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:

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(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.

ACKNOWLEDGEMENT

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)
TENAGA NASIONAL BERHAD	SARAWAK ENERGY	SESB
• 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.

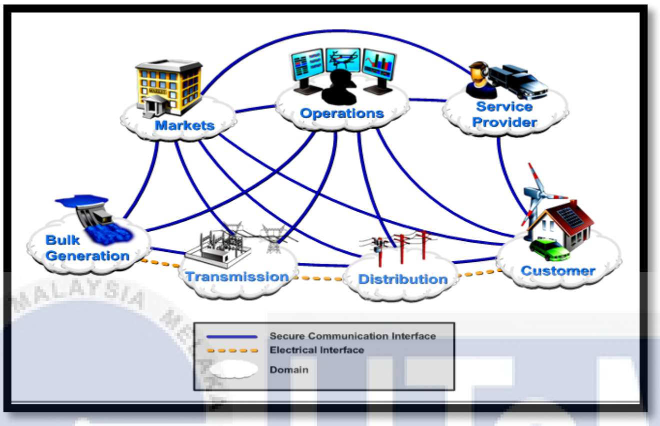


Figure 2.1b: The conceptual model of smart grid

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.

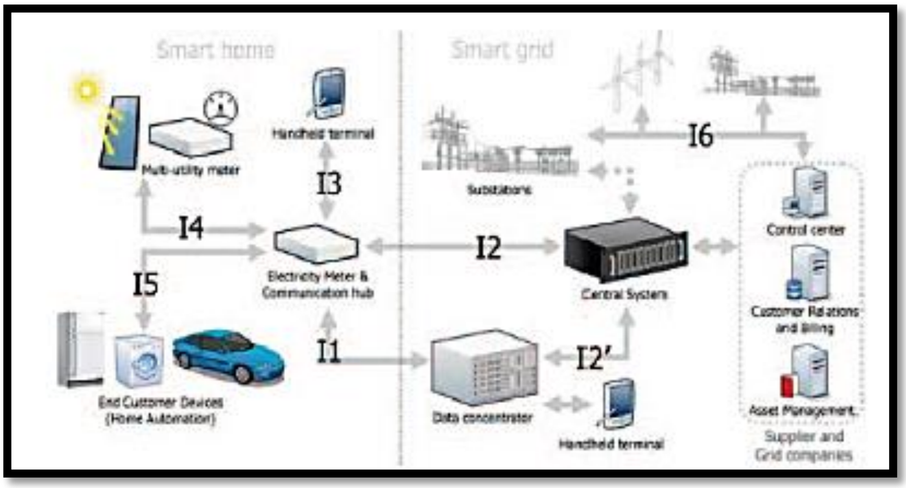


Figure 2.1c: Smart grid system architecture

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.

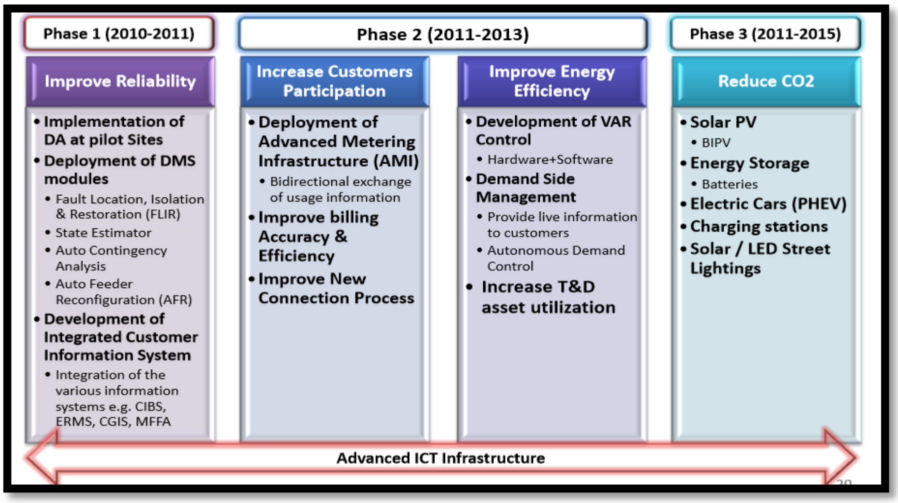


Figure 2.2d: The implementation initiatives of smart grid in Malaysia

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:

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

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.

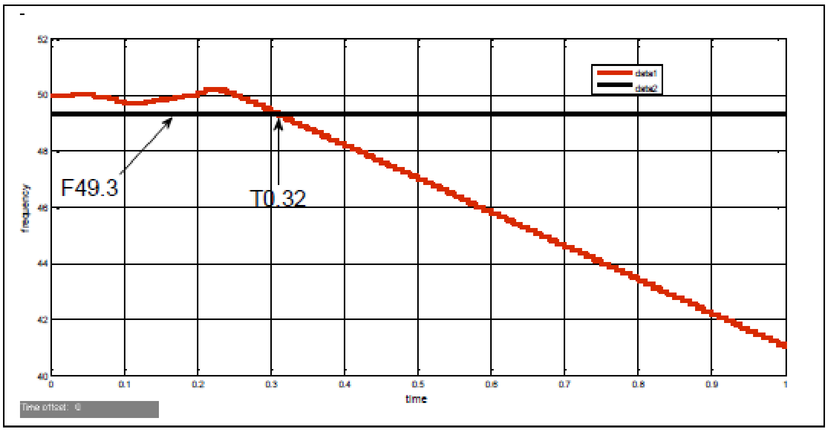


Figure 2.2b: Reactive power setting value, the inverter frequency curve

Then, same goes to Figure 2.2a. Based on Figure 2.2b, Q=1000W and at this time the theoretical $Q_{DG}<Q_{LOAD}$. 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 0.23s the limit exceeding. The islanding condition will effectively detect. With the combination of domestic situation the lower limit of the normal operating frequency is 50.5Hz.

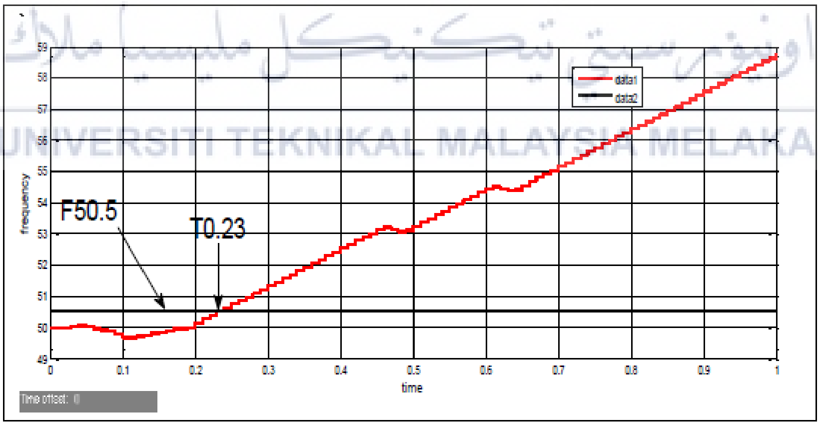


Figure 2.2c: Reactive power setting value, the inverter frequency curve

This simulation conclude that when DG inverter output power and load power are nearby, it can reduce non-detection zone effectively and actually mismatch degree between inverter reactive power output and reactive power load indirectly rise, so that the frequency will vary constantly in one direction until the final limit frequency, hence the islanding was detected. When the reactive power is rise, the performance of power factor will decline. This is because the performance of power factor due to reactive power. This can be proved by the power triangle.

2.2.2 Performance at intentional island

Refer to the paper of Morris Brenna, Federica Foiadelli, Paola Petroni, Gianluca Sapienza and Dario Zaninelli the network islanding had an essential concept in the smart grid context like from the main electric system it had the possibility to work disconnected. Nowadays the generators were PQ regulated and the MV bus bar operated as slack node due to this procedure it is not possible. Drift had happens in case of opening the main circuit breaker at the beginning of a line, occur in active and reactive power imbalance and the frequency and also the voltage. This drift happen the interface protections trip and the generators disconnected from the network. There was the balance between generated power and absorbed power (included the losses) and any active and reactive powers are absorbed by the upstream HV because the island is maintained only in particular cases. At this case the unintentional island is indefinitely maintained only if this balance is perfect clearly. The depending on the power unbalance on the opposite, the island overstayed is more or less long.

From PQ to PV regulation the issue of intentional island was studied considering the reactive power unbalanced 10% and main generator G2. This paper aims the simulation to verify the possibility to retain the island in order to ensure the continuity of supply to the connected end users. It is possible to raising the power quality level and to better exploit the renewable sources as an important function in smart grid application. To the steady state conditions the system was initially stabilized and then the line circuit breaker has been opened. The biggest generator was G2 and was switched to PV regulation. The power regulator was able to regulate the frequency droop. The performance of frequency and voltage was represented in Figure 2.2d and Figure 2.2e. When there is not enough reactive power the voltage sags down and it is not possible through the lines to deliver the required power to the load. Therefore, it is very essential to improve the performance of AC systems by the reactive power (VAR) compensation. There can be no transfer of real power without the reactive power.

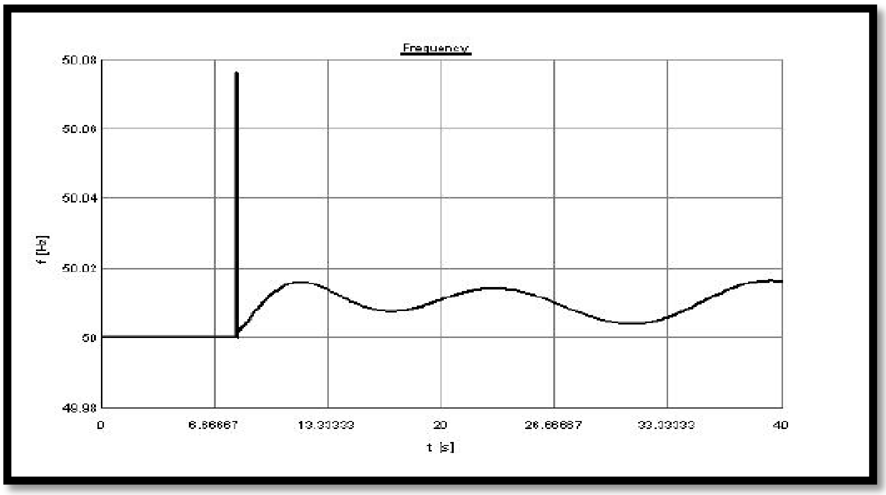


Figure 2.2d: Frequency with active power balanced and reactive power unbalanced of 10%

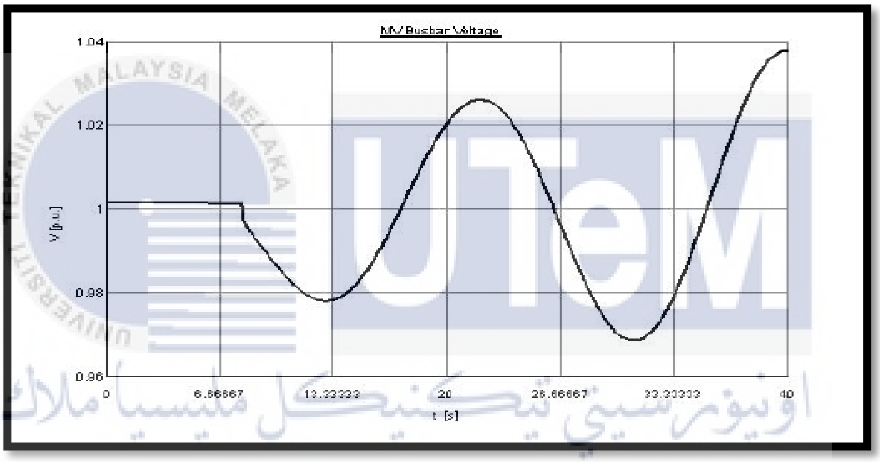


Figure 2.2e: Voltage with active power balanced and reactive power unbalanced of 10%

The result of graph shows that, the island cannot be stable for a long time even the PV controlled generator occurred but to overcome the perturbations that occur in the MV network will be possible. The losses occur more for the reactive power unstable so that the performance of power factor will be affected according to theory of losses. If losses higher the performance of power factor is less. The performance of power factor is depending to the losses in the system.

2.3 Distributed Generator (DG)

My research will be focus on DG as a main part that on in smart grid system and also in an intentional islanding mode since it have been widely focused on by many researchers [11]. The reason use DG is it plays a main role that it can supply the power during the islanding mode [8]. So, the islanding area will be continuous energized. Furthermore, the approach of main DG can impact the whole grid, affect the safety and stable the operation mode of grid. After the power grid is loss, DG penetration and local load independent operate which is called as island (islanding) phenomenon [7]. For an example when the TNB needs to shut down the utility grid to make service maintenance in the certain area means that to be an intentional islanding mode, that area still can operate like normal due to the supply given by the DG. Regarding to TNB operate in peninsular Malaysia for customers receiving less than 132kV the imposed a surcharge to the customer if the power factor is less than 0.85. To maintain their load power factor to a minimum of 0.85 for voltage level less than 132kV and 0.90 for voltage level for 132kV are the consumers need [21]. The power factor can be improved by install the capacitor (KVAR Generators), reduce operations of idling or lightly loaded motor, avoid operating equipment above its rated voltage and replace standard motors as they burn out with energy efficient motors.

2.3.1 Unity power factor

Based on paper M.S. Kandil M.M. El-Saadawi A.E. Hassan K.M. Abo-Al-Ez the utility grid need to supply extra reactive power to compensate for the predict power factor failure caused by DG active power injection with industrial inductive loads and supply the reactive power needs. Local reactive power compensation is a particular feature of fuel cell systems, as will always be very close to the point of usage electricity.

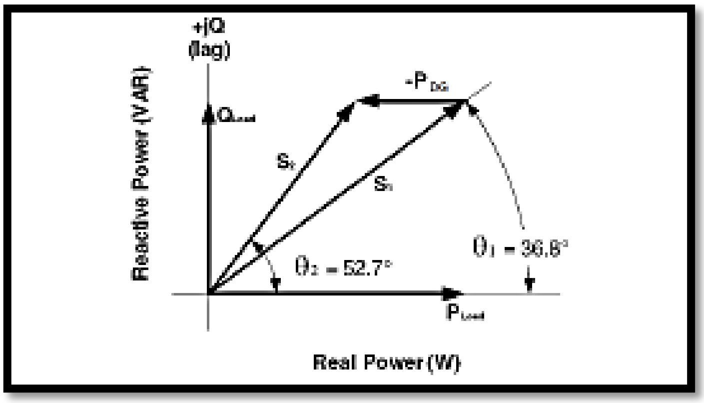


Figure 2.3a: Example of reactive and relationship for unity power factor operation of DG system with inductive load

Figure 2.3a is an example as seen by the grid may fall out of the fix limits allowed by the utility of the power factor at the PCC. The main selection of a DG system for reactive power compensation is the familiarity to the point of electricity usage, the economic viability and the controllability and range of DG active power ratings. Due to fuel storage microturbines and fuel cells have normally continuous active power generation. Hence, based on the power production of the DG which is controlled by the owner the reactive power supply capacity was calculated in (Eq.1). Therefore, increase the reactive power compensation, capacity increased power ratings.

$$Q_{max}(t) = \sqrt{S^2{}_{max} - P^2{}_{act}(t)} \qquad (1)$$

A simulation was proposed on fuel cell DG power grid connected system. During the operation scenario the reactive power production and absorption at different operating points were measured in Figure 2.3b. Power factor measurements also shown in Figure 2.3c.

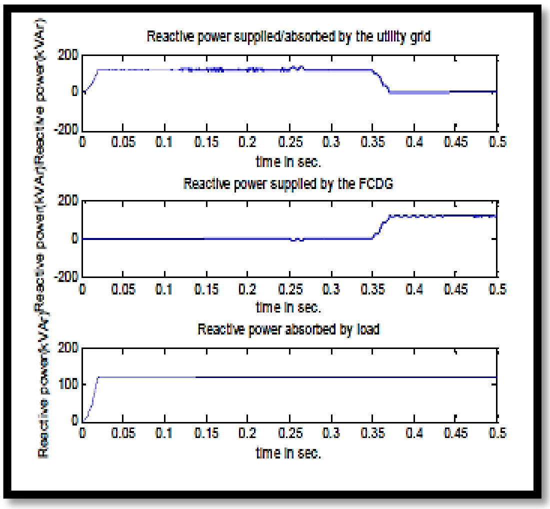


Figure 2.3b: Measured reactive power (kVAr)

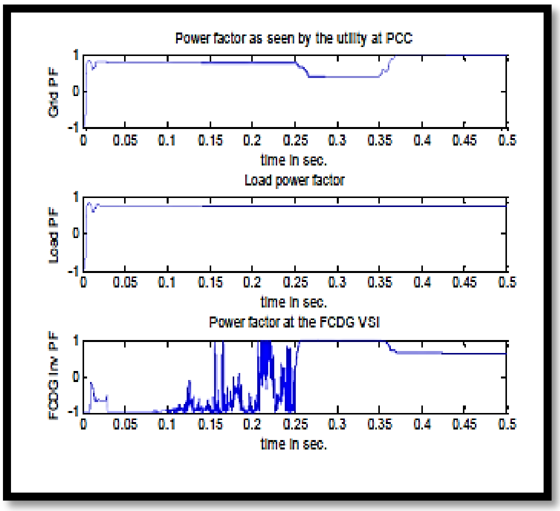


Figure 2.3c: Measured power factor

Hence, this paper concludes the normal operating mode of fuel cell DG systems should be reactive power control capability in addition to supplying the active power. At the PCC equal to unity under contrasting load conditions would keep this operating mode.

2.3.2 Islanding operation

Paper of Chandra Shekhar Chandrakar, Bharti Dewani and Deepali Chandrakar to improve the quality of power, reduce peak loads and remove the need for reserve margin the DG may make a contribution. During the interference of utility power, the DG connected must detect the losses of utility power and disconnect itself from power grid as soon as possible to avoid the several negative impacts on utility power system and DG itself such as the quality problems of electric service to the utility customers. During maintenance service the loss of the grid is voluntary become islanding are called intentional while caused by accidentally shut down of the grid is called non-intentional islanding. Figure 2.3d show scenario of islanding operation.

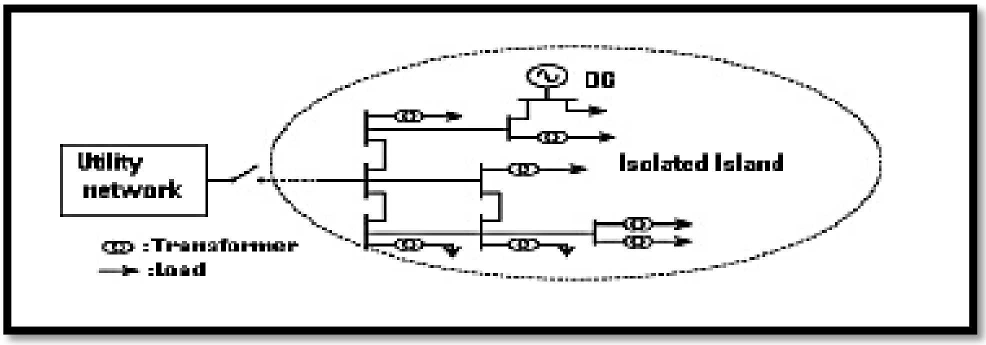


Figure 2.3d: Scenario of islanding operation

Others paper of Yin zhuan and Liu tian-qi,Jiang dong-lin high energy efficiency, environmentally friendly and use of renewable energy are the benefits of DG. To encourage supply side and user side through technical means to achieve the intentional islanding so that the improved on the system power supply reliability. Based on the simplified distribution network model, the DG from the grid to the island is to ensure the active power balance between islands was proposed on the principle of separating island which can reflect the essential level of load. The simulation and results for this paper was discussed. It used U.S. PG&E69-bus distribution network system as a test system. Loads are 28kW, 8kW, 45.5kW, 3.6kW, 26.4kW, 28kW and those essential loads nodes at 10, 14, 16, 41, 43, 58, 65. The maximum outputs respectively are 100kW and 210kW and the capacities of the storage batteries are 300kW.h and 600kW.h accessing storage batteries to node 9 and node 12 respectively. The outputs under failure respectively at the DGs of 250kW, 200kW, 40kW, 50kW, 1300kW, 100kW accessing DGs to nodes 5, 19, 32, 36, 52. Figure 2.3e was shown that the island implemented distribution in accordance with algorithm.

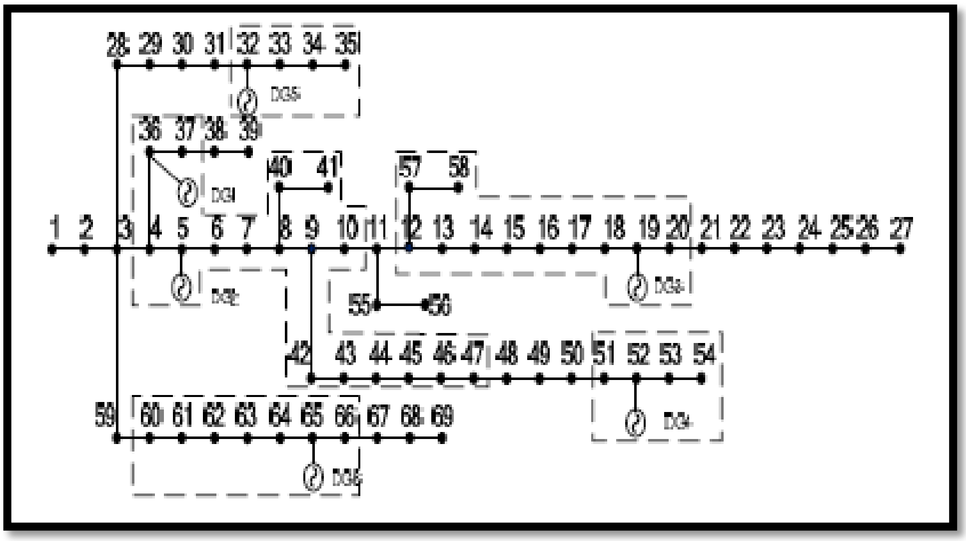


Figure 2.3e: After fault islanding scheme of distribution system with DGs

Hence, the paper concluded that divide loads into general loads and important loads based on real situation during division of island. Next, the essential loads ensure the power stability and power quality of essential loads was depending on the energy storage battery to supply.

2.4 Intentional islanding

2.4.1 Maintenance stable operation

Regarding paper of H. Jouybari-Moghaddam, S.H. Hosseinian, B.Vahidi for future revisions of the IEEE standard 1547 which is under consideration, the intentional islanding can be defined as probably caused by opening the circuit breaker located at point of common coupling the island. In case of difference significant of voltage or frequency at the PCC, intentional islanding can prevent from being damaged. The higher DG penetration, for loss of grid (LOG) situations automatic disconnection of DGs, dramatically reduce the expected benefits of DGs in (i) maintain the power quality and reliability, (ii) improving system security and (iii) many accessory services. As DG are being advanced and the power demand is growing up it will gain larger commercial and technical importance. Aspects on active distribution network operation are one of the most challenging parts of an unplanning island. It refers to distribution systems that contain on-site distributed energy resource. When the utility fault occurs, the unnecessary loss of DG power also occurs. For a better utilization of DG benefits, the distribution energy sources are connected during system disturbances and also islanding operation but protection of DGs are being discuss upon by researcher. Table 2.4a represent selected case study system. In grid the connected case, within the system at PQ operate at DGs while in case from grid disconnected operation mode of DG must include a V-f control mode to have full controllability of bus voltage and frequency.

DG	Case 1: only tie 1-2 is closed	Case 2	Case 3
GT #1	Master (V-f)	Master (V-f)	Master/Slave
GT #2	Slave (Fixed)	Slave (Fixed)	Master/Slave
GT#3	Self-Ctrl (V-f), Own bus Ctrl	Slave (Fixed)	Master/Slave

Table 2.4a: Example case studies

Figure 2.4a is the summarize scenario of each case. Case 1 illustrated two separate islands operation, island 1 consist GT#1 and GT#2 with their relation bus loads and island 2 consist GT#3 with its bus load. The mentioned above in the second case parts form a single island. For Case 3 condition is the same as case 2 , but in this case only one master DG each time had while as slave ones the other DGs operated. Controls the frequency and voltage of the island, and fixed generation as slave DGs are the master DG.

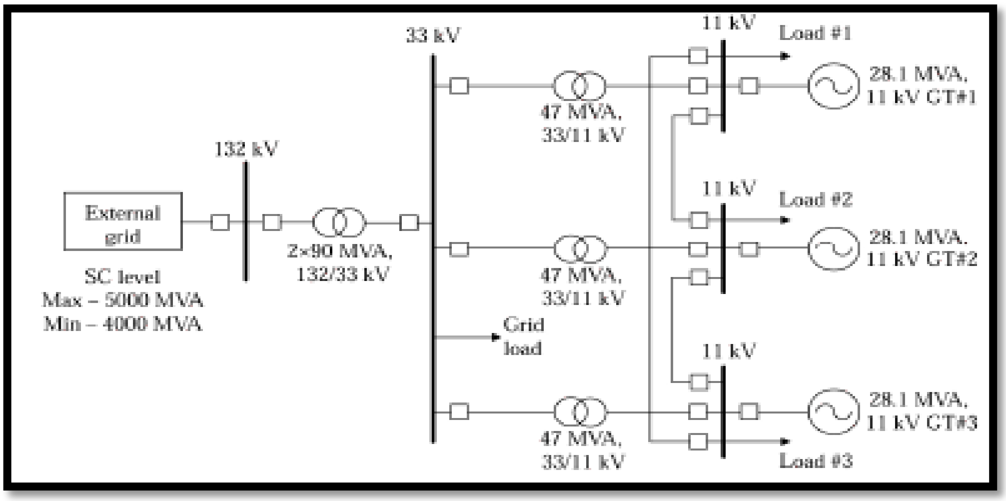


Figure 2.4a: System under study: operation feasibility

The results of simulation of successful island shows that operation in all case was practicable because after beginning of stand-alone operation, frequency and voltage of the islanded parts are kept within allowed limits after an allowable time being employed. In case of interconnected DGs the contrast were the quicker recovery in case of non-interconnected DGs and better frequency and voltage dip transient responses.

2.4.2 Optimum islanding scheme

By paper of Amany El-Zonkoly Mostafa Saad Reem Khalil based algorithm a CLPSO is suggest to find the optimum islanding scheme of distribution network. The suggested algorithm is to find the proper lines to be disconnected to reduce the active and reactive generation cost and the cost of unserved power while satisfying the system operational restraint. Left for the algorithm will determine but the number of island is not pre-specified. To determine the branches included in each island a bus-brunch incidence matrix model was used. The reliability occurrences are calculated for each system during islanding with and without utility owned DGs (UGs) penetration. The simulation results for this paper which is applied two test systems. The test systems are the radial 33 bus system and the Egyptian 66kV, 45 bus meshed network of Alexandria. The parameters of the CLPSO are, swarm size=25, maximum generation=100, $w \in [0.4\text{-}0.9]$, c=1, P_{ci}=10 and m=7. The loads of each system are varies with a load scaling of [0.9, 0.95, 0.94, 0.93, 0.94, 1, 1.1, 1.15, 1.1, 1, 0.97, 0.85]. Table 2.4b throughout the simulation period along with their maximum and minimum limits in two cases, the maximum and minimum active and reactive power was generated. The generation limits was not contravention.

	Gen. Limits*10^{-3}				With UGs*10^{-3}				Without UGs*10^{-3}			
	P (pu)		Q (pu)		P (pu)		Q (pu)		P (pu)		Q (pu)	
	min	max	min	max	min	max	min	max	min	max	min	max
DG11	0	20	-15	15	2.76	19.7	-0.28	1.41	Not connected			
DG13	0	5	-4	4	5	5	-2.76	-0.14	4.39	4.94	-1.79	-1.33
DG21	0	20	-15	15	15.6	19.7	-10.5	-8.08	Not connected			
DG25	0	5	-4	4	5	5	1.115	1.59	3.64	4.9	-1.13	-1.08
DG30	0	7	-5	5	5.27	6.81	0.89	3.09	Not connected			

Table 2.4b: The power generation during islanding in 33 bus

Instantly after islanding, to satisfy the power balance condition load shedding must take place if required. Figure 2.4b shows the unserved power as a percent of the power demand at all busses.

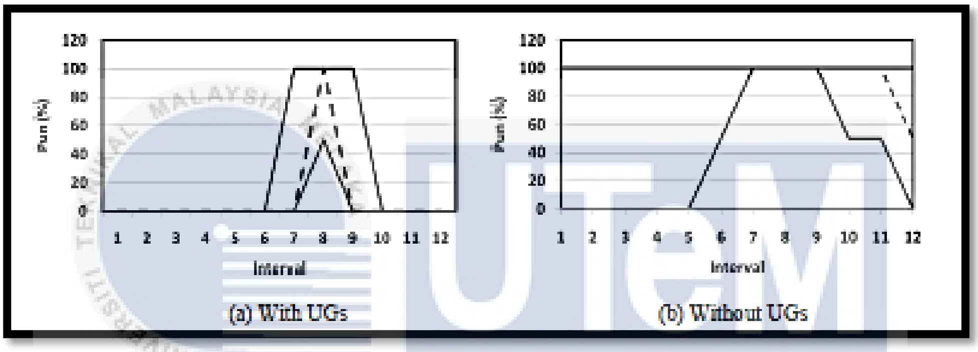


Figure 2.4b: The unserved power as a percent of the power demand at all busses.

Table 2.4c throughout the simulation period along with their maximum and minimum limits in two cases, the maximum and minimum active and reactive power was generated. The generation limits was not contravation.

	Gen. Limits				With UGs				Without UGs			
	P (pu)		Q (pu)		P (pu)		Q (pu)		P (pu)		Q (pu)	
	min	max	min	max	min	max	min	max	min	max	min	max
DG2	0	12	-6	8	8.45	11.36	4.56	5.24	10.75	11.94	6.57	7.61
DG7	0	4.2	-2	4	3.55	4.17	0.75	1.05	Not connected			
DG12	0	0.8	-1	1	0	0.8	-0.65	-0.32	Not connected			
DG21	0	0.8	-1	1	0.8	0.8	-0.29	0.2	Not connected			
DG34	0	3.8	-2	5	0	0.31	2.13	2.44	Not connected			
DG41	0	0.5	-1	5	0.5	0.5	2.09	3.24	Not connected			
DG44	0	0.5	-1	2	0.5	0.5	0.26	0.53	Not connected			

Table 2.4c: The power generation during islanding in 45 bus

Instantly after islanding, to satisfy the power balance condition load shedding must take place if required. Figure 2.4c shows the percent of unserved power during the simulation period.

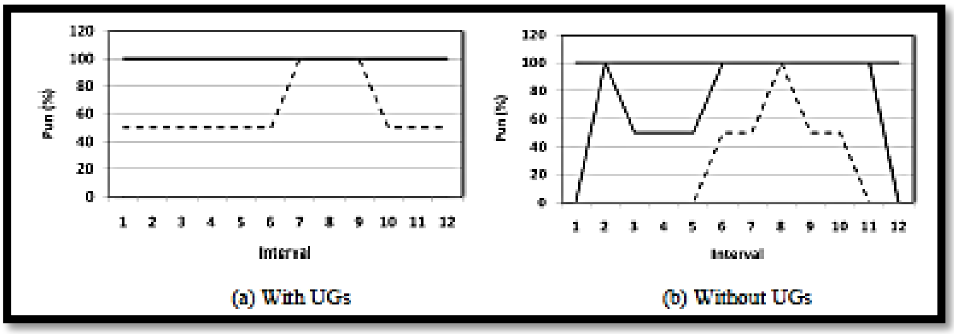


Figure 2.4c shows the percent of unserved power during the simulation period.

Therefore, both of the result was shown in the graph. The effect of intentional islanding with and without utility owned DGs on the system reliability indices was studied.

2.5 Islanding mode

2.5.1 Performance of control grid and islanding mode

By Geethi Krishnan, D.N.Gaonkar a portion of power system electrically separated from the interconnected network, providing power to local loads is represent an island. As soon the islanding wills detect, current protection practices mandate the disconnection of the DG system. To realize smooth transition of power between grid connected and islanding mode, a key features of intentional islanding operation, with little or no interference to the local loads. When the grid disconnected, the interface controller must be switched to voltage control mode. Instead of directly controlling voltage, voltage control through current compensation was executed. The result was occurred and Figure 2.5a shown the performance of the system to changing load parameters in grid connected. The UPF operations was designed at the inverter rated active power was controlled at 20kW. From the graph, the inverter constant at the rated value while the grid is meeting the changing load demand. Throughout the load steps, the voltage is kept constant.

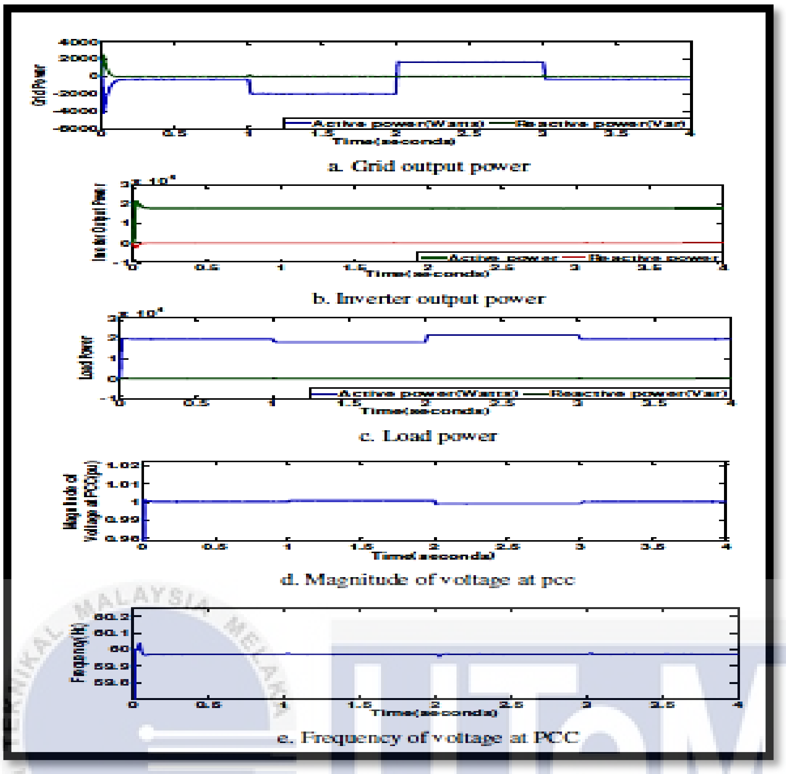


Figure 2.5a: Performance of the system to changing load parameters in grid connected mode

Figure 2.5b show the performance of the system to load variations in islanded mode. After the grid disconnected, an algorithm should work to detect the condition and transfer the controller to islanding mode. But the time segment between immediate of the loss of main and immediate of control switching should be as short as possible to execute smooth transition.

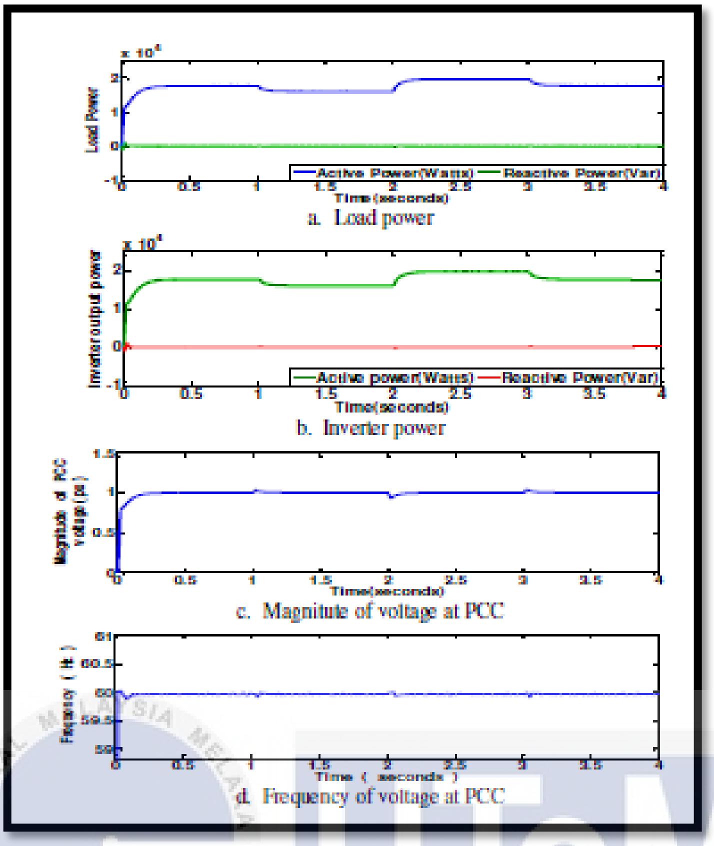


Figure 2.5b: Performance of the system to load variations in Islanded mode

Figure 2.5c show the seamless transition between modes of operations. Hence, it concludes that the transition from islanding to grid connected mode can be occurred without any downtimes when a reclosed and synchronization algorithm is designed such that even.

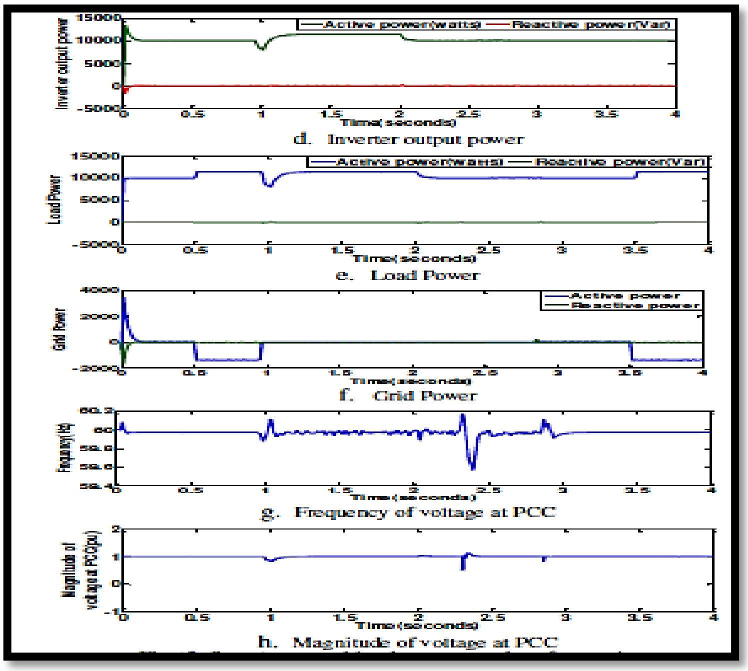


Figure 2.5c: The seamless transition between modes of operations

2.5.2 Effective Forced Islanding and Restoration Scheme

Refer to paper Sumi Soman, Polly Thomas, John George and Ganesh M, the main purpose of the paper is at preventing cascading events from propagating further across a transmission network thus the development of a new and effective power system forced islanding and restoration scheme. Hence, will minimize the possibility of a large scale blackout. At the base system analysis was done to detect the state of the system for continuous load flow. Eliminates the risks with minimal load generation imbalance during the forced islanding technique was after contingency analysis and determination of risks involved in each contingency case, appropriate islands are selected. The restoration process is initiated to restore the islands back to the original power system after forming stable islands and clearing of contingency. Figure 2.5d shows the flow chart for Forced Islanding Scheme. Islands for each outage case are predefined for implementation of the forced islanding scheme. Load demand equals generation in these islands. Table 2.5a shows pre-defined Islanding.

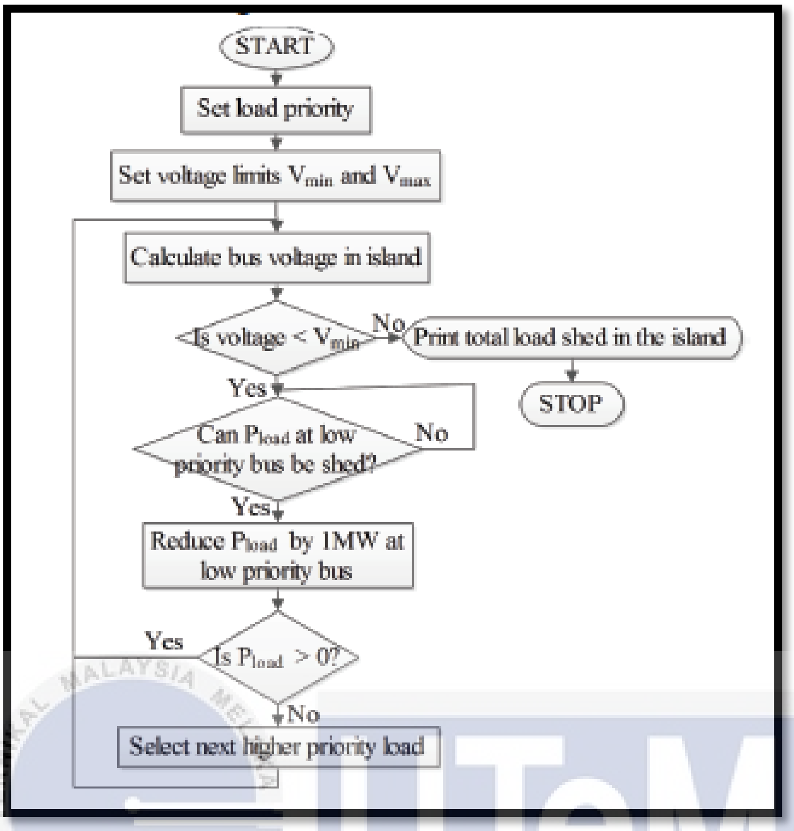


Figure 2.5d: Flow chart for Forced Islanding Scheme

Outage Case	Island 1	Island 2
Gen 2	2, 3, 6	1, 4, 5
Gen 3	2, 3, 6	1, 4, 5
Line 1	1, 2, 4, 5	3, 6
Line 2	1, 2, 3, 5	3, 6
Line 3	1, 2, 4, 6	3, 5
Line 4	No Island	
Line 5	2, 3, 6	1, 4, 5
Line 6	2, 3, 6	1, 4, 5
Line 7	2, 3, 6	1, 4, 5
Line 8	1, 2, 4, 5	3, 6
Line 9	2, 3, 4	1, 5, 6
Line 10	No Island	
Line 11	No Island	

Table 2.5a: Pre-defined Islanding

After separated the system into islands, to warn for a higher of generation or a lower of load in each island if the mismatch is positive or negative by an amount equal to the mismatch. Load the flow analysis is done on each island and power mismatch is calculated in each island. Besides, considering a tolerance limit of ±10% for the voltage the voltage stability of the islands was analysed.

Hence, the results of forced island formed during 2 generator outage case had briefly discussed below:

Island 1 (Bus Nos.: 1, 2, 4, 6):

Power Flow result of island 1 is -

From Bus	To Bus	Power Flow
1	2	40
1	4	50
2	4	20
2	6	70

Voltage at buses of island 1 is -

V_1	V_2	V_4	V_6
1.05	1.05	0.9887	0.8165

Bus voltage is below limit.

Island 2 (Bus Nos.: 3, 5):

Power Flow result of island 2 is -

From Bus	To Bus	Power Flow
3	5	70

Voltage at buses of island 2 is -

V_3	V_5
1.07	0.6618

Bus voltage is below limit.

Table 2.5b: Forced islanding during 2 generator

2.6 Compensator on power factor

As we know that compensation is very important in our system. Improving power factor means reducing the phase difference between voltage and current. Since majority of loads are of inductive nature, they require some amount of reactive power for them to function. This reactive power is provided by the capacitor or bank of capacitors installed parallel to the load. Compensating the load lagging power factor with the bus connected shunt capacitor bank improves the power factor and minimize current flow through transmission lines, transformers, generators. Hence, it will reduce power losses (I^2R losses) in the equipment but for my case at electrical grid. They act as a source of local reactive power and thus less reactive power flows through the line. Basically they reduce the phase difference between the voltage and current.

2.6.1 With and without MPFC

The papers of Adel M. Sharaf and Amirkabir capacitor banks had been widely used to minimize feeder active and reactive power losses and resultant bad power factor problems due to bad power quality, fixed, switched, and modulated. To improve the power quality and minimize the level of harmonic distortion, fixed power filters which have low cost and simple robust structure had usually installed especially in industrial utilization network. In this paper switched FACT based capacitors and filter devices are utilized with dynamic flexible dynamic control systems. The FACT devices such as STATCOM, SVC and SSSC. In this paper a validated for power quality and power factor improvement with effective voltage stabilization for use in smart grid-fed industrial, commercial, and residential loads, especially for short duration, short circuit and load excursions was developed a novel low-cost switched capacitor compensator (SCC). Besides that, this paper also was develop with extra error squared and rate adjusting addition loops for fast action to switch the dual IGBT/GTO switches, a multi-loop dynamic error driven coordinated dual regulation dynamic control scheme and a weighed-modified PID controller.

This paper had come out with the digital simulation results. According to goal of purpose to verify the dynamic effectiveness of the introduced SCC, with and without SCC under different conditions that are normal and load was investigated operation of an AC grid (Fig 2.6a) provides three types of industrial loads (Fig 2.6b).

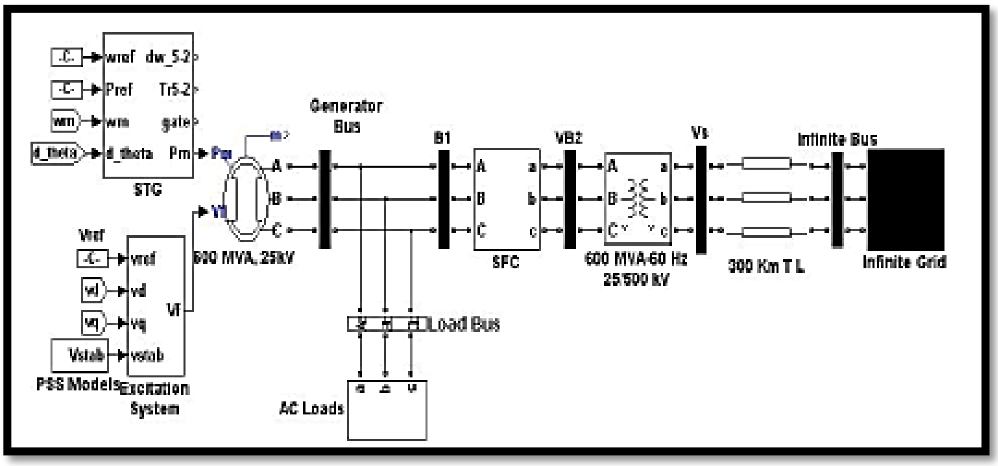


Figure 2.6a: AC grid as the study case

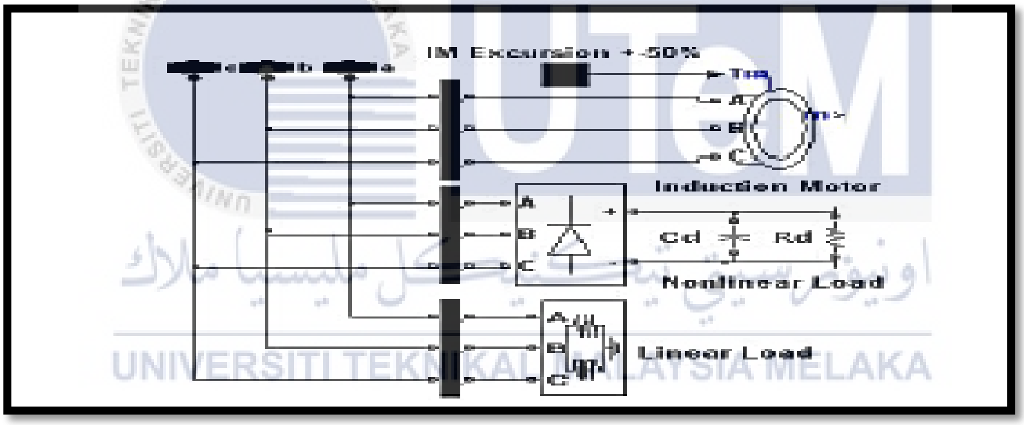


Figure 2.6b: Loads feed by AC Smart Grid

Figure 2.6c, 2.6d and 2.6e shows the graph of power factor with and without MPFC. The graph shows unstable condition when without MPFC added, but after MPFC added the graph is look more stable. Hence, this paper conclude that the results of simulation in improving voltage regulation, limiting inrush current conditions, and modifying power factor was validated the fast response and effectiveness of the proposed fast acting FACTS scheme.

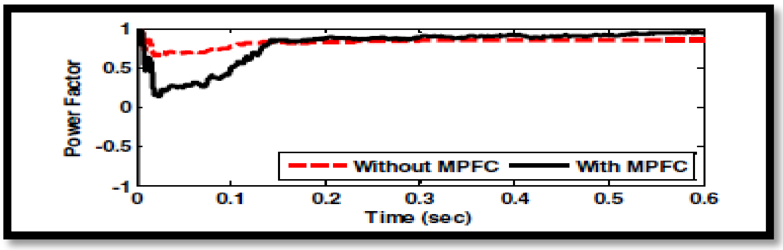


Figure 2.6c: Power factor in generator bus

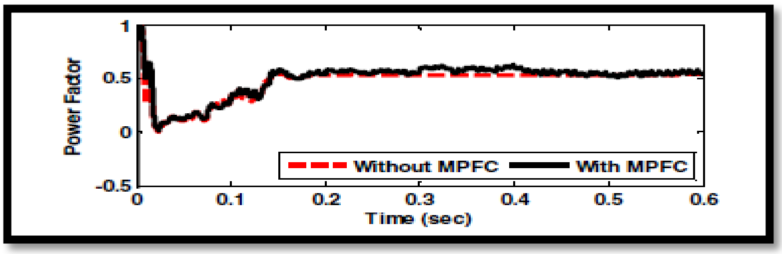


Figure 2.6d: Power factor in load bus

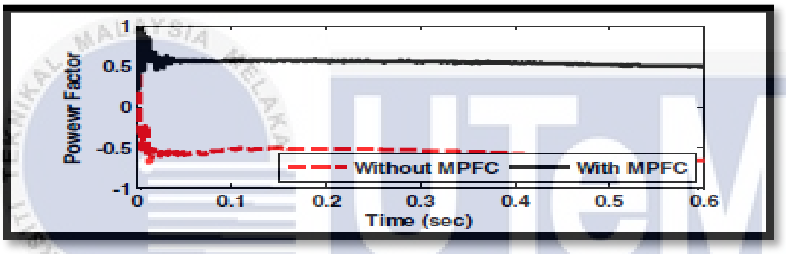


Figure 2.6e: Power factor in infinite bus

2.6.2 With and without SSFC

Same paper of Abdelazeem A. Abdelsalam and Adel M. Sharaf the results was obtained for the proposed FACTS-Switched Filter Compensation Scheme using Matlab/Simulink digital simulation. Figure 2.6f shows the power factor at the generator, load and infinite buses without (dashed line) and with SSFC (solid line).

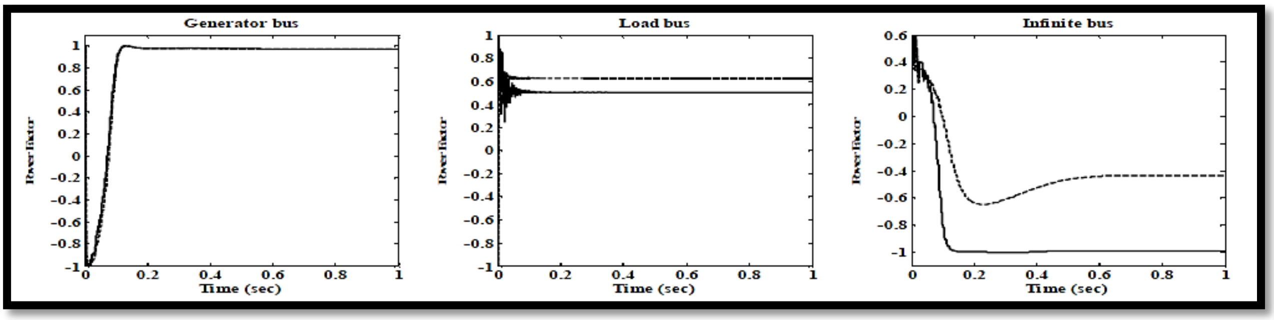


Figure 2.6f: The power factor at the generator, load and infinite buses without (dashed line) and with SSFC (solid line)

Therefore, for effective power quality mitigation, voltage stabilization, losses reduction and power factor correction using Matlab Simulink environment was the device scheme had been verified of the SSFC-FACTS. In hybrid wind PV fuel cell AC-DC renewable energy utilization systems FACT SSFC topology variations and other flexible dynamic control techniques can be utilized.

2.6.3 Grid connected VSC

Besides that, paper by Naga Brahmendra Yadav Gorla, Kawsar Ali, Chia Chew Lin and Sanjib Kumar Panda to improve the utilization factor like converters by using them to support the reactive power to the local loads when they are idle had present by a single phase PQ theory based control strategy. At the rearranged of distribution network with high penetration of RES the contents of smart grid implementation in recent times was primarily aimed. In the form of EV battery charge, RES fed grid connected inverters that can be used for active and reactive power support to the grid in smart grid there had plentiful number of grid connected VSC.

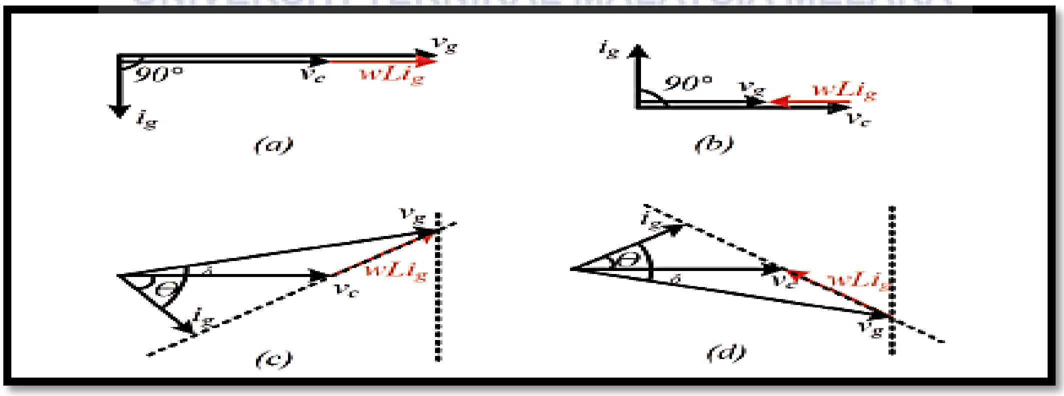


Figure 2.6g: Phasor diagram showing different modes of operation: (a) VSC supporting inductive VAR to the grid (+Q axis), (b) VSC supporting capacitive VAR to the grid (-Q axis), (c) VSC supporting inductive VAR to the grid while charging the battery (Quadrant-I), (d) VSC supporting capacitive VAR to the grid while charging the battery (Quadrant-IV)

Figure 2.6g (a) and 27 (b) show when operating in pure inductive reactive power mode respectively of that the vector diagram of VSC currents and voltages. In Figure 2.6g (c) while charging the battery the VSC was supporting inductive VAR to the grid and in Figure 2.6g (d) while charging the battery the VCS was supporting capacitive VAR to the grid.

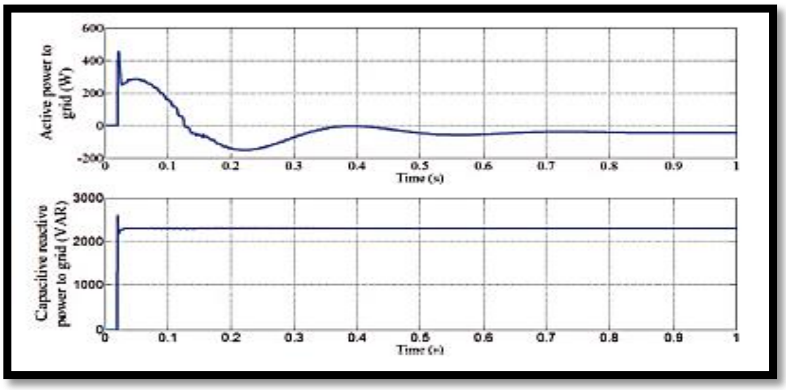


Figure 2.6h: Active and reactive power waveform of optimal DC bus voltage of 341V

To analyse the effect of reactive power operation on the converter was very important. Focus in given to analyse the design parameters viz, capacitor voltage ripple, peak switch stress (voltage across the switch) under the reactive mode operation, since the suggestion algorithm was intended to be deployed on the available converters. The capacitor voltage ripple will increase since the reactive power is circulated between the grid and the DC bus was mentioned clearly. The simulation results occur in Figure 2.6h. It drawn from the grid is around 50W for the active power. To minimize the active power drawn from the grid, the optimum DC voltage of 341V was chosen instead of 400V (standard Vdc for 1 phase application). This minimize the switching stress and hence the losses in the VSC. Hence, this paper had concluded to support the reactive power PQ based control technique for grid connected VSC.

2.6.4 Accurate reactive power

By Ayadoure Srinivasane@Stalin1, Shiva Balan. M2, Revanth. R3, Velbharathi. A4 and DuraiRaj.D key features of the hybrid grid systems are operational performance in transmission, optimization of the hybrid, reliability of the system and efficiency of the transmission. The paper accurate reactive power compensator for the same was developed and also developed on an integrated model of hybrid grid-connected Photo-Voltaic and Wind Turbine system. The main goal of this paper is to reduce reactive power flow in transmission line by power factor correction which will in turn minimize fare for electrical energy. In the study, a detailed open loop model simulation of a hybrid grid-connected photovoltaic and wind turbine hybrid power generation system was studied and the reactive power compensator system by capacitor is introduced to same system.

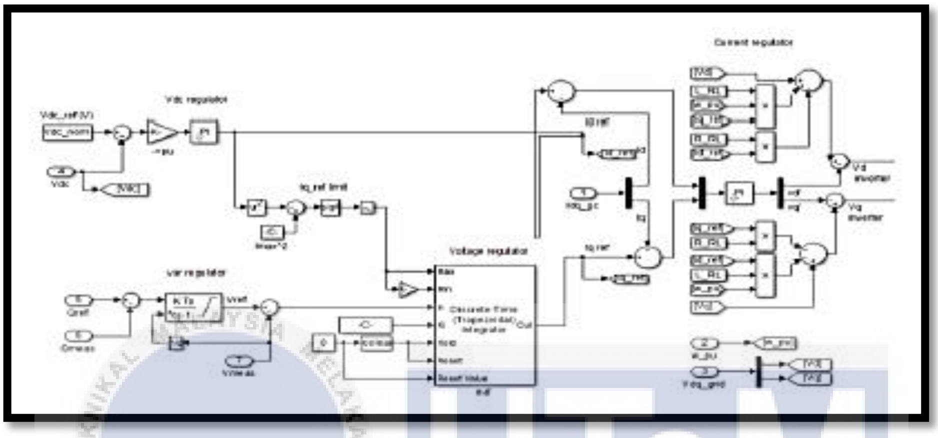


Figure 2.6i: Simulink Subsystem for Hybrid Grid Connected System

The Simulink view of hybrid renewable grid connected transmission system, the input to the photo-voltaic panel the cell temperature and irradiation of the panel, the input to the wind turbine is the speed of the wind with which it strikes against the turbine blades was shows in Figure 2.6i.

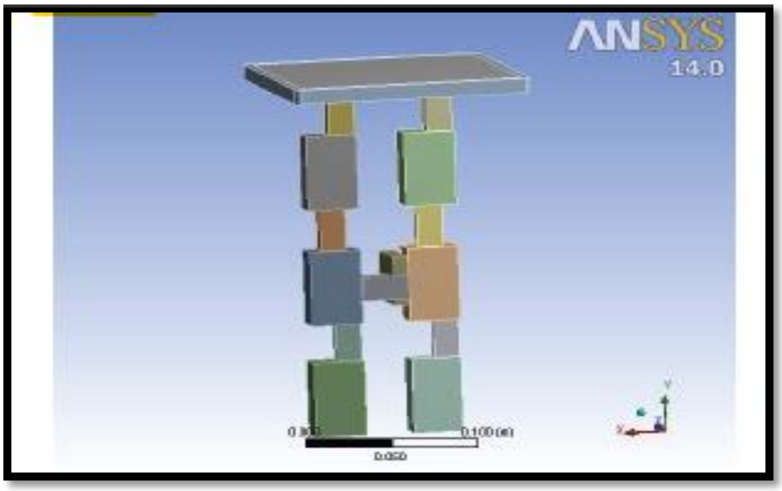


Figure 2.6j: Schematic View of Hybrid Capacitor Bank

The schematic view of the hybrid capacitor bank which designed by using Ansys 14 software packages was shown in Figure 2.6j. The total length of the bank is 14 meter and the material was assigned as per data sheet that the designed hybrid capacitor had been drawn.

Reactive Power Generated in KVAr	Power Factor	Steady State Temperature in °C	Ambient Temperature in °C
127	1	79	39
94	1	76.5	38.6
92	1	76.3	38.3
88	1	79	38.8
90	1	79	39
93	1	79.1	39

Table 2.6a: Steady State Temperature and Ambient Temperature for Hybrid Capacitor Bank

Therefore, by using MATLAB software package the Table 2.6a showed the steady state and ambient temperature recorded for Hybrid Capacitor Bank. The paper conclude that inductive in nature was the loads which had used will leads to production of more reactive power in the transmission line and from that influence lower in the efficiency of the transmission line. For reactive power compensation the capacitor bank of fixed capacitor ratings were employed. The excess reactive power which was generated in the system does not compensate such compensation technique.

2.7 Capacitor bank for minimization power losses

Refers to thesis of Ziana Bt Che Ros, to improve the power factor the capacitor bank is the importance installed. The correction capacitor must add to the plant power distribution system as the solution to improve the power factor. To achieved KW of work act as is reactive power generators and provide the needed reactive power. This will minimize the amount of reactive power, and thus total power, that generated by the utilities. There is some mathematical representation on how to calculate the improved power factor (Dr. G. Thomas Bellarmine, 1997). Power factor improvement by capacitor addition have several advantages which are minimize the reactive component of the network hence the total current in the system from the source end. Besides that, the reduction in current will cause the I^2R power losses are reducing in the system. The increasing of voltage level at the load end and also the kVA stacking on the source generators as additionally on the transformers and lines up to the capacitors diminishes giving limit help. Furthermore, in utilising the full capacity of your electrical system a high power factor may be help. To minimize loss reduction within the plants distribution network and hence benefit to the user by minimize consumption will help by installing capacitors at suitable location.

2.7.1 Calculation of kVar demand

Below is the equation (2.2) to calculate the capacity, in MVar or kVar of the capacitor bank that needed to improve the power factor from pf_1 (actual power factor) to pf_2 (target power factor).

$$Q_{cap} = P \text{ x } [(\text{sq rt } (1-pf_1^2)/pf_1) - (\text{sq rt } (1-pf_2^2)/pf_2)] \quad (2.2)$$

2.7.2 Using kVar Multiplier

Table 2.7a below shows the multiplication factors which are to be multiplying with the input power (kW) to give the kVar of capacitance that required to improve the present power factor to a new desired power factor. Hence, the procedures of using Table 2.7a are follows:

a) Locate (original power factor) in column (1)

b) Read across desired power factor to 0.85 column. Then find the multiplier

c) Multiply (average kW) by multiplier (b) = value of kVar

d) Installed the value of calculate kVar (c) to improved power factor to 95%

Original Power Factor	Corrected Power Factor 0.8	0.81	0.82	0.83	0.84	0.85	0.86	0.87	0.88	0.89	0.9	0.91	0.92	0.93	0.94	0.95	0.96	0.97	0.98	0.99	1.0
0.50	0.982	1.008	1.034	1.060	1.086	1.112	1.139	1.165	1.192	1.220	1.248	1.276	1.306	1.337	1.369	1.403	1.440	1.481	1.529	1.589	1.732
0.51	0.937	0.962	0.989	1.015	1.041	1.067	1.094	1.120	1.147	1.175	1.203	1.231	1.261	1.292	1.324	1.358	1.395	1.436	1.484	1.544	1.687
0.52	0.893	0.919	0.945	0.971	0.997	1.023	1.050	1.076	1.103	1.131	1.159	1.187	1.217	1.248	1.280	1.314	1.351	1.392	1.440	1.500	1.643
0.53	0.850	0.876	0.902	0.928	0.954	0.980	1.007	1.033	1.060	1.088	1.116	1.144	1.174	1.205	1.237	1.271	1.308	1.349	1.397	1.457	1.600
0.54	0.809	0.835	0.861	0.887	0.913	0.939	0.966	0.992	1.019	1.047	1.075	1.103	1.133	1.164	1.196	1.230	1.267	1.308	1.356	1.416	1.559
0.55	0.769	0.795	0.821	0.847	0.873	0.899	0.926	0.952	0.979	1.007	1.035	1.063	1.093	1.124	1.156	1.190	1.227	1.268	1.316	1.376	1.519
0.56	0.730	0.756	0.782	0.808	0.834	0.860	0.887	0.913	0.940	0.968	0.996	1.024	1.054	1.085	1.117	1.151	1.188	1.229	1.277	1.337	1.480
0.57	0.692	0.718	0.744	0.770	0.796	0.822	0.849	0.875	0.902	0.930	0.958	0.986	1.016	1.047	1.079	1.113	1.150	1.191	1.239	1.299	1.442
0.58	0.655	0.681	0.707	0.733	0.759	0.785	0.812	0.838	0.865	0.893	0.921	0.949	0.979	1.010	1.042	1.076	1.113	1.154	1.202	1.262	1.405
0.59	0.619	0.645	0.671	0.697	0.723	0.749	0.776	0.802	0.829	0.857	0.885	0.913	0.943	0.974	1.006	1.040	1.077	1.118	1.166	1.226	1.369
0.60	0.583	0.609	0.635	0.661	0.687	0.713	0.740	0.766	0.793	0.821	0.849	0.877	0.907	0.938	0.970	1.004	1.041	1.082	1.130	1.190	1.333
0.61	0.549	0.575	0.601	0.627	0.653	0.679	0.706	0.732	0.759	0.787	0.815	0.843	0.873	0.904	0.936	0.970	1.007	1.048	1.096	1.156	1.299
0.62	0.516	0.542	0.568	0.594	0.620	0.646	0.673	0.699	0.726	0.754	0.782	0.810	0.840	0.871	0.903	0.937	0.974	1.015	1.063	1.123	1.266
0.63	0.483	0.509	0.535	0.561	0.587	0.613	0.640	0.666	0.693	0.721	0.749	0.777	0.807	0.838	0.870	0.904	0.941	0.982	1.030	1.090	1.233
0.64	0.451	0.474	0.503	0.529	0.555	0.581	0.608	0.634	0.661	0.689	0.717	0.745	0.775	0.806	0.838	0.872	0.909	0.950	0.998	1.068	1.201
0.65	0.419	0.445	0.471	0.497	0.523	0.549	0.576	0.602	0.629	0.657	0.685	0.713	0.743	0.774	0.806	0.840	0.877	0.918	0.966	1.026	1.169
0.66	0.388	0.414	0.440	0.466	0.492	0.518	0.545	0.571	0.598	0.626	0.654	0.682	0.712	0.743	0.775	0.809	0.846	0.887	0.935	0.995	1.138
0.67	0.358	0.384	0.410	0.436	0.462	0.488	0.515	0.541	0.568	0.596	0.624	0.652	0.682	0.713	0.745	0.779	0.816	0.857	0.905	0.965	1.108
0.68	0.328	0.354	0.380	0.406	0.432	0.458	0.485	0.511	0.538	0.566	0.594	0.622	0.652	0.683	0.715	0.749	0.786	0.827	0.875	0.935	1.078
0.69	0.299	0.325	0.351	0.377	0.403	0.429	0.456	0.482	0.509	0.537	0.565	0.593	0.623	0.654	0.686	0.720	0.757	0.798	0.846	0.906	1.049
0.70	0.270	0.296	0.322	0.348	0.374	0.400	0.427	0.453	0.480	0.508	0.536	0.564	0.594	0.625	0.657	0.691	0.728	0.769	0.817	0.877	1.020
0.71	0.242	0.268	0.294	0.320	0.346	0.372	0.399	0.425	0.452	0.480	0.508	0.536	0.566	0.597	0.629	0.663	0.700	0.741	0.789	0.849	0.992
0.72	0.214	0.24.0	0.266	0.292	0.318	0.344	0.371	0.397	0.424	0.452	0.480	0.508	0.538	0.569	0.601	0.635	0.672	0.713	0.761	0.821	0.964
0.73	0.186	0.212	0.238	0.264	0.290	0.316	0.343	0.369	0.396	0.424	0.452	0.480	0.510	0.541	0.573	0.607	0.644	0.685	0.733	0.793	0.936
0.74	0.159	0.185	0.211	0.237	0.263	0.289	0.316	0.342	0.369	0.397	0.425	0.453	0.483	0.514	0.546	0.580	0.617	0.658	0.706	0.766	0.909
0.75	0.132	0.158	0.184	0.210	0.236	0.262	0.289	0.315	0.342	0.370	0.398	0.426	0.456	0.487	0.519	0.553	0.590	0.631	0.679	0.739	0.882
0.76	0.105	0.131	0.157	0.183	0.209	0.235	0.262	0.288	0.315	0.343	0.371	0.399	0.429	0.460	0.492	0.526	0.563	0.604	0.652	0.712	0.855
0.77	0.079	0.105	0.131	0.157	0.183	0.209	0.236	0.262	0.289	0.317	0.345	0.373	0.403	0.434	0.466	0.500	0.537	0.578	0.626	0.685	0.829
0.78	0.052	0.078	0.104	0.130	0.156	0.182	0.209	0.235	0.262	0.290	0.318	0.346	0.376	0.407	0.439	0.473	0.510	0.551	0.599	0.659	0.802
0.79	0.026	0.052	0.078	0.104	0.130	0.156	0.183	0.209	0.236	0.264	0.292	0.320	0.350	0.381	0.413	0.447	0.484	0.525	0.573	0.633	0.776
0.80	0.000	0.026	0.052	0.078	0.104	0.130	0.157	0.183	0.210	0.238	0.266	0.294	0.324	0.355	0.387	0.421	0.458	0.499	0.547	0.609	0.750
0.81		0.000	0.026	0.052	0.078	0.104	0.131	0.157	0.184	0.212	0.240	0.268	0.298	0.329	0.361	0.395	0.432	0.473	0.521	0.581	0.724
0.82			0.000	0.026	0.052	0.078	0.105	0.131	0.158	0.186	0.214	0.242	0.272	0.303	0.335	0.369	0.406	0.447	0.495	0.555	0.698
0.83				0.000	0.026	0.052	0.079	0.105	0.132	0.160	0.188	0.216	0.246	0.277	0.309	0.343	0.380	0.421	0.469	0.529	0.672
0.84					0.000	0.026	0.053	0.079	0.106	0.134	0.162	0.190	0.220	0.251	0.283	0.317	0.354	0.395	0.443	0.503	0.646
0.85						0.000	0.027	0.053	0.080	0.108	0.136	0.164	0.194	0.225	0.257	0.291	0.328	0.369	0.417	0.477	0.620
0.86							0.000	0.026	0.053	0.081	0.109	0.137	0.167	0.198	0.230	0.264	0.301	0.342	0.390	0.450	0.593
0.87								0.000	0.027	0.055	0.083	0.111	0.141	0.172	0.204	0.238	0.275	0.316	0.364	0.424	0.567
0.88									0.000	0.028	0.056	0.084	0.114	0.145	0.177	0.211	0.248	0.289	0.337	0.397	0.540
0.89										0.000	0.028	0.056	0.086	0.117	0.149	0.183	0.220	0.261	0.309	0.369	0.512
0.90											0.000	0.028	0.058	0.089	0.121	0.155	0.192	0.233	0.281	0.341	0.484
0.91												0.000	0.030	0.061	0.093	0.127	0.164	0.205	0.253	0.313	0.456
0.92													0.000	0.031	0.063	0.097	0.134	0.175	0.223	0.283	0.426
0.93														0.000	0.032	0.066	0.103	0.144	0.192	0.252	0.395
0.94															0.000	0.034	0.071	0.112	0.160	0.220	0.363
0.95																0.000	0.037	0.079	0.126	0.186	0.329
0.96																	0.000	0.041	0.089	0.149	0.292
0.97																		0.000	0.048	0.108	0.251
0.98																			0.000	0.060	0.203
0.99																				0.000	0.143
																					0.000

Table 2.7a: The multiplication factors kVar (Dr. G. Thomas Bellarmine,1997)

2.8 Major power stations and grid system in Malaysia

According to Electricity Supply Industry in Malaysia Figure 2.8a shows the location of major Power Stations and grid system in Peninsular Malaysia, Figure 2.8b shows the location of major Power Stations and grid system in Sabah and Figure 2.8c shows the location of major Power Stations and grid system in Sarawak [19].

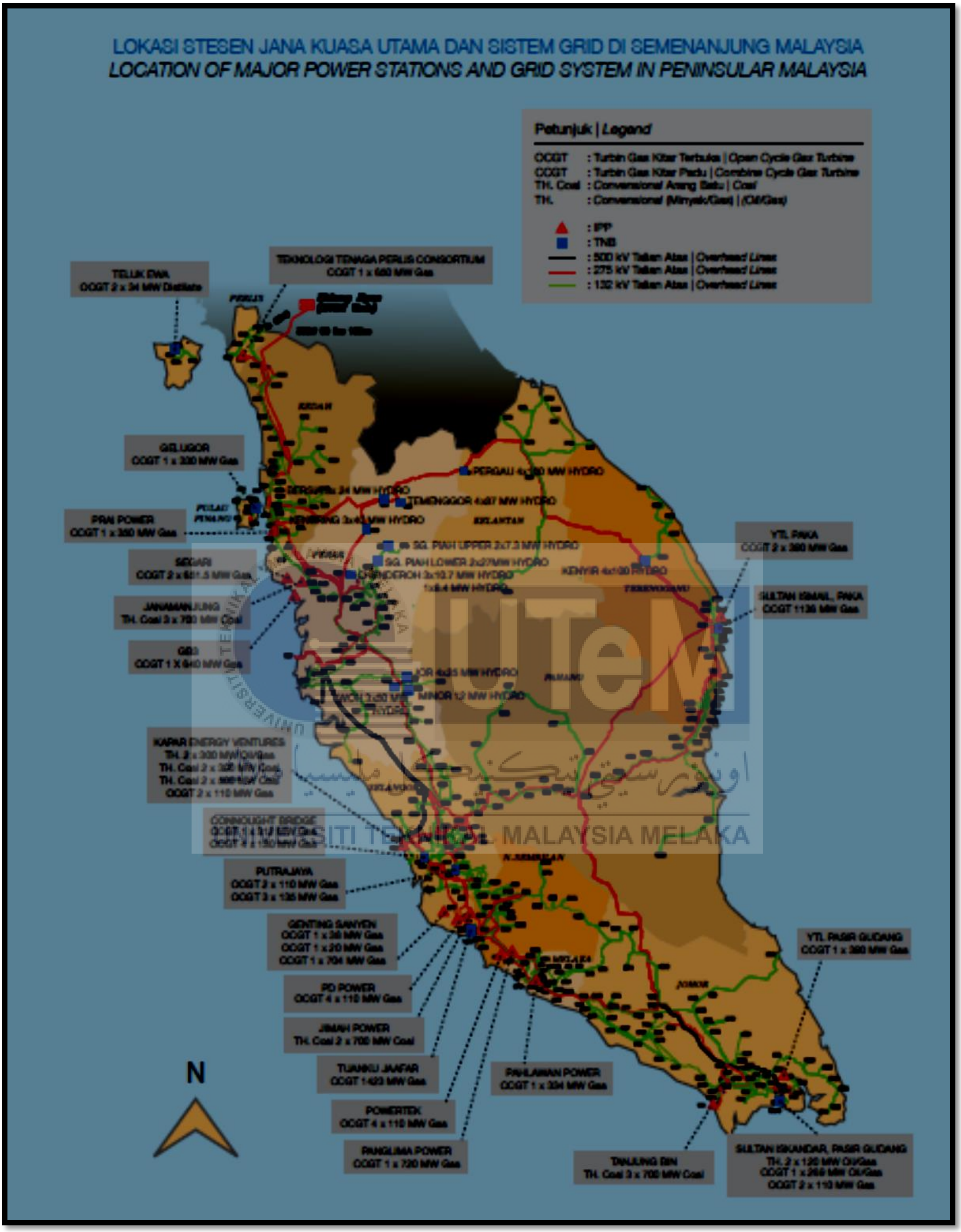


Figure 2.8a: Location of major Power Stations and grid system in Peninsular Malaysia

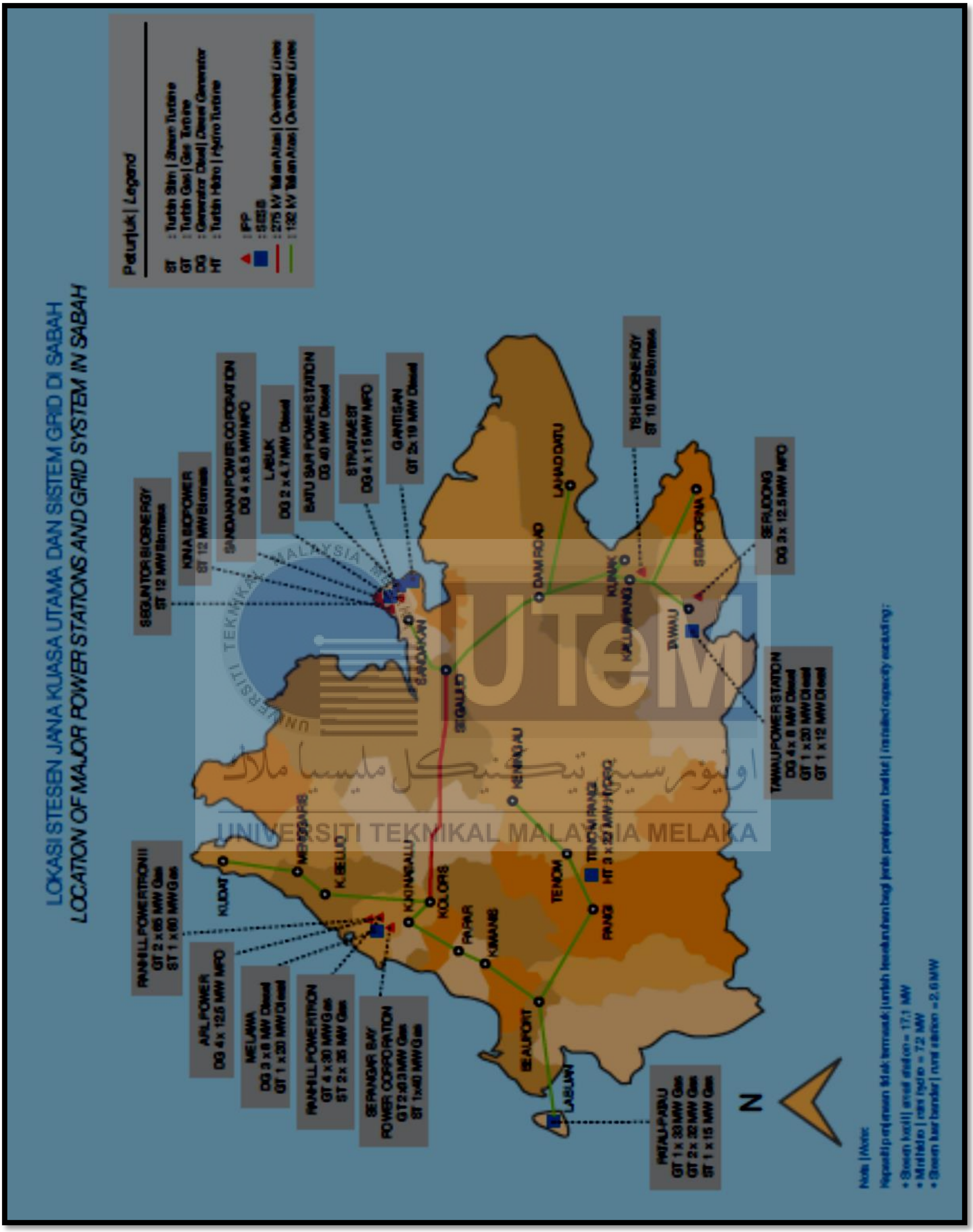


Figure 2.8b: Location of major Power Stations and grid system in Sabah

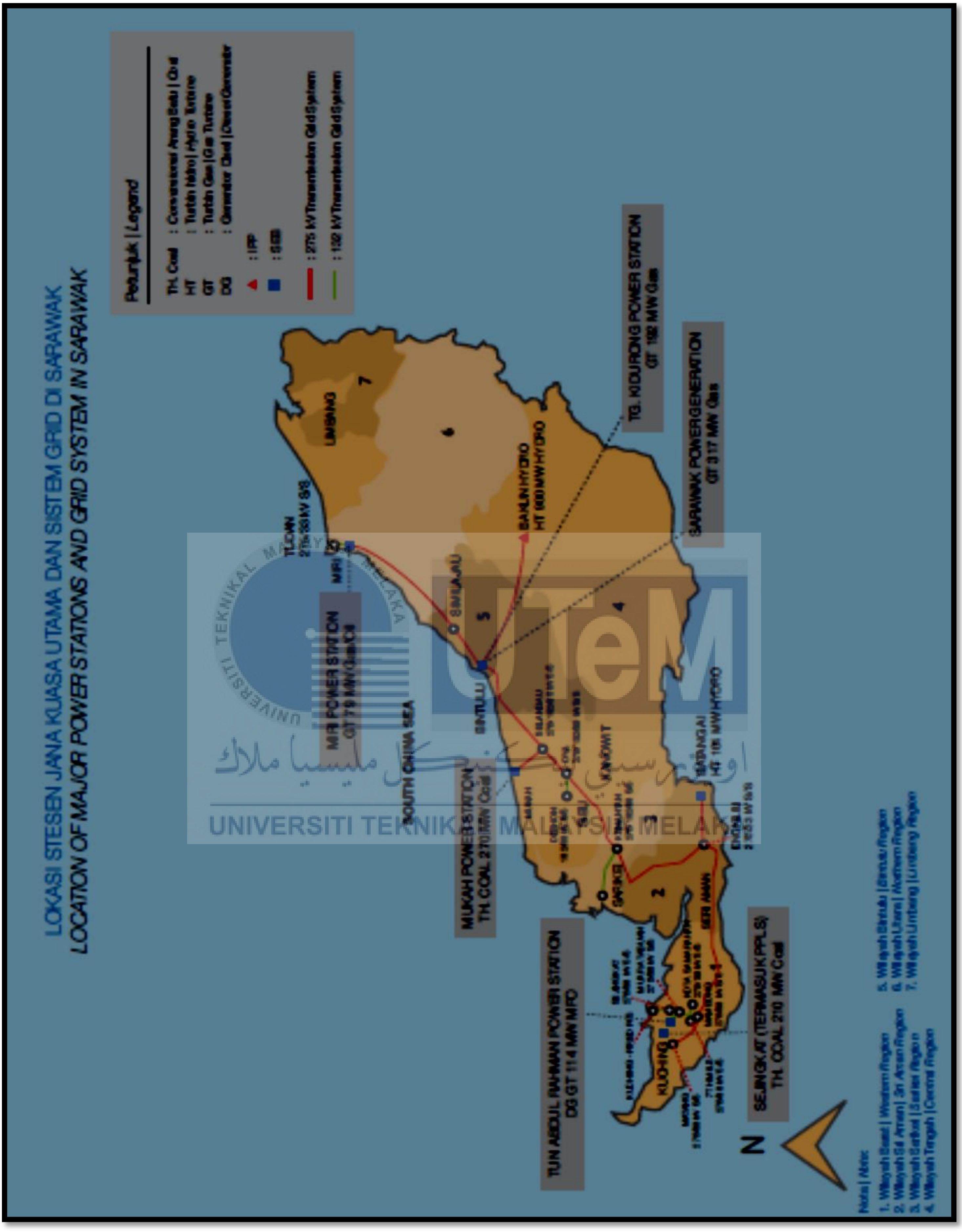


Figure 2.8c: Location of major Power Stations and grid system in Sarawak

CHAPTER 3

METHODOLOGY

3.0 Introduction

This chapter is about overall process when doing my project on assessment of islanding mode performance towards better power utilization in smart grid system. The process will follow step by step from the objectives. Then, the process will go depth explanations one by one.

3.1 Research Methodolgy

For the first objective, the circuit design of smart grid will be constructed and the performance of power factor will be focus in the transmission line losses. But before that, the simulation will run and the performance of power factor at the busses will occur when the output load was varies. 5 buses had been used in this circuit. 5 buses mean that the substation in the electrical grid distributes the electricity power to the consumers. The substation is on the rural area. The circuit of Figure 3.1a shows the sketching modelling circuit of smart grid with power factor and the first objective achieved.

For the second objective, the condition of intentional islanding mode by opening the switch of DG at one of the busses of the circuit and the performance of power factor will be focus at the transmission line losses. The circuit of Figure 3.1b shows the sketching modelling circuit when becoming an intentional islanding mode with power factor at the transmission line.

For the third objective, this project will analyze for both of two results and the possible improvement method will be recommended on power factor correction during intentional islanding if exist. If the power factor at the transmission line losses is below from 0.85 refers to Malaysia's standard of TNB the power factor will be improved but if the power factor is upper from 0.85 and be the perfect power factor is 1.00, so the power factor correction will not be occurred.

Last but not least my expected outcome is to improve method on power factor correction if exist during intentional islanding towards better power utilization in smart grid system.

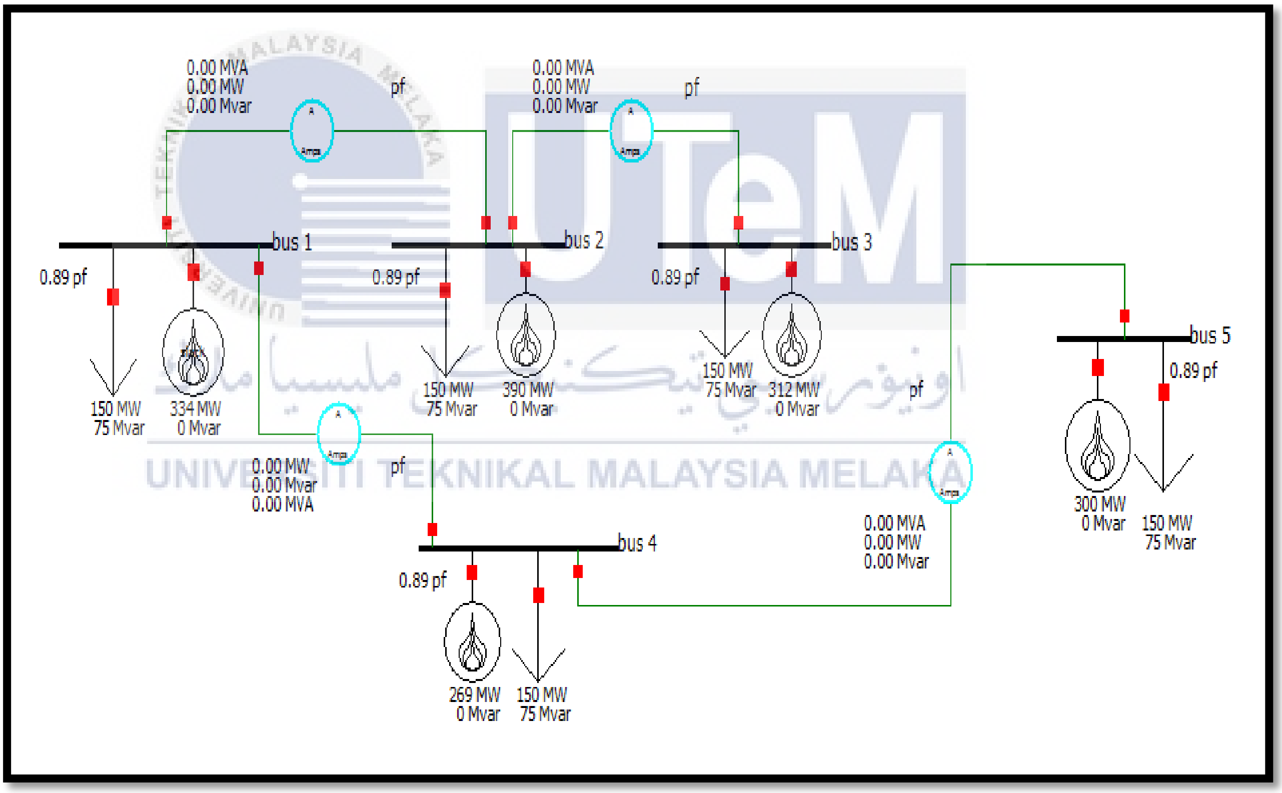


Figure 3.1a: Modelling circuit of Smart grid with power factor

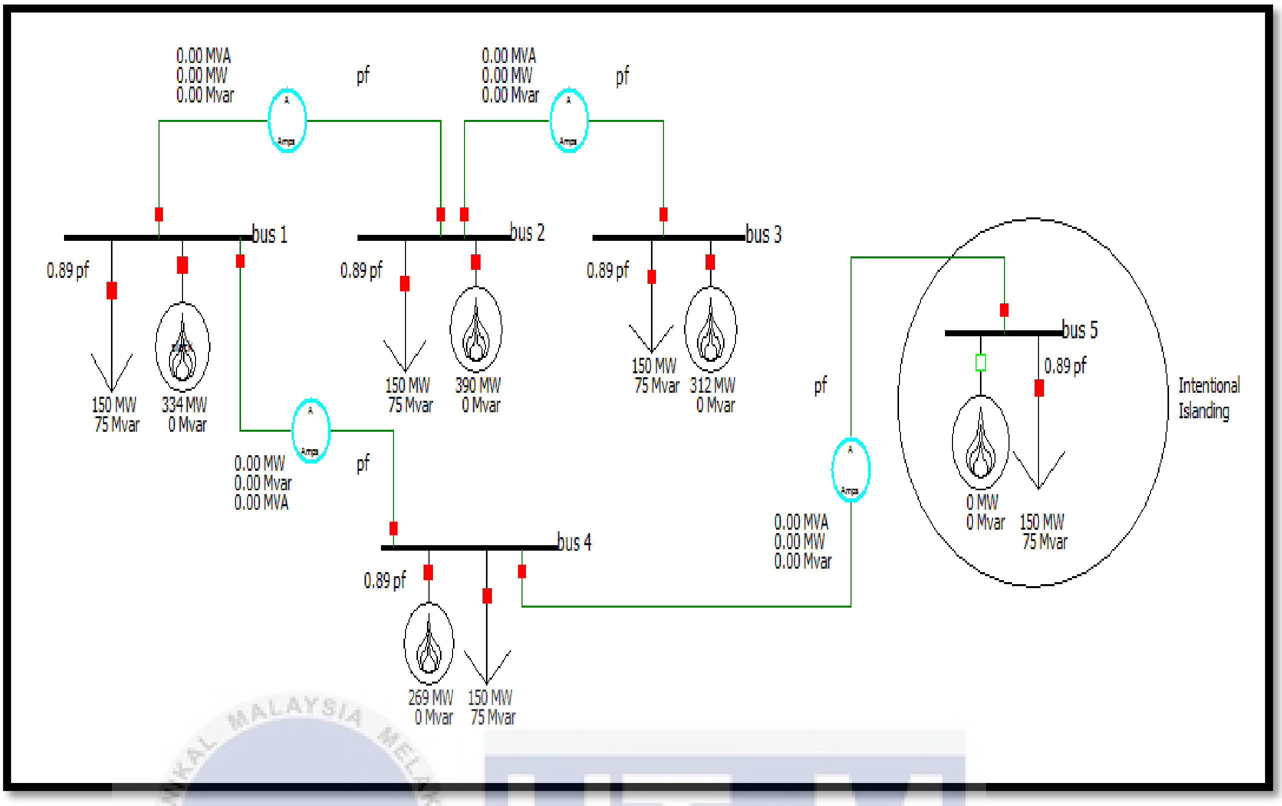
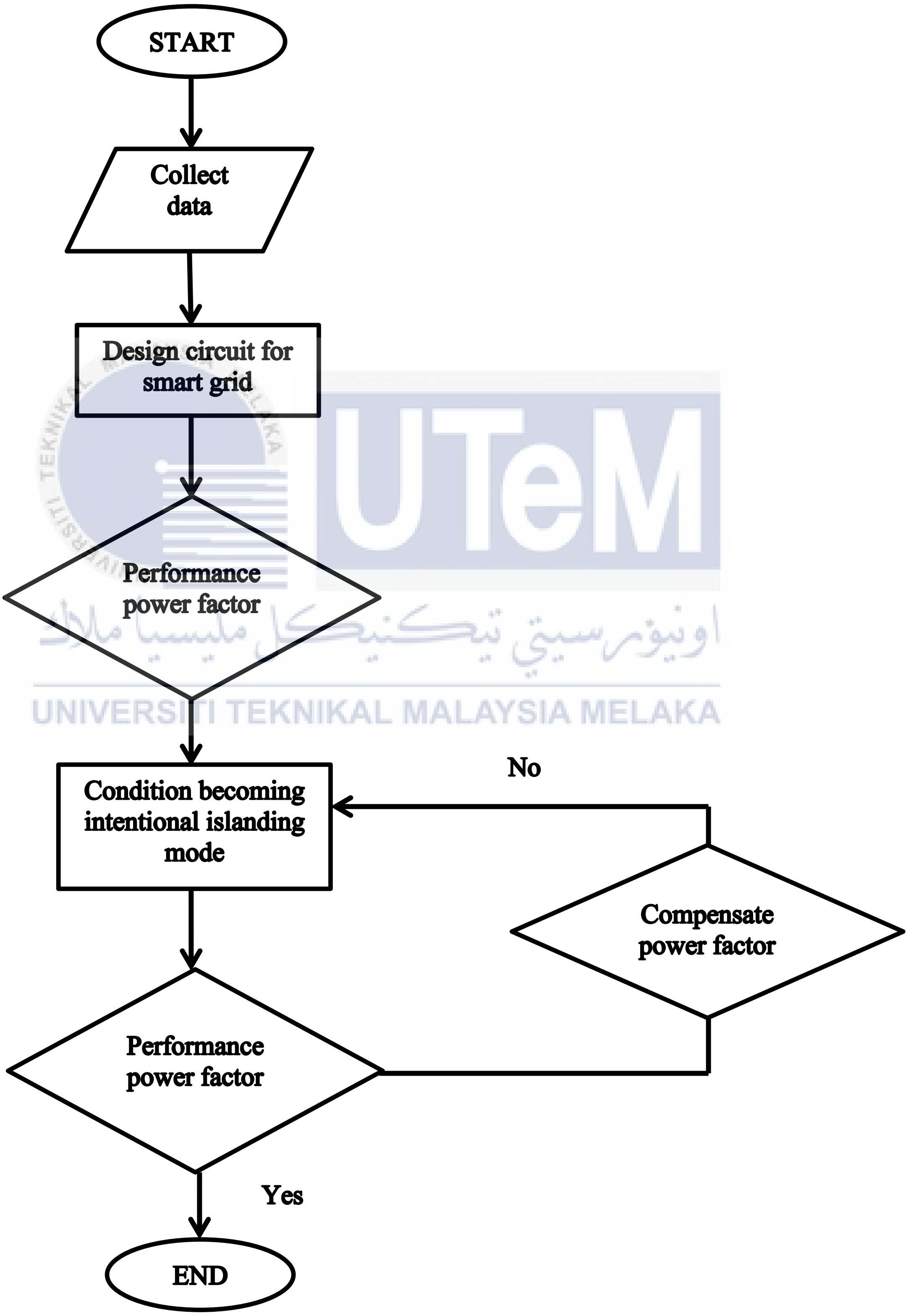


Figure 3.1b: Modelling circuit when becoming intentional islanding with power factor at the transmission line

3.2 Research Flow Chart

Below is the overall flow chart of my project. The process from start to end.



CHAPTER 4

RESULTS AND DISCUSSION

4.0 Introduction

This chapter is overall details what are the findings outcome for my project. It will discuss thoroughly the meaning of the entire findings outcome.

4.1 One-line diagram for original setting

Figure 4.1a shows the schematic one-line diagram for the original setting of the 5 bus smart grid system drawn by using the powerWorld software. 5 buses had been used in this circuit. All the value of DG, Load, Transmission line and bus was set in the circuit before the simulation run.

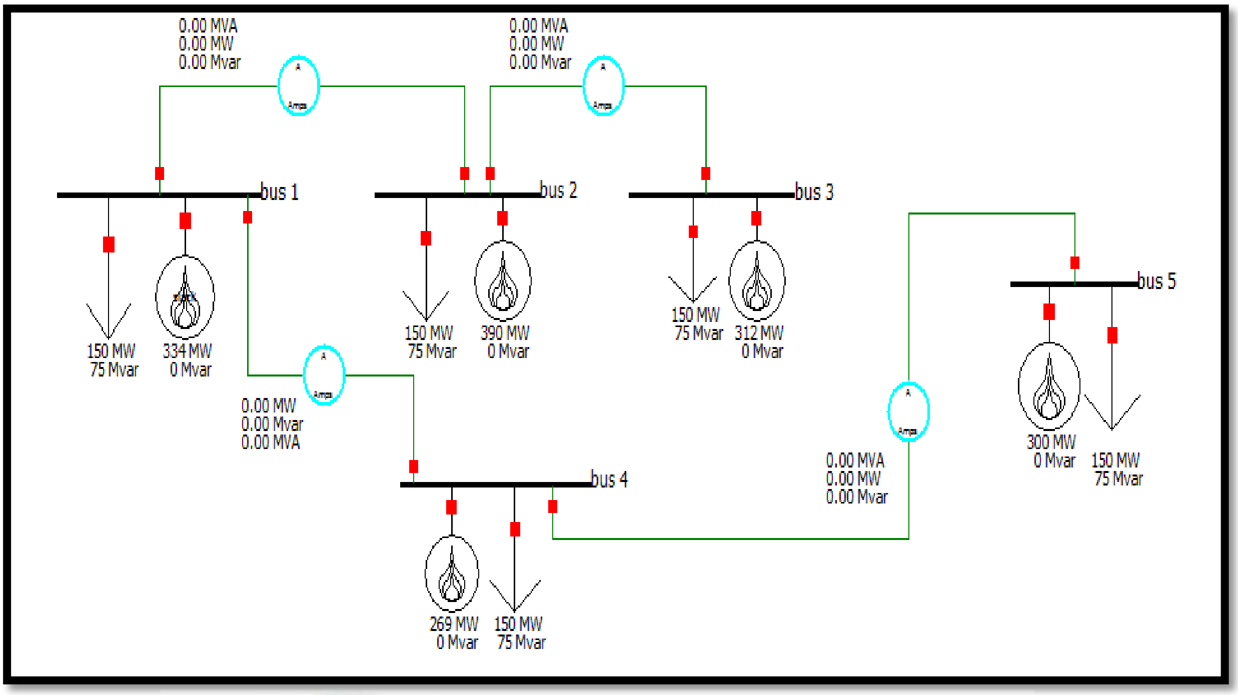


Figure 4.1a: Schematic one-line diagram for the 5 bus smart grid system

The entire component values are set by the powerWorld software and the value of generator are set according to the value of TNB of grid system in Peninsular Malaysia. Table 4.1a shows all the components value for the original setting in tabulated form.

Component	MW Output	Mvar Output	Load	
			MW Output	Mvar Output
Generator 1	334	0	150	75
Generator 2	390	0	150	75
Generator 3	312	0	150	75
Generator 4	269	0	150	75
Generator 5	300	0	150	75

Bus No	Nominal Voltage (kV)	Bus (p.u)	Angle
1	11	1.00	0.000
2	11	1.00	0.000
3	11	1.00	0.000
4	11	1.00	0.000
5	11	1.00	0.000

Line	Line Voltage (kV)	R (p.u)	X (p.u)
1 to 2	11 to 11	0.18	0.20
2 to 3	11 to 11	0.18	0.20
1 to 4	11 to 11	0.18	0.20
4 to 5	11 to 11	0.18	0.20

Table 4.1a List of components of the original setting

4.2 Power flow results

4.2.1 Smart grid system with power factor

After the original setting for the smart grid system was stimulated, all the busses were set to the fixed power factor which is standard substation of TNB is 0.85. The load will play the main role as varies the output to get the power factor to 0.85. Figure 4.2a shows the result of smart grid system with varies power factor to 0.85. Hence, the value for the MW for generator, MVar for generator, MW for transmission line, MVar for transmission line, MVA for transmission line and power factor at all transmission line was obtained and was recorded at tabulated form below. Figure 4.2b is the result of smart grid system design with power factor at transmission line after the powerWorld software was run and the following Table 4.2a show all the data obtained by respectively.

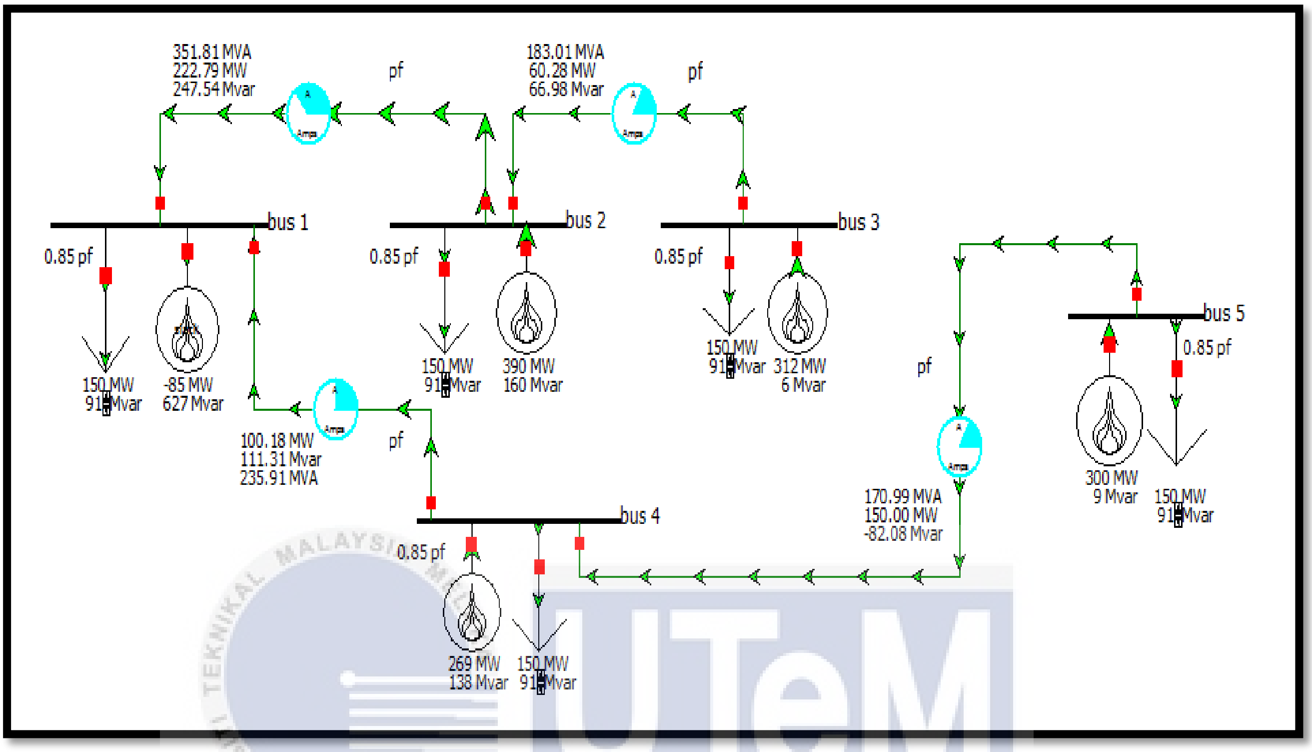


Figure 4.2a: Result of smart grid system with varies power factor to 0.85

Bus No	**MW at Load**	**MVar at Load**	**MW at Generator**	**MVar at Generator**
1	-85	627	150	91
2	390	160	150	91
3	312	6	150	91
4	269	138	150	91
5	300	9	150	91

Table 4.2a Data obtained by result of smart grid system when varies power factor to 0.85

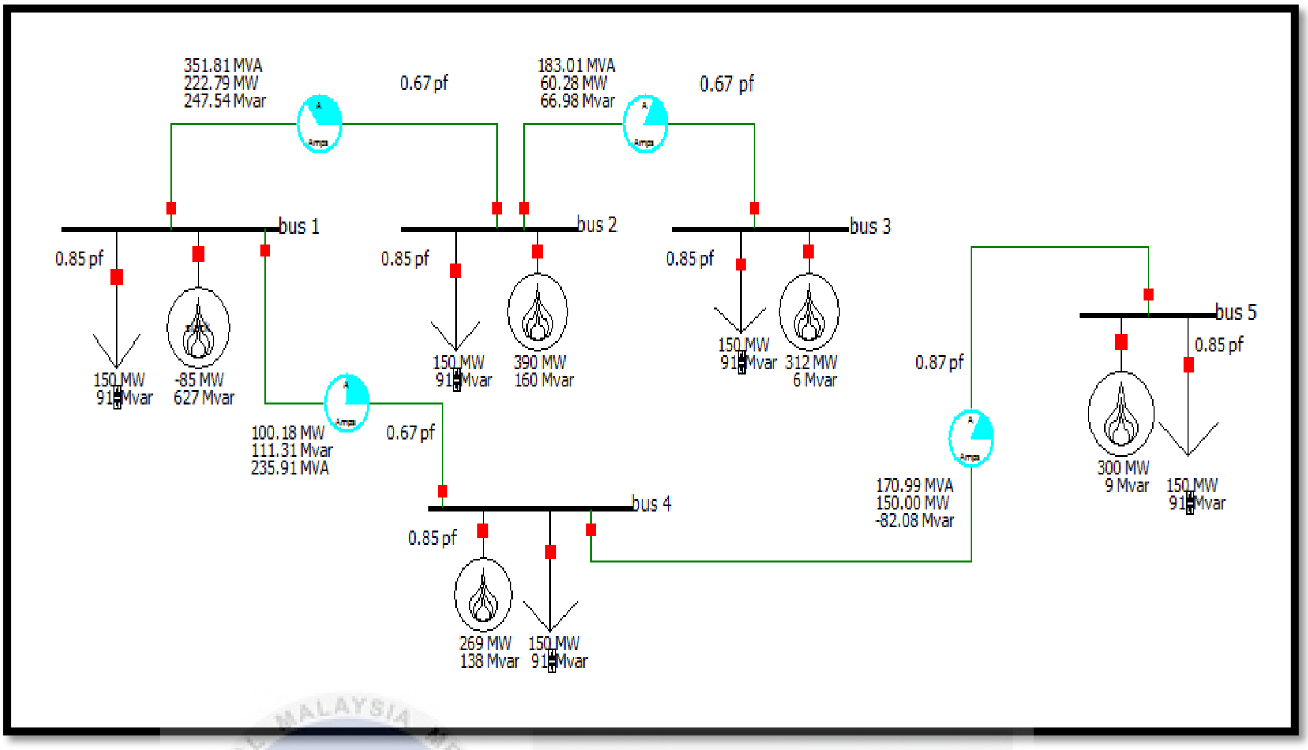


Figure 4.2b: Result of smart grid system with power factor at transmission line

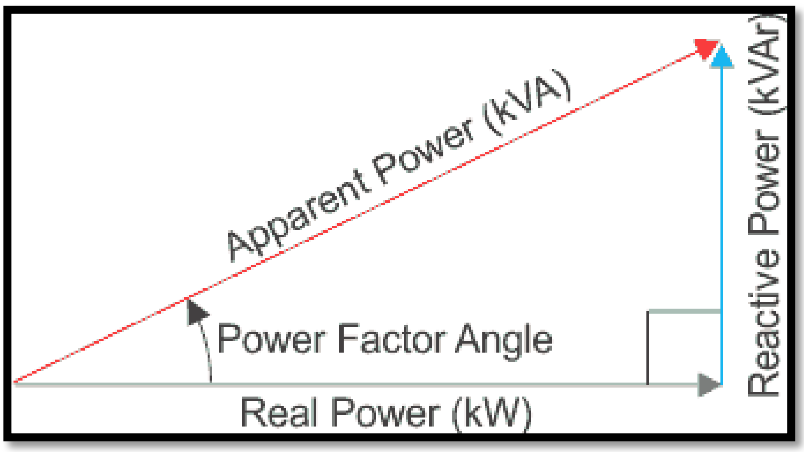
Bus No	MW at Generator	MVar at Generator
1	-85	627
2	390	160
3	312	6
4	269	138
5	300	9

Bus No	MW at Transmission line	MVar at Transmission line	MVA at Transmission line	Power Factor at Transmission line
1 to 2	222.79	247.54	351.81	0.67
2 to 3	60.28	66.98	183.01	0.67
1 to 4	100.18	111.31	235.91	0.67
4 to 5	150.00	-82.08	170.99	0.87

Table 4.2b Data obtained by result of smart grid system

4.2.1.1 Calculation of power factor for each transmission line

Below is the calculation of power factor for each transmission line. Start from bus 1 to 2, bus 2 to 3, bus 1 to 4 and bus 4 to 5. The calculation was referring to the formula of power triangle that had been shown below.



Bus 1 to 2

$\emptyset = \tan^{-1}((Q/P))$

$= \tan^{-1}((247.54MVar/222.79MW))$

$= 48^{\circ}$

$pf = \cos(48^{\circ})$

$= 0.67$

Bus 2 to 3

$\emptyset = \tan^{-1}((Q/P))$

$= \tan^{-1}((66.98MVar/60.28MW))$

$= 48^{\circ}$

$pf = \cos(48^{\circ})$

$= 0.67$

Bus 1 to 4

$\emptyset = \tan^{-1}((Q/P))$

$= \tan^{-1}((111.31MVar/100.18MW))$

$= 48^{\circ}$

$pf = \cos(48^{\circ})$

$= 0.67$

Bus 4 to 5

$\emptyset = \tan^{-1}((Q/P))$

$= \tan^{-1}((82.08MVar/150.00MW))$

$= 29^{\circ}$

$pf = \cos(29^{\circ})$

$= 0.87$

4.2.2 Smart grid system when becoming intentional islanding at bus 5 with power factor at their transmission line

Figure 4.2c is the result when becoming intentional islanding of smart grid system design with power factor at their transmission line at bus 5 in the powerWorld software. The focus intentional islanding is on bus 5 when the DG of their own busses will open and hence the values of the MW for generator, MVar for generator are 0. MW for transmission line, MVar for transmission line, MVA for transmission line and power factor at transmission line 4 to 5 was obtained and was recorded at tabulated form below. Table 4.2b show all the data obtained by respectively.

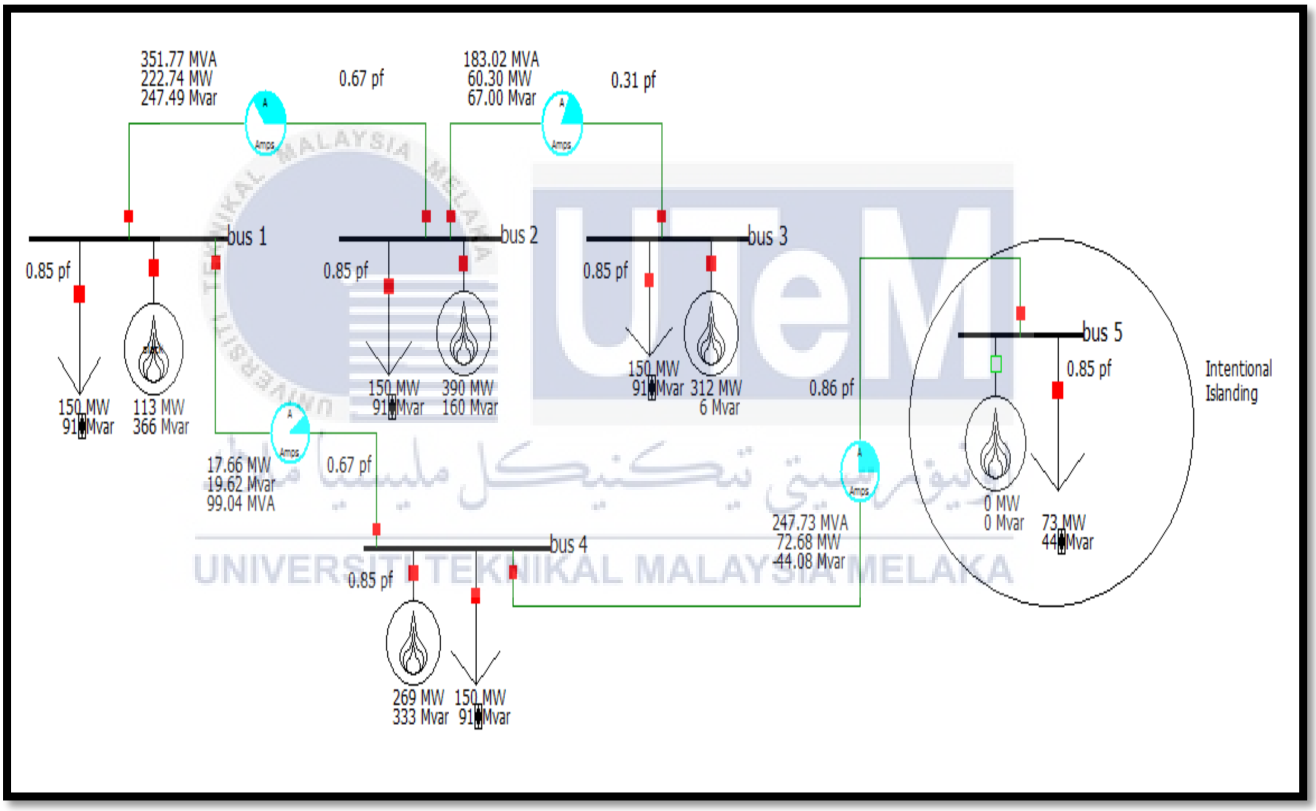


Figure 4.2c: Result when becoming intentional islanding of smart grid system with power factor at the transmission line bus 5

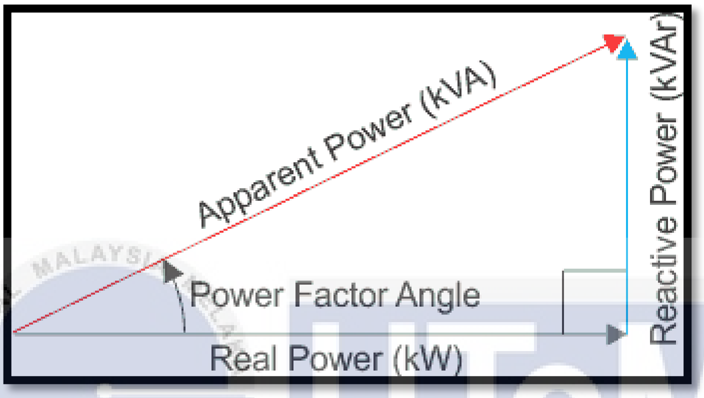
Bus No	MW at Generator	MVar at Generator
1	113	366
2	390	160
3	312	6
4	269	333
5	0	0

Bus No	MW at Transmission line	MVar at Transmission line	MVA at Transmission line	Power Factor at Transmission line
1 to 2	222.74	247.49	351.77	0.67
2 to 3	60.30	183.02	60.30	0.31
1 to 4	17.66	19.62	99.04	0.67
4 to 5	72.68	-44.08	247.73	0.86

Table 4.2c: Data obtained by result when becoming intentional islanding of smart grid system

4.2.2.1 Calculation of power factor of transmission line at bus 5 when becoming intentional islanding

Same goes to 4.2.1.1 below is the calculation of power factor for each transmission line. Start from bus 1 to 2, bus 2 to 3, bus 1 to 4 and bus 4 to 5. The calculation was referring to the formula of power triangle that had been shown below.



<u>Bus 1 to 2</u>

$\emptyset = \tan^{-1}((Q/P))$

$= \tan^{-1}((247.49MVar/222.74MW))$

$= 48^o$

$pf = \cos(48^o)$

$= 0.67$

<u>Bus 2 to 3</u>

$\emptyset = \tan^{-1}((Q/P))$

$= \tan^{-1}((183.02MVar/60.30MW))$

$= 72^o$

$pf = \cos(72^{o})$

$= 0.31$

<u>Bus 1 to 4</u>

$\emptyset = \tan\text{-}1\ ((Q/P))$

$= \tan\text{-}1\ ((19.60 MVar/17.66 MW))$

$= 48^{o}$

$pf = \cos(48^{o})$

$= 0.67$

<u>Bus 4 to 5</u>

$\emptyset = \tan\text{-}1\ ((Q/P))$

$= \tan\text{-}1\ ((44.08 MVar/72.68 MW))$

$= 31^{o}$

$pf = \cos(31^{o})$

$= 0.86$

4.3 Analysis results

Based on Table 4.2a, the results shown the power factor at the transmission line for bus 1 to 2, bus 2 to 3 and 1 to 4 are 0.67. For bus 4 to 5 the power factor at the transmission line is 0.87. This is because at bus 1, 2 and 4 has 2 transmission line that attached on it while for bus 3 and 5 has only 1 transmission line that attached on it. The value for power factor at transmission line was calculated using the formula of trigonometric triangle. Besides that, the value of power factor refers to the losses at the transmission line. In theoretically, when the Q which is the losses (MVar) is higher than P (MW) the power factor will decrease. If the Q which is the losses (MVar) is lower than P (MW) the power factor will increase.

Refer to the Figure 4.2c, the situation of intentional islanding happens when there is repairing maintenance at the bus and automatically the power at the bus means the switch of DG will open and cannot supply the power. Hence, the load at bus 5 still can be operate as usual because of it will get the supply power from the line that attached at the transmission line which is transmission line on bus 4 to 5. The performance of power factor at transmission line at bus 4 to 5 will be consider.

Based on Table 4.2b, the value of DG at the bus 5 is 0 according to open circuit. The results shown the power factor at the transmission line for bus 1 to 2, bus 1 to 4 are 0.67. For bus 2 to 3 the power factor at the transmission line is 0.31 and for bus 4 to 5 is 0.86 this is because of losses at the transmission line. The value for power factor at transmission line was calculated using the formula of trigonometric triangle. It shown that at the transmission line 4 to 5 the differences of P (MW) and Q (MVar) are significantly difference. In theoretically, when the P (MW) higher than Q (MVar) the power factor will consider good which is higher than 0.85.

Comparing to this results which at bus 5 when on smart grid system and becoming intentional islanding, the power factor only difference 0.01. Hence, there will not been improvement method on power factor correction during intentional islanding towards better power utilization in smart grid system since the power factor after becoming intentional islanding was consider good.

CHAPTER 5

CONCLUSION AND FUTURE WORK

5.0 Introduction

This chapter is about overall of what is doing and what had been done and also conclusion on overall project. Besides that, future work on what that can possible outcome that other method can be continuous doing this project by others researcher.

5.1 Conclusion

The simulation had been run using powerWorld software. The entire objective had been done. Firstly, model a smart grid with power factor and using PowerWorld software. The model as circuit design is using 5 bus, 5 DG and 4 transmission lines. First of all, the simulation will run and the performance of power factor at the busses will occur. Then, the power factor at the bus will set to 0.85 according to TNB standard substation. It will set with varies the load at each of the bus. 5 buses mean the substation that distributes the electricity power to the consumers. All the value of power factor transmission line must be calculated according to the value of MW losses at transmission line and MVar losses at transmission line. The value of power factor at transmission line cannot occur automatically as the value power factor at the bus. Hence, the first objective was achieved.

Secondly, investigate the effect on power factor during intentional islanding in smart grid system. This is the condition when the service must shut down according to repairing maintenance at the substation. The circuit condition of intentional islanding mode by opening the switch of DG at one of the busses of the circuit and the performance of power factor will be focus at the transmission line losses. At this situation, the switch of DG at bus 5 was open. Then, the value of power factor transmission line at bus 4 to 5 must be calculated according to the value of MW losses at transmission line and MVar losses at transmission line. The value of power factor at transmission line cannot occur automatically as the value power factor at the bus. Hence, the second objective was achieved.

Then, the performance of power factor at transmission line at bus 4 to 5 will be focus when in the condition of smart grid and when becoming intentional islanding mode. Since the value of power factor is slightly different 0.01 and still on the range of power factor for distribution of TNB. If the power factor at the transmission line losses is below from 0.85 refers to Malaysia's standard of TNB the power factor will be improved but if the power factor is upper from 0.85 and be the perfect power factor is 1.00, so the power factor correction will not be occurred. Hence, the third objective was achieved.

Lastly, the recommend the possible improvement method on power factor correction during intentional islanding towards better power utilization in smart grid system. Since, the value of power factor during intentional islanding is 0.86 and before becoming intentional islanding which is on smart grid system is 0.87, hence the improvement method on power factor correction during intentional islanding does not occur.

5.2 Future Work

5.2.1 Different Load

When the load is use in different value what is the value of power factor at the busses, the MW for generator, MVar for generator, MW for transmission line, MVar for transmission line, MVA for transmission line and also performance power factor at all transmission line. If the load is different, the losses which is Q (MVar) will effect or not and if the Q (MVar) difference it will effect or not to the powr factor at the transmission line.

5.2.2 Add more DG at each bus

When the DG at each bus is added more what is the value of power factor at the busses, the MW for generator, MVar for generator, MW for transmission line, MVar for transmission line, MVA for transmission line and also performance power factor at all transmission line. If the load is different, the losses which is Q (MVar) will effect or not and if the Q (MVar) difference it will effect or not to the powr factor at the transmission line.

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