UNIVERSITI TEKNIKAL MALAYSIA MELAKA

ASSESSMENT ON THE IMPACT OF DISTRIBUTED GENERATION (DG) PENETRATION ON GRID PROTECTION SYSTEM

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

by

FAZLIANA BINTI AHMAD BUDERI

B071210145

911227-06-5018

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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) (Hons.). The member of the supervisory is as follow:

……………………………….

(Project Supervisor)

ABSTRACT

Distributed Generation (DG) is the generation of electricity from multiple renewable energy sources and is located closer to the user, or load. These days the DGs is developing rapidly because of the advantages it could bring into the system such as enhance the transmission efficiency energy as well as reduction of climate change. However, the penetration of a DG to the existing distribution system potentially may contributes too many impacts, with the power system protection being one of the major issues. This is because renewable energy sources, such as solar or wind-power generating systems produce intermittent electrical energy that is not fully compatible with existing electrical grid protection systems. The introduction of a DG into a distribution system brings about a change in the fault current level of the system and causes many impacts in the protection system, such as false tripping of protective devices, protection blinding, an increase and decrease in short circuit levels, undesirable network islanding and out of synchronism reclosers. The main goal of this assessment is to investigate the possible impacts that may occur on the grid protection system with the presence of the DG. In this assessment, different cases of simulation have been developed in the Power System Computer Aided Design (PSCAD) regarding to the distribution network without and with the presence of DG on the system and the results from this both cases have been compared. Based on the results from this assessment, penetration of DG increases the level of the fault current eventually causes the affect towards the unit and non-unit protection in the system. This condition leads to two main problems in protection system which are protection blinding and loss of coordination or sympathetic tripping. In the future works, author intended to find a suitable solution in order to mitigate either blinding of protection or loss of coordination/sympathetic tripping problems that arise when the DG is penetrated to the distribution network.

ABSTRAK

Penjanaan Teragih merupakan salah satu penjanaan elektrik yang dihasilkan daripada sumber tenaga boleh diperbaharui dan ditempatkan berhampiran dengan pengguna atau beban. Pada masa kini, pembangunan Penjanaan Teragih berada pada tahap yang tinggi memandangkan ia telah mendatangkan banyak kebaikan kepada sistem kuasa itu sendiri. Antaranya ialah dapat mengurangkan beban permintaan daripada pengguna selain dapat meningkatkan kecekapan talian penghantaran. Namun begitu, kehadiran Penjanaan Teragih telah mendatangkan pelbagai kesan teknikal terutamanya terhadap sistem perlindungan di dalam sistem kuasa. Ini kerana tenaga boleh diperbaharui menghasilkan tenaga yang tidak stabil di mana ia tidak sesuai digunakan untuk sistem perlindungan grid konvensional. Selain itu, Penjanaan Teragih juga telah menyebabkan perubahan tahap arus ketika kerosakan di dalam sistem perlindungan dan ia memberikan kesan terhadap penyelarasan alat perlindungan arus lebihan. Oleh yang demikian, melalui pembelajaran ini beberapa simulasi berdasarkan beberapa senario yang berbeza telah dilakukan di dalam perisian "Power System Computer Aided Design (PSCAD)". Simulasi ini dilakukan berdasarkan talian pengagihan tanpa kehadiran Penjanaan Teragih dan juga dengan kehadiran Penjanaan Teragih seterusnya analisis akan dijalankan berdasarkan keputusan yang telah diperolehi melalui simulasi ini. Analisis ini akan menentukan beberapa kesan yang jelas terhadap sistem perlindungan apabila Penjanaan Teragih ini diletakkan di dalam sistem kuasa. Berdasarkan kepada keputusan simulasi tersebut, pemasangan Penjanaan Teragih di atas talian penghantaran telah menyebabkan arus ketika kerosakan meningkat dan telah membawa dua implikasi terhadap sistem perlindungan iaitu *"Blinding of Protection"* dan *"Loss of Coordination/Sympathetic Tripping"*. Pada masa hadapan, penulis bercadang untuk mencari beberapa solusi yang sesuai untuk mengatasi masalah *"Blinding of Protection"* dan *"Loss of Coordination/Sympathetic Tripping"* ini.

DEDICATIONS

To my beloved parents

Late Mother

Noriah Binti Hj Abd Rahman

Father

Ahmad Buderi Bin Hj Nipah

Siblings

Mohd Hafifi

Farahanim

Fahira

Mohd Hafizam

Muhammad Hafizul Helmi

Farahanum

Fathin Hanani

Farisyawati

For the love.

For the prayers, supports and encouragement.

Thank you very much.

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First and foremost, I would like to express my appreciation and gratefulness to Allah SWT for His blessing and giving the opportunity to conduct this case study. Never be the last, I would like to express my deepest gratitude to my family, especially to my late mother who motivated me a lot to complete this Bachelor Degree Project. Besides that, I would like to express my deepest appreciation to my respected supervisor, Mr Adlan Bin Ali, for his most precious and valuable supervision, advice and constructive criticism from the very early stage of this Bachelor Degree Project as well as giving me extraordinary knowledges and experiences throughout the learning period. Above all and the most needed, he provided me with unflinching encouragement and support in many ways. In addition, I would like to seize the opportunity to thank to all parties who have been participating and contribute during this Bachelor Degree Project. Not to be forgotten, I would like to offer my earnest gratitude to Faculty of Engineering Technology for giving me opportunity to participate in this project. Without their guidance and persistent help, this Bachelor Degree Project program would not have been possible to accomplish effectively. Those directly and indirectly support, guidance and encouragement from all parties will always be an unforgettable experiences and it would be very useful for my future upon the completion of my Bachelor Degree Project.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLE

LIST OF SYMBOLS AND ABBREVIATIONS

AC	=	Alternating Current
CH_4	=	Methane
CO_2	=	Carbon Dioxide
DC	=	Direct Current
DG	=	Distributed Generation
EC	=	Energy Commission
GHG	=	Green House Gases
IDMT	=	Inverse Definite Minimum Time
kV	=	Kilo-volt
MVA	=	Mega Voltage-Ampere
N_2O	=	Nitrous Oxide
PSCAD	=	Power System Computer Aided Design
RE	=	Renewable Energy
TNB	=	Tenaga Nasional Berhad

CHAPTER 1

INTRODUCTION

1.0 Background of Project

In the past hundred years, the fossil fuel was the only sources of energy that could hit the spot of user's electricity and energy demand. However, the depletion of fuel reserve and towards maintaining electrical supply security for next generation has made certain countries changing their direction to Renewable Energy (RE). In Malaysia, the contribution of RE into the energy mix help to reduce the reliance on the imported fuels and this option also help to boost the energy security in our country. On the hand, the mitigation of climate change made the Malaysia Government to take several initiative towards the usage of clean generator based on the RE sources in order to reduce the greenhouse gases (GHG) such as Carbon Dioxide (CO_2), Methane (CH_4) and Nitrous Oxide (N_2O) on the nature.

Renewable generation connected on the distribution network or Distributed Generation (DG) is believed to be the best possible way to supply electricity and at the same time reducing the climate change effect. When DG has been widely promoted in terms of generating electricity for the customers, careful considerations need to be taken to generate and supply the electricity to the customer securely and reliably. Initially power systems purpose is to provide electricity in a way to be economically and reliably but need not to forget, supply security and reliability is the priority, therefore it leads to power system investment becoming expensive due to huge investment in protection systems. This shows a direct relationship between power systems and protection system, therefore the impact of DG to protection systems when it is connected to the main grid especially at distribution level need to be assessed and investigated before further steps to be taken. Further in this report explained about some important details about protection systems and several potential impacts that could take place on a network with DG connected.

1.1 Problem Statement

Yadav and Srivastava (2014) suggested that Distributed Generation (DG) is the generation of electricity from small scale of generation and is located closer to the user, or customer which is commonly at the distribution level. These days DG technology is developing rapidly because of the advantages it could bring into the system such as enhance the transmission efficiency energy as well as reduction of climate change. However, the penetration of a DG to the existing distribution system potentially may contribute too many impacts, with the power system protection being one of the major issues. According to the study response by Gevorkian (2011), renewable energy sources, such as solar or wind-power generating systems produce intermittent electrical energy that is not fully compatible with existing electrical grid protection systems. Moreover, the intermittent sources of DG also contributes to vary the value of source impedance on the network (George et al. (2013)).

According to Javadian (2010), the level of fault current in the system could change as the penetration of DG on the system eventually causes several impacts to the protection system, such as false tripping of protective devices, protection blinding, loss of coordination of the protective devices, undesirable network islanding and unsynchronized reclosing.

Nevertheless, some problems will arise when the new generation is integrated in the power distribution network, because the distribution system is not supplied by a single main power source and it is no longer radial in nature. Hence, it will affects the coordination of over-current protection as the increasing of fault current contribution on the system (Mashau (2011)). With DG in a distribution network, the final becomes active and causes the power flows and fault currents may have new directions (Kumpulainen and Kauhaniemi (2004)). Thus, in order to ensure safe and selective protection devices coordination, the impact of DG to the system need to be considered when planning the interconnection of DG on the grid system.

1.2 Objectives of Project

In the assessment of the impact of DG penetration on the grid protection system, the specific objectives could be:

- To calculate and simulate the magnitude of fault current without presence of DG on the grid system using Power System Computer Aided Design (PSCAD) software.

- To calculate and simulate the magnitude of fault current with presence of DG on the grid system using Power System Computer Aided Design (PSCAD) software.

- To investigate the potential problems that may occur on the grid protection system with the presence of the distributed generation.

1.3 Scope of Project

This assessment would be focusing on the renewable energy (RE) and impact of on-grid distributed generation (DG) protection system. In order to assess this condition, several models are going to develop in Power System Computer Aided Design (PSCAD) software. The simulations are based on two main cases; firstly in Case 1, the test system is analyzed without the presence of Distributed Generation (DG) on the distribution network and the Case 2, the test system is analyzed with the presence of Distributed Generation (DG) on the distribution network. The simulation results then will be compared with the calculation results based on the developed model.

1.4 Organization of Report

In this project report, the first chapter discussing about the background of a project, problem statement, objectives of project and scope of the project. In chapter two, the literature review which acts as the references of the project to be reviewed. The architecture and description of flow chart explained in the third chapter. However, in chapter four the results of the project are presented along with its discussion and analysis. Lastly in the chapter five, the assessment have come out with a conclusion and the recommendation are presented for the future planning.

1.5 Summary

This chapter is about the background of the project and the problem statement which encouraged this project to be conducted. The aims of this assessment also discussed in this chapter. In addition, the scope also discussed in order to ensure this assessment was conducted systematically according to its objectives.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

In this chapter, the purposes of literature review are to discuss about the renewable energy in Malaysia, different types of DG technologies and their application in power system. Besides that, this chapter discuss the property of scheme protection criteria in power system. The information obtained through the researches are used to conduct this assessment.

2.1 Generation and Demands Scenarios in Malaysia

2.1.1 Power Supply Generation Trends

Figure 2.1.1(a) and Figure 2.1.1(b) shows the generation trends of energy supply in Malaysia for the period from 1990 to 2012. According to the graph, coal's share indicates slightly increment from 46.6 percent in 2011 to 48.3 percent in 2012. Then, it was followed by the natural gas which is slightly increased from 39.3 percent to 39.4 percent, hydro at 7.3 percent, diesel 2.8 percent, fuel oil 1.9 percent and 0.2 percent for renewable energy. The increase of the electricity generation is due to the higher growth of energy consumption in our country. As the result, strong growth of energy supply and demand was recorded in the end of year 2012. According to National Energy Balance (2012), total primary energy supply and final energy consumption recorded a growth of 5.9 percent and 7.5 percent.

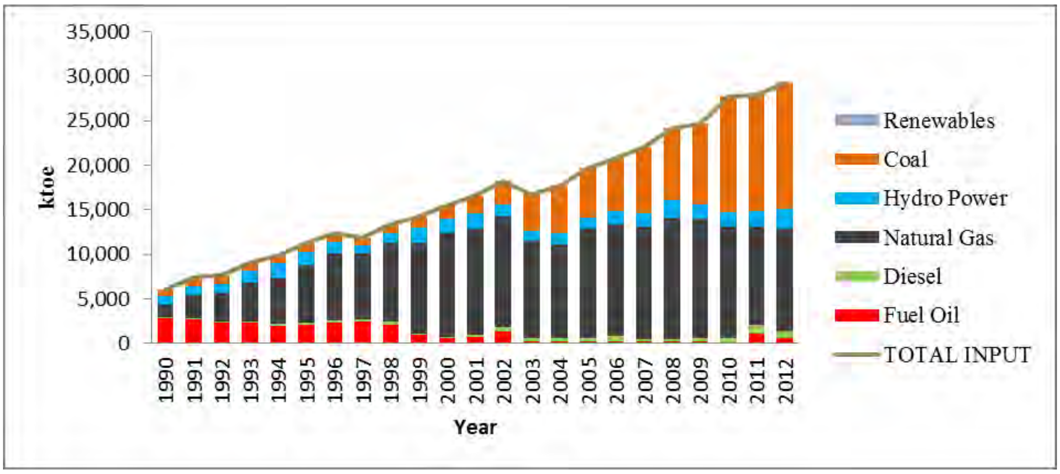

Figure 2.1.1(a): Malaysia Installed Generation Capacity (in ktoe)
(Source: National Energy Balance 2012)

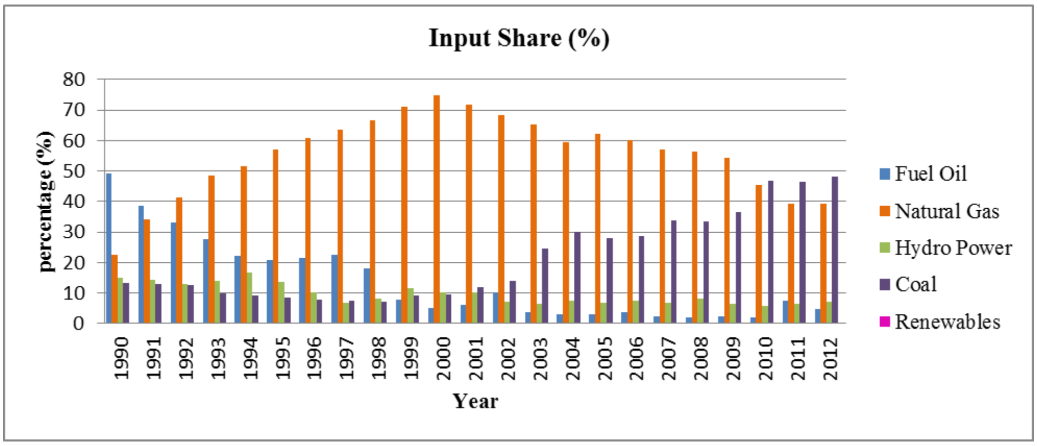

Figure 2.1.1(b): Malaysia Input Share of Generation (in %)
(Source: National Energy Balance 2012)

2.1.2 Final Energy Demand by Sectors

According to Malaysia Energy Statistics Handbook (2014) and National Energy Balance (2012) provided by Energy Commission (EC), Table 2.1.2 below summarized the energy consumption by sectors in Malaysia for the period from 1990 to 2012.

Table 2.1.2: Final Energy Demand by Sectors
(Source: National Energy Balance 2012)

Year	Final Energy Demand by Sectors (ktoe)				
	Industrial	Transport	Agriculture	Non-Energy	Residential and Commercial
1990	5,300	5,386	0	838	1,622
1991	5,835	5,806	130	1,071	1,721
1992	6,455	6,226	391	1,222	1,891
1993	7,012	6,558	62	2,027	2,069
1994	7,486	7,262	422	1,817	2,300
1995	8,341	7,827	446	2,994	2,556
1996	9,838	8,951	486	1,744	3,162
1997	10,106	10,201	490	2,298	3,072
1998	10,121	9,793	307	2,023	3,314
1999	10,277	11,393	106	1,799	3,653
2000	11,406	12,071	104	2,250	3,868
2001	11,852	13,138	98	2,378	4,049
2002	12,854	13,442	96	2,511	4,387
2003	13,472	14,271	98	2,345	4,400
2004	14,913	15,385	87	2,183	4,754
2005	15,492	15,384	101	2,173	5,134
2006	15,248	14,825	253	2,809	5,429
2007	16,454	15,717	281	2,958	6,196
2008	16,205	16,395	287	2,876	6,205
2009	14,312	16,119	211	3,868	6,336
2010	12,928	16,828	1,074	3,696	6,951
2011	12,100	17,070	916	6,377	6,993
2012	13,919	17,180	1,052	7,494	7,064

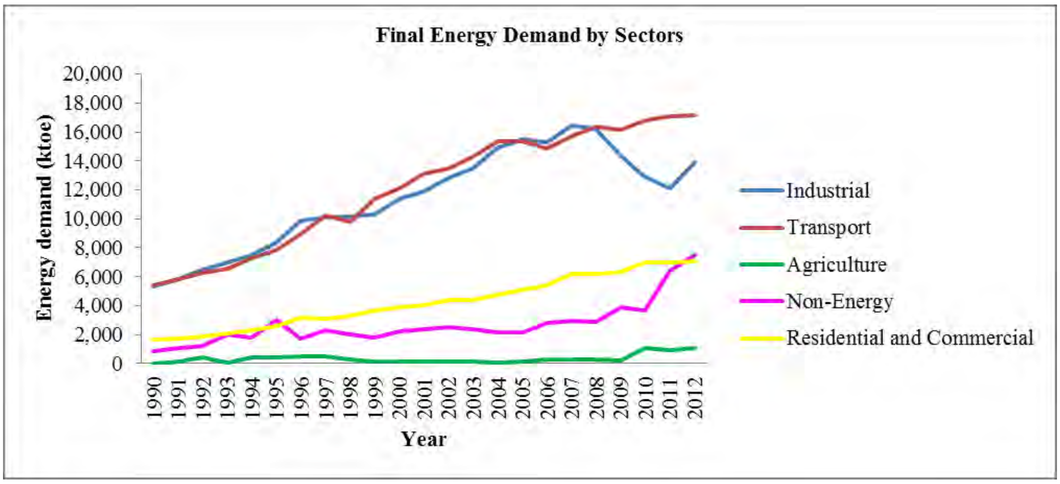

Figure 2.1.2: Graph of Final Energy Demand by Sectors (ktoe)
(Source: National Energy Balance 2012)

Figure 2.1.2 above shows total final energy consumption recorded a higher growth of 7.5 percent in 2012. This was the highest growth experienced since 2007 when a growth of 7.9 percent was recorded. As the final results, the energy consumption growth was experienced by all sectors, especially the non-energy sector which increase by 17.5 percent and the industry sector by 15.0 percent. The sectors which resulted to the highest energy consumption was consumed by the transport for 36.8 percent and the industry for 29.8 percent (National Energy Balance, 2012).

In a nutshell, the statistics clearly illustrates that the demands of energy for every sector in our country was increasing year by year which encouraged Malaysia Government to take some initiatives in order to ensure the security of energy supplies. In order to surmount this challenge, in 9th Malaysia Plan (2006-2010) Malaysia has targeted the Renewable Energy (RE) capacity to be connected to power utility for 300MW in Peninsular Malaysia and 50MW in Sabah. Unfortunately, the RE targeted set out under the 9th Malaysia Plan was not achieved and was continued to the 10th Malaysia Plan (2011-2015) which target for renewable energy to account for 985MW or 5.5% in 2015 and 2,080MW or 11% towards 2020 of the country’s total capacity mix.