UNIVERSITI TEKNIKAL MALAYSIA MELAKA

ASSESSMENT ON THE IMPACT OF DISTRIBUTED GENERATION ON GRID'S POWER FACTOR COMPENSATION BY USING POWER WORLD SOFTWARE

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

Lecturer

ABSTRAK

Penjanaan Teragih digunakan secara meluas di dalam industri utiliti kerana dapat mengurangkan kesan rumah hijau, mengurangkan kemelesetan elektrik, meningkatkan keselamatan grid dan mengurangkan bill utiliti. Panel photovoltaic, turbin angin dan roda tenaga adalah beberapa contoh penjanaan teragih. Penjanaan teragih boleh disalurkan melalui grid ataupun tidak melalui grid tetapi penyelidikan ini hanya menumpukan kepada saluran melalui grid. Malangnya, penjanaan teragih mempunyai kapasiti yang rendah berbanding penjanaan konvensional yang sedia ada. Tetapi penjanaan teragih sangat berguna untuk menyokong penjanaan ke kawasan yang jauh dari pusat penjanaan untuk mengurangkan kehilangan kuasa. Setiap penjanaan teragih mempunyai parameter tersendiri contohnya nilai regangan yang tentunya menghasilkan kuasa reaktif kepada pengguna. Terdapat 3 jenis kuasa elektrik iaitu kuasa sebenar, kuasa reaktif dan kuasa jelas. Kesemua kuasa tersebut berkait dengan sudut kuasa dan faktor kuasa yang menjadi penyukat kecekapan pengagihan tenaga. Semakin kurang faktor kuasa akan meningkatkan arus punca min persegi seterusnya menyebabkan peralatan utility menjadi panas. Kesemua parameter boleh di simulasi dengan menggunakan perisian Powerworld. Perisian tersebut boleh disimulasikan berdasarkan reka bentuk litar penjanaan, penghantaran dan beban grid kebangsaan. Simulasi tersebut akan mendedahkan dengan jelas tentang hubungan antara penjanaan teragih dan faktor kuasa. Oleh yang demikian, kajian in akan mencadangkan cara terbaik untuk pemasangan penjanaan teragih ke grid tanpa atau mengurangkan pembaikan faktor kuasa dengan simulasi.

ABSTRACT

Distributed Generation are widely used in utility industries due to not produce greenhouse gasses, less electricity loss, improves grid security and lower utility bills. Photovoltaic panels, wind turbines and flywheels are the example of distributed generation. Distributed Generation can be transmit on grid or off grid but in this research it mainly focused on the on grid transmission. Unfortunately, Distributed generation has small capacity rather than conventional generation but it really useful to support the generation in rural area that far from the generator to reduce power losses. Every distributed generation has different parameters such as reactance due to different actuators used that surely produce reactive power to the consumer. There are 3 types of electrical powers that is real power, reactive power and apparent power. All these power much related to the power angle and power factor that indicates the efficiency of power generation. It stated that the lower the power factor will increase the current RMS that will lead to overheat he utility equipment. All the parameter can be simulated easily by using Power World Software. The software simulates all parameters in generators, transmission lines and load by design the suitable circuit diagram of national grid. The simulation will provide a clear view about the relationship between distributed generation and power factor. Besides that, this research will suggest the best way to install the distributed generation without or decrease the power factor compensation of the grid with the simulation.

DEDICATION

I would like to present this research to my family
for giving me all the inspiration
and support I need.

ACKNOWLEDGEMENT

First and foremost, I humbly express my gratefulness to Allah s.w.t with praised for His blessing, kind and compassionate for giving me the opportunity to perform this research. Not forgettable, I would like to express my very great appreciation to my parents especially my father Mr. Kahar bin Sariaat for his support in all side as he have a lot of experience in electrical world and also my mother Mrs. Suriati binti Roslan for her prayer every day. Besides that, I would like to express my deep gratitude to my supervisor, Mr. Adlan bin Ali for his time and precious ideas in helping me to construct the journey to complete the Bachelor Degree Project I. He inspired me so much as he never stop to encourage and support me with his priceless knowledge, unforgettable experience and beautiful advices in success to run the research. I would like to thanks United Kingdom Generic Distribution System (UKGDS) as they provide guidance and examples parameters in a conventional grid. Next, I would like to thanks all staffs and lecturers of Faculty of Engineering Technology that participate for giving opportunity to contribute to this Bachelor Degree Project I. lastly I would like to thank to my fellow friends that directly and indirectly give support, guidance and encouragement. Without their guidance and continuous help, this Bachelor Degree Project will not meet the success.

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AC	-	Alternating Current
ASEAN	-	Association of Southeast Asian Nations
ATE	-	Average Thermal Efficiency
BLDC	-	Brushless Direct Current Machine
CO_2	-	Carbon dioxide
DC	-	Direct Current
DFIG	-	Double Field Induction Generator
DG	-	Distributed Generation
DSP	-	Digital Signal Processor
EAF	-	Equivalent Availability Factor
EU	-	European Union
EUOF	-	Equivalent Unplanned Outage Factors
FIFA	-	Fédération Internationale de Football Association
FiT	-	Feed-in Tariff
GWh	-	Giga-Watt hour
Hz	-	Hertz
ICT	-	Information and Communication Technology
IEC	-	International Electrotechnical Commission
ITIF	-	Information Technology and Innovation Foundation
IGBT	-	Insulated-gate Bipolar Transistor
kg	-	kilogram
ktoe	-	kilo toe
LCL	-	Inductor-Capacitor-Inductor
LNG	-	Liquefied Natural Gas
MFO	-	Medium Fuel Oil
MHD	-	Magnetohydrodynamic
MW	-	Mega Watt
NaS	-	Sodium Sulphate

$PbSO_4$	-	Lead Sulphate
PCC	-	Point of Common Coupling
PEMFC	-	Proton Exchange Membrane Fuel Cell
PF	-	Power Factor
PMSM	-	Permanent Magnet Synchronous Machines
PV	-	Photovoltaic
PWM	-	Pulse Width Modulation
Q	-	Reactive Power
RE	-	Renewable Energy
rpm	-	revolution per minute
SCAG	-	Squirrel Cage Asynchronous Generator
TNB	-	Tenaga Nasional Berhad
V-A	-	Voltage-Ampere
VSC	-	Voltage Source Converter
WECS	-	Wind Energy Conversion System
+	-	Cathode
-	-	Anode

CHAPTER 1
INTRODUCTION

1.1 Introduction

This section provide the explanation about the background, problem statement, objective, scope and organisation of this project report.

1.2 Background of Project

For the next decades, world will see a big approaches to energy transition challenges to be faced by industrial country and developing country. In industrial countries, the tough challenge might be carbon reduction. This can be done with continuous effort to have greater penetration of energy with energy storage as back up. An aggressive step towards electricity should be continued since most of renewable energy nowadays are adopted as preferred energy source. Societies also must play their role to maintain a positive thinking for next generation to have a better quality of their lives. It is no longer the time for the present societies to steal nature resources of future generations. For developing countries, the challenge must be faced to have a better quality of life. The existing information worldwide continues to achieve these ambitions. It is accepted that improving the quality of life will provide better access to energy. Therefore, the challenge will be how to deal with the challenge without causing damage to environment.

The renewable energies are one of the distributed generation (DG) that can be defined as electric power generation within distribution networks or on the consumer side networked. Penetration of DG into an existing grid can result in a lot of benefits. The benefits are reduce line losses, reduce environmental damage, increased energy efficiency, reduce transmission and distribution crowding, voltage support, and produce smart investments to upgrade existing generation, transmission, and distribution systems. However there is less study has been done to investigate the power factor effect in transmission line after penetrating DG. This is important, since different type of DG using different type of machines as their actuator. Since the machines not only generates real power but also reactive power that effect drop of power angle. Therefore the impact of penetration of DG to grid's power factor need to be investigated and simulated. This report will explain the important of power factor in grid and potential effect if installing DG into grid.

1.3 Problem statement

Distributed generation (DG) is a small capacity power plants based on combustion based technologies, such as reciprocating engines and turbines, and non-combustion based technologies such as flywheels, photovoltaics, wind turbines, etc (P., K., Ganesh, 2013). Normally DG contributes small capacity generation about less than 100MW. According to Ke, Jiqing, Tong, Bo (2011), the penetration of DG into an existing utility can result in several benefits. These benefits include reduction of line loss, reduced environmental destruction, peak shaving, increased energy efficiency, relieved transmission and distribution congestion, voltage support, and lower investments to upgrade existing generation, transmission, and distribution systems.

In the other hand, power loss normally caused at distributed grid and transmission grid. This loss is depends by the current and the impedance of the grid (Wang,Lan, 2011). The location of penetration of DG also would be influence the power loss of the grid. Since DG has many types of sources, there must be different actuators to use and different way in causing decrease of power factor. There are conventional and non-conventional DG that usually use to connect to the grid according to Alka Yadav, Laxmi Srivastava (2014). Devices like Permanent Magnet Synchronous Machines (PMSM) is using as an actuator for micro turbine (Li, 2010). The machines itself contain an inductive load that produce reactive power to transmission line. Same goes to an asynchronous generator that being used in wind turbine (Haan, Frunt, Kling, 2010) and brushless DC machines (BLDC) in flywheels generation (Archana, Homi, 2013). Mostly past research state that there are some issues of the actuators used generates reactive powers as long as real powers.

The higher the reactive power, the higher the power angle thus power factor will drop. According to Suma, L., Usha (2014), power factor indicates how efficient the equipment generates power from the utility. When the power factor reduced in operation for a given voltage and power level, the current flow by the equipment will be large, thus utility requiring higher V-A ratings of the equipment such as transformers, transmission lines and generators. The efficiency of the distribution network is reduced by presence of reactive and distortion powers which produce high RMS currents. As the result, resulting extra losses lead will forced utility to use bigger size of copper area of the distribution power wires.

1.4 Objectives of Projects

The first objective of this project is to analyse the power factor compensation at the conventional grid without DG. The analysis must be made to have the initial condition of conventional grid's power factor and easily observe the different after adding DG.

The second objective of this project is to expose the impact of DG penetration such as photovoltaic (PV), wind turbine, batteries, micro-turbines and flywheel on grid's power factor compensation by referring to the conventional power generation and distribution. Since DG has no problem to be installed anywhere in the grid, the penetration of DG must be made in many ways to observe the different behavior of power factor.

The third objective is to suggest the suitable way for penetration of DG in maintaining the power factor compensation. This can be succeed by varies the capacity of DG or find the most suitable bus to penetrate the DG in the simulation.

1.5 Scope of Projects

This project will construct a grid system models as an example of grid system in Malaysia. Every parameters and devices use for simulation in the project are partly referring TNB Technical Guidebook on Grid-interconnection of Photovoltaic Power Generation, The Malaysian code(2012), renewable energy(technical & operational Requirements) Rules 2011 and IEC 61727. This is important for reference in future studies and improvement of Malaysian National Grid with DG compensation.

For the model of the power system, this project are referring the design of KLIA distribution grid since there use their own generators, transmission lines and substations. The parameters in this simulation mostly referring to United Kingdom Generic Distribution System (UKGDS) since there are limitation to find the parameter in Malaysia's Grid. This project only covers certain part of the power system due to software limitation. The Power world Software licensed only for evaluation and university educational use. The software is limited to 13 bus bars even though the real transmission is more than that, this project will cover until the maximum bus bar that the software support. This project also only cover the effect of power factor compensation by adding DG to the grid. This project not covered others effect of adding DG to existing grid such as high dispatch mode if their penetration and affect the load forecasting result as the writer states in previous studies. This project only cover the constant generation and load in steady state condition. This project not cover the comparison of generation with DG of working day and holiday. This project also not covering the difference of power factor when peak hours and normal. Other than that, this project also not covering the unexpected load from event such as FIFA world cup or other event that using high unexpected load. This projects will find the best place to install DG without interrupting power factor compensation.