"I hereby declare that I have read through this report entitle "Impact Of Grid-Connected To PV System" and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Industrial Power)"

Signature : …….

Supervisor's Name : Prof. Madya. Dr. Gan Chin Kim

Date : …….

IMPACT OF GRID-CONNECTED TO PV SYSTEM

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A thesis submitted in partial fulfillment of the requirement for the degree of Bachelor of Electrical Engineering (Industrial Power)

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

I declare that this report entitle “Impact Of Grid-Connected To PV System” is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : …….

Name : MUHAMMAD ZULHILMI BIN MOHD NOH

Date : …….

DEDICATION

To my beloved father, mother and whole family. And not to forget to beloved lecturer and friend.

ACKNOWLEDGEMENT

To complete this report and research i have go through many obstacle, so I have refer to many side such as researchers, academicians and practitioners. Those of them help me a lot of to understand and improve my knowledge. I wish to express my sincere appreciation to my main project supervisor, Prof.Madya Dr. Gan Chin Kim for guidance in order to compete my research. I was survive now because their continued support and interest to follow up my research.

And do not miss, for my fellow postgraduate student that also support me in term of physically and mentality. Without their support I may be not strong enough to fulfil my research.

And lastly, I am grateful to all may family member for their kindness and supportive. I was fortunate to be a part of this family.

ABSTRACT

The increasing of Distributed Generation (DG) in the electrical network may cause power quality problem such as fluctuation, voltage rise, unbalance voltage and other [1]. In this research, residential grid-connected solar system was considered as the DG in the low voltage network. This research starts to model the low voltage residential network at the selected location. In Malaysia solar system at residential was directly selling to TNB without connected to the load. Hence, the area of research randomly selected. Subsequently, it will continue to install the PV system at the network. Main of this research is to analyse the impact of grid-connected on the distribution network. This research utilises Digsilent software which is well known as simulation software in power system analysis. The results obtained can be divided by two parts which are the result before PV installation and after installation. Both of the result will be compared to analyse its impact to the network.

ABSTRAK

Peningkatan pengjanaan elektrik dikawasan pembahagian (DG) dalam rangkaian elektrik boleh memperngaruhi masalah didalam kualiti kuasa seperti turun naik voltan, kenaikan voltan, voltan tidak seimbang dan lain-lain [1]. Dalam kajian ini, kediaman sistem solar grid yang berkaitan adalah mempertimbangkan sebagai KP dalam rangkaian voltan rendah. Kajian ini bermula untuk model rangkaian kediaman voltan yang rendah pada lokasi yang dipilih. Di Malaysia sistem solar di kediaman telah terus menjual kepada TNB tanpa disambungkan ke beban. Oleh itu, bidang penyelidikan yang dipilih secara rawak. Selepas itu, ia akan terus memasang sistem PV di rangkaian. Utama kajian ini adalah untuk menganalisis kesan grid yang berkaitan pada rangkaian pengagihan. Kajian ini menggunakan perisian Digsilent yang terkenal sebagai perisian simulasi dalam analisis sistem kuasa. Keputusan yang diperolehi boleh dibahagikan kepada dua bahagian yang hasilnya sebelum pemasangan PV dan selepas pemasangan. Kedua-dua keputusan yang akan dibandingkan untuk menganalisis kesannya kepada rangkaian.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Malaysia is in the midst of an era of strong industrial growth due to strong domestic demand together with the development of science and technology is significant. To cope with the economic and industrial growth, energy demand is growing rapidly. So, government must take other alternative to accommodate the energy needed in this country. Renewable Energy (RE) was marked as the 'fifth fuel' that supplied the energy needs of the country. Thus, in 2011 parliament of Malaysia has given approval to the Renewable Energy (RE) in Malaysia. Hence, "Renewable Energy Act 2011" is introduced as law in RE by SEDA [2]. This act intend to establishment and implementation of tariff system. This important to encouraging Malaysia citizen for install renewable generation. In 2014, the total RE capacity approval is 396.61MW and it represents year by year growth of 466% [2]. It has been found that among all the renewable energy sources, solar energy is the most prospective one in Malaysia. Malaysia's strategic geographical location makes it an advantage because of its huge amount of the solar irradiance. The longitude of Malaysia is located at the equatorial region with an average solar radiation of 400–600 MJ/m2 per month [3]. That mean land of Malaysia achieves a higher exposure to the sun's rays throughout most day. As a result, The Small Renewable Energy Power Programme (SREP) was launched to allow independent producers of renewable power to connect to the distribution network and gain compensation for their energy generation [3]. And another programme, dubbed Malaysian Building Integrated Photovoltaic Technology Application Project (MBIPV) encouraged the public and commercial sectors to institute solar technology into their premises, providing energy for a portion of their electricity consumption [1]. On the governmental effort to explore renewable generation technologies and to reduce the carbon footprint, now there are many areas such as residential, premise or other type of building had ben install the solar photovoltaic system on their place.

1.2 Background research

Photovoltaic (PV) generation has now-a-days proved to be a cost-effective method for renewable power generation with minimum environmental impact. Due to environmental and economic benefits, PV is now being widely deployed as a distributed energy resources (DER) in distributed generation systems. Photovoltaic (PV) is the technology that converts energy from sunlight into electrical energy. Photovoltaic generation have two type which are solar photovoltaic (PV) connected to grid and stand-alone solar system. Nowadays, the number of installation PV system was increasing does not matter in individual, community or non-individual scope producing. Individual installation for the residential distribution while community include for school or other government building. And non-individual for reseller of electric company. In 2014, statistic show the number of approve by FiAH to generate electricity using PV system is 4065 for individual, 91 for community and 342 for non-individual [20]. Hence, mostly connected to distribution network system which means connected to the grid. The total estimation in (MW) of capacity for individual for 2014 installation is 4.32% from total RE in Malaysia and it not include the available PV system that already install. Due to increasing installation PV system to the distribution, it could have the impact to the network grid base on the reverse power flow.

1.3 Problem statement

Photovoltaic (PV) are suitable for the energy generation in Malaysia. However, when a certain time the penetration of PV is higher than total load used, meaning higher ratio of PV generate voltage will injected to the grid system , significant grid stability issues may arise. Grid voltage fluctuation is a notable concern [1]. The previous power flow designing system of the national producer only consider the one way direction of power flow without consideration a reverse power flow by the distribution generation. Since that situation, the reverse power flow may have impact on the national grid system. Moreover, the research have found about PV integration may bring the reverse power flow and cause voltage rise in the grid [5]. Hence, several serious technical issues relating to power quality, distribution system efficiency and else must be study .This analysis important to minimise the potential negative impact of the PV integration to national grid system.

1.4 Objective

The objective of this project is:

1. To model the power flow of the residential area.
2. To study impact of grid-connected solar system to residential low voltage network due to voltage profile and losses of the system.
3. To understand the use of Digsilent software.

1.5 Scope Of Research

The scope of research is

1. Select the low voltage residential area at Taman PD Impian Putra Port Dickson Negeri Sembilan.
2. Modelling the residential area using Digsilent software.
3. Compare voltage profile at each feeder.
4. Check the the statutory limit for voltage variation
5. Analyse the losses of the network when PV was install.

1.6 Contribution Of Research

This research will give benefit to the distribution low voltage system network if it was study deeply. Whether the impact distribution generation will give positive impact to voltage profile and losses or negative. This because if the PV have positive impact to the grid, the government have to concern the community to install the PV for every each residential home. So consumer will generate their own power supply thus minimise the energy consumption and monthly bill.

1.7 Report Outline

This research will cover five chapters. Chapter one will cover the introduction, project background, project objective, scope of project and problem statement. These to intend the motive of this project occur. Chapter two will elaborate about the theory and basic concept of the project and comparison between previous researches. And then chapter three explain the method used in this research. All the equipment and type of modelling will be introduces. Then in chapter 4, there are overall results for this research. And lastly, there are conclusion about the study impact of grid-connected solar system to residential low voltage network due to the voltage profile and losses that are study.

CHAPTER 2

LITERATURE REVIEW

2.1 Theory And Basic Principle

A grid connected photovoltaic power system is electricity generating at the distribution area which will transfer to the grid network. For a basic connection of photovoltaic connected to the grid usually have a few part that needed such as solar panel, inverter, power conditioning units and grid connection equipment.

2.2 System Of Solar

PV generation systems usually consist of series-parallel Combinations of PV cells in order to obtain the required voltage and current output. These combinations, known as PV panels and arrays, generate DC power that has to be converted to AC at standard power frequency in order to feed the loads [4]. Therefore system of photovoltaic has been available for inverter to ease conversation power from DC to AC supply. There are a few type of PV panel that famous used in the building such as monocrystalline, polycrystalline, thin-film types. Each of the PV panel has their own characteristic and behaviour.

2.3 Module technology

2.3.1 Monocrystalline

Monocrystalline are made off from single silicon seed crystal which is took to the crucible of molten silicon and then was pulled slowly while rotating, so the content of the monocrystalline cell can produce pure crystalline silicon ingot [10]. Between existing solar panel, monocrystalline are most efficient and expensive. Commercially available of solar cell have efficiencies of 22.5% [7].The typical monocrystalline solar cell usually is a dark black colour look alike figure 2.3.1 below.

Figure 2.3.1: Monocrystalline cell

2.3.2 Polycrystalline

Different with monocrsytalline, polycrystalline are not manufacture from single crystal ingots. It made off from block casting molten silicon [7]. Polycrystalline is less efficient than monocrystalline because it content from many small of crystals which the molecule are random orientations. However, it easier to install and less expensive. The laboratory research about efficiency of polycrystalline are recorded which is 17.84% [7]. In figure 2.3.2 is polycrystalline look alike.

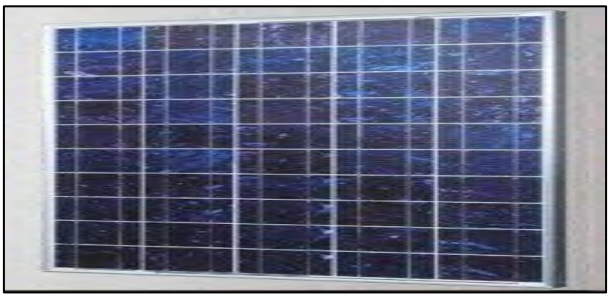

Figure 2.3.2 : Polycrystalline

2.3.3 Thin-film

There are three primary type of thin film which is amorphous silicon, cadmium telluride and copper indium [9]. Mostly all the thin film is expensive rather than other type of solar cell. Previous research has upgrade to increase the efficiencies of solar cell to 20.1% [7].

Figure 2.3.3 : Thin-film cell

2.4 Operation Of Solar Cell

When sunlight strikes the solar cell, electrons are knocked loose. They move toward the treated front surface. An electron imbalance is created between the front and back. When the two surfaces are joined by a connector, like a wire, a current of electricity occurs between the negative and positive sides [1].

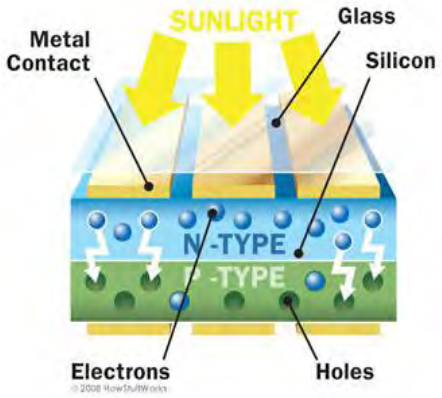

Figure 2.4.1: Structure of solar sell

2.5 Solar Radiation

The operation of PV system depends on radiation of sunlight. There are three type of solar radiation strike on PV panel which direct, diffusion and reflected radiation [18]. Direct radiation means there no shading between sunlight to the solar cell. The diffusion radiation is when sunlight is blocking by cloud or other component. And lastly reflected radiation is the part that reflected by surfaces in front of panel. If radiation of sunlight high toward to solar cell then the value generating current increase.

2.6 Technical impact of PV generation to distribution network

2.6.1 Voltage Fluctuation

From previous research, Installation of PV system to the grid may influence the voltage fluctuations [8]. Voltage fluctuation may occur when the weather is uncertain, sometime a formation of thick cloud or bright situation which no shading from obstacle. Hence, make the uneven power generation to the grid.

2.6.2 Harmonic

Harmonics distortion one of the effect toward installation of PV system to the grid [8]. The existing of harmonics because there are electronic devices used in the PV system such as inverter. Inverter is use to convert DC current to AC. Means, when the installation of PV system is increase so the use of electronic devices also increase. Thus, harmonics distortion may occur or maybe will exist in big amount.

2.6.3 Reverse Power Flow

PV is distribution generation for a small scale. For PV connected to grid, when extra power was produces, it will flow to the national grid. And when power generates by PV cannot support the maximum demand, the TNB power will supply. That makes the network flow two way condition.

2.7 Digsilent Software

Digsilent power factory is power system analysis software that currently used in electrical modelling, analysis and simulation for more than 2 decade [19]. It applicability to modelling of generation, transmission line, distribution and industrial network. Digsilent preparing the whole modelling features for studying all kind of phasing technologies, meshed or radial topologies. Hence to minimize network unbalance, improve quality of generation and optimize distribution network. Our grid system was design for one flow direction only, but existing of distribution generation will give reverse power flow. Digsilent software is suitable tool to analyse the impact of distributed generation on the network and in figure 2.7.1 is logo of Digsilent software. It includes calculating voltage drop, unbalancing network, load and generation model [19]. In Malaysia, digsilent is one of the software that has been use in modelling and analysis among other software by TNB. In this research, digsilent software was used to get the overall analysis.

Figure2.7.1: Logo of Dig silent

2.8 Load Profile And PV Generation

By referring typical aggregated Malaysia domestic load shape [12], 24 hour load shape was assigned to the each house of the residential network at figure 2.8.1 below. Base on the load shape, the lowest demand start in working hour period where starting 9.00 a.m. until 5.00 p.m. It can be assumed nobody have at the house in the range and only small of quantity power was consume for the appliance at the house. Hence, the demand was increase when time achieve at 5.00 p.m until night. The increase of power consume maybe all the major appliance was totally used such as air-Cond, washing machine, television and other that contribute of power consume.

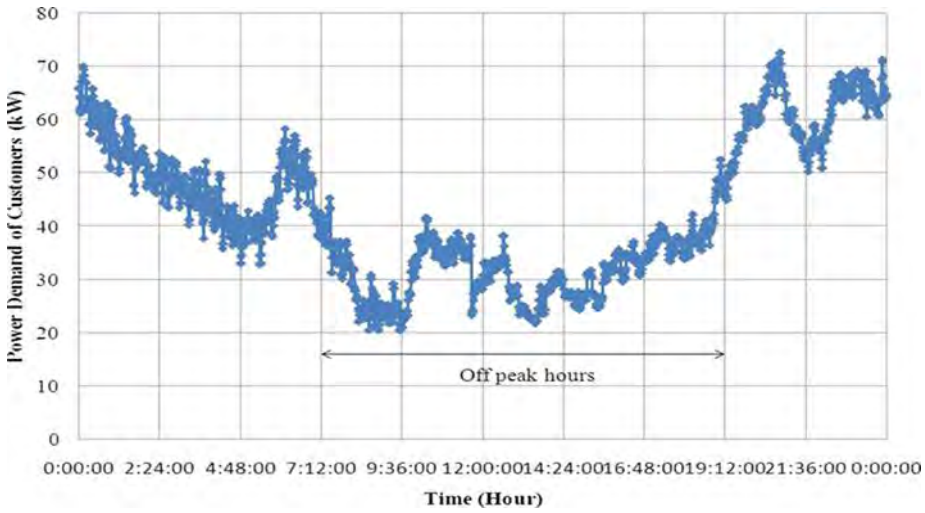

Figure2.8.1: Load demand

The other graph is the 24 hour power generation of PV system taken from [12] at figure 2.8.2 below. PV system generate the maximum power 11.00 am until 5.00 p.m. According the This

time, the irradiation of solar was high to generate the electric. Hence when night and early morning, the PV no generate the electricity.

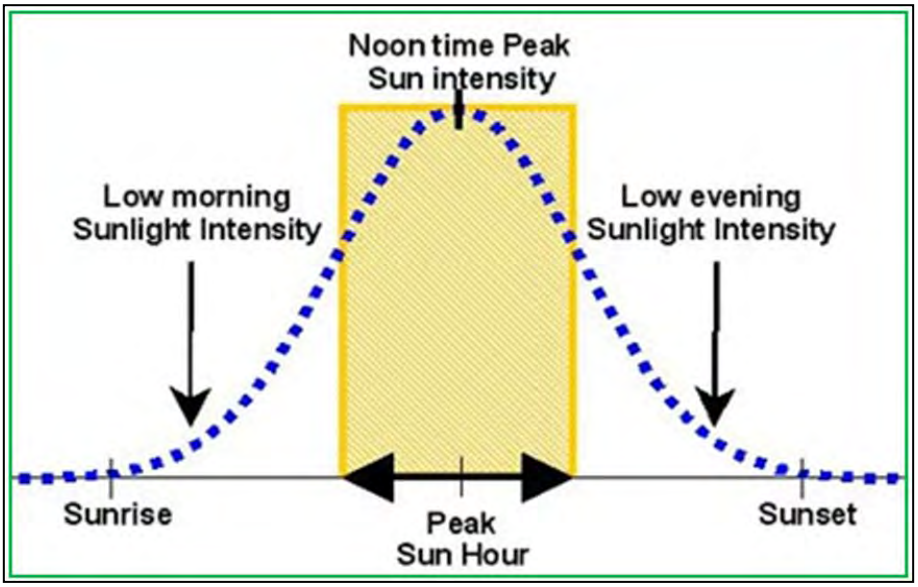

Figure2.8.2: Radiation of sunlight

However comparison between both of graph at figure 2.8.3, we know at the time PV generate maximum electricity the minimum load was use. So surplus of voltage will flow back to grid. It is important to investigate the impact of reverse power flow to the grid.

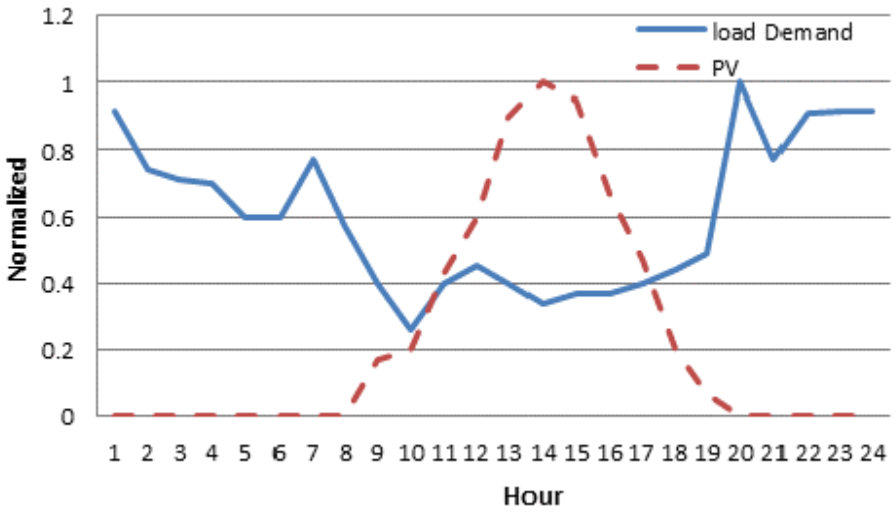

Figure 2.8.3: Load profile and PV generation profile

CHAPTER 3

METHODOLOGY

3.1 Introduction

Based on the available network data at figure 3.1.2 and table 3.1.1 given from TNB, several approaches have been used to model the residential distribution network. Taman PD Impian Putra Port Dickson Negeri Sembilan was chosen as the location research. The available data are transformer rating, the number of feeder, cable rating and cable type. The residential low voltage network is supply 11KV incoming from TNB network. And then was step down by transformer to 415KV at rating transformer 500kva. The type of cable using to connect between the transformer and feeder pillar is 4x500 mm^2 PVC/PVC Aluminium (Al) which is along 10 metre. There are 5 feeders that connected to the bus bar at the feeder pillar. The type of cable using between feeder pillar and pole is 185 mm^2 4C Al. XLPE. The Aerial bundle cable (ABC) 3 x 185 mm^2 + 120 mm^2 was used for distribute the electric to the houses in that area.

The residential LV network is three-phase four wire radial system. For feeder 1 and 2 it serves a total of 30 houses, feeder 3 serves 31 houses. And then, feeder 4 is the shortest feeder measuring 186 metre which has 26 houses. Lastly, feeder 1 with longest length of 360 metre which serves 32 houses.

According the TNB, standard maximum demand for the terrace type of house will consume 2kw for each consumer [11]. All consumers are modelled for the same power load with power factor 0.95 for each house. And for the overall maximum demand for the total house will consume 298KW.