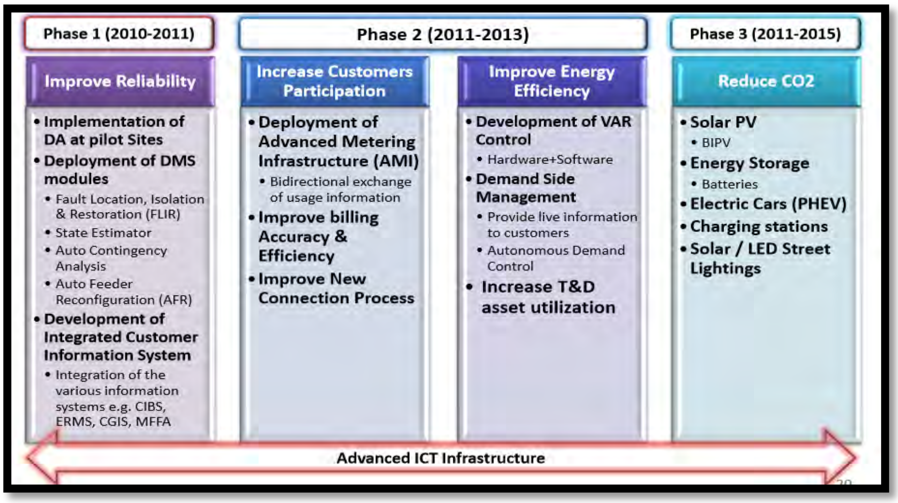

Figure 2.2d: The implementation initiatives of smart grid in Malaysia

2.2 Active power and Reactive power

2.2.1 Performance at grid

By paper of Shibo Wang, Qi Wei and Siwen Cai the large combination of utility grid and distributed penetration by many of world energy, electricity experts is recognize as able to save investment, reducing energy consumption and upgrade power system reliability and flexibility of the many ways. DG had been heavily used with the growth of smart grid. At this paper, the load of reactive power requirements was proposed. The inverter system providing only in part of reactive power then the rest was provided by the main power grid. The value of this experiments is the load active power was set to P=10kW but the value of the load reactive power was varies to Q=900W and Q=1000W. When the mains is switching off, slight difference occur in power and q axes current reference phase was changed by slight difference in frequency changes since the frequency presence-reactive power feedback that power inverter and carried load had frequency or voltage variation so both of DG frequency and reactive power output were changed. Then, islanding will detect when frequency exceeds the limit. See Figure 2.2a:

$$\Delta P = 0 \quad \begin{matrix} Q_{DG} > Q_{load} \rightarrow \omega\downarrow \rightarrow I_{qref}\uparrow \rightarrow Q_{DG}\uparrow \rightarrow \omega\downarrow \\ Q_{DG} < Q_{load} \rightarrow \omega\uparrow \rightarrow I_{qref}\downarrow \rightarrow Q_{DG}\downarrow \rightarrow \omega\uparrow \end{matrix}$$

Figure 2.2a: q axes frequency reactive power feedback

Based on Figure 2.2a, Q=900W and at this time the theoretical is $Q_{DG}>Q_{LOAD}$. The result was obtained then it found that when the mains frequency stabilize in 50Hz in parallel condition. The mains switching off by 0.2s and then put into the feedback, the frequency change by accelerate and the frequency decreases dramatically but when at 0.32s the limit exceeding. The islanding condition will effectively detect. With the combination of domestic situation the lower limit of the normal operating frequency is 49.3Hz.