Faculty of Electrical and Electronic Engineering Technology

DEVELOPMENT OF EXCEL BASED VBA APPLICATION FOR GCPV SYSTEM DESIGN

ABDUL LUQMAN HAKIM BIN ABDUL RAHMAT

Bachelor of Electrical Engineering Technology with Honours

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A project report submitted in partial fulfilment of the requirements for the degree of Bachelor of Electrical Engineering Technology with Honours

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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I hereby declare that I have checked this project report and in my opinion, this project report is adequate in terms of scope and quality for the award of the degree of Bachelor of Electrical Engineering Technology with Honours

Signature :

Supervisor Name : DR AZHAN BIN AB RAHMAN

Date : 3/7/2023

DEDICATION

To my beloved parents

ABDUL RAHMAT BIN ABDUL GHANI and **NORAINI BINTI MUHAMMAD.**

Thank you for your kindness in caring for me, supporting, advising, and loving me, which brings me constant joy.

My siblings,

SITI HUMAIRAH BINTI ABDUL RAHMAT, **SITI ALYA BALQIS BINTI ABDUL RAHMAT** and **SITI ANIS ZULAIKHA BINTI ABDUL RAHMAT.**

Your support has always motivated me when I need it the most.

My project supervisor,

DR. AZHAN BIN AB RAHMAN.

For the lesson and guidance for this project.

To my close buddies,

Many thanks for your support.

We hope that happiness and joy continue to colour our lives forever.

ABSTRACT

Solar photovoltaic (PV) system installation is now a multi million industry in Malaysia. This is due to the successful implementation of several government incentives such as Feed in Tariff (FiT), Net Metering (NEM) and Large Scale Solar (LSS). Designing a solar PV system involves several steps of calculation which are normally performed by a certified PV system designer. This can be a problem for potential consumers planning to install such system in estimating the size a solar system which suits their allowable budgets. Therefore, this final year project aims to rectify this issue by designing a simple application which can produce an approximation on the relative capacity of a solar PV system based on the financial input given by a user. To do so, a Microsoft Excel based Virtual Basic (VBA) are used as the platform for this application to run. The calculation set in the application are based on the datasheet of Yingli YL400D-36B PV panel and Huawei SUN2000-2KTL-L1 PV inverter. The project calculate the output power of PV panel and PV inverter can produced according to the customer's budget. The correctness of its calculation are comparable to manual calculation. It is hope that user friendly nature of the application will be useful by solar PV installer in order to increase the number of customers.

ABSTRAK

Pemasangan sistem solar photovoltaic (PV) kini menjadi industri berjuta-juta di Malaysia. Ini berikutan kejayaan pelaksanaan beberapa insentif kerajaan seperti Feed in Tariff (FiT), Net Metering (NEM) dan Large Scale Solar (LSS). Mereka bentuk sistem PV solar melibatkan beberapa langkah pengiraan yang biasanya dilakukan oleh pereka sistem PV bertauliah. Ini boleh menjadi masalah kepada bakal pengguna yang merancang untuk memasang sistem sedemikian dalam menganggar saiz sistem suria yang sesuai dengan belanjawan mereka yang dibenarkan. Oleh itu, projek tahun akhir ini bertujuan untuk membetulkan isu ini dengan mereka bentuk aplikasi mudah yang boleh menghasilkan anggaran kapasiti relatif sistem PV solar berdasarkan input kewangan yang diberikan oleh pengguna. Untuk berbuat demikian, Asas Maya (VBA) berasaskan Microsoft Excel digunakan sebagai platform untuk aplikasi ini dijalankan. Set pengiraan dalam aplikasi adalah berdasarkan lembaran data panel PV Yingli YL400D-36B dan penyongsang PV Huawei SUN2000-2KTL-L1. Projek ini mengira kuasa keluaran panel PV dan penyongsang PV boleh dihasilkan mengikut bajet pelanggan. Ketepatan pengiraannya adalah setanding dengan pengiraan manual. Diharapkan sifat mesra pengguna aplikasi ini akan berguna oleh pemasang PV solar untuk meningkatkan bilangan pelanggan.

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CHAPTER 1

INTRODUCTION

1.1 Project Background

The majority of the energy required to power our automobiles, enterprises, and residences has been derived from the combustion of fossil fuels for more than a century. Coal, crude oil, and petroleum are categorized as fossil fuels because they were formed from the fossilized remains of extinct plants and animals. Due to their origins, fossil fuels contain significant quantities of carbon. The extraction of coal, oil, and gas poses numerous hazards to our waterways and groundwater. Coal mining operations pollute streams, rivers, and lakes with toxic discharge and deposit vast quantities of undesirable detritus and sediment in streams. Fossil fuels emanate toxic air pollutants long before they are burned [1]. Carbon dioxide is produced in enormous quantities when fossil fuels are burned. Carbon emissions induce climate change by retaining heat in the atmosphere. Renewable energy is an excellent option for the generation of clean energy. Renewables are on course to become an affordable energy source than fossil fuels, resulting in a surge in the development and use of renewable energy technologies [1].

Greenhouse gas emissions from the overwhelming majority of renewable energy sources are negligible or nonexistent. Even when "life cycle" emissions (emissions from each stage of a technology's existence—manufacturing, installation, operation, and decommissioning) are taken into account, the contribution of renewable energy sources to global warming is negligible. Currently, renewable energy provides affordable electricity to the nation, and in the future, it can help stabilize energy prices. Wind and solar energy are less susceptible to large-scale malfunctions due to their distributed and modular design. Distributed systems are geographically dispersed, so a severe weather event in a single location will not result in the loss of power to an entire region [2]. The majority of adverse health effects are caused by air and water pollution, neither of which are produced by renewable energy technologies. Wind, solar, and hydroelectric power generation systems do not contribute to air pollution. Even though geothermal and biomass systems emit some air pollutants, their total air emissions are typically much lower than those of coal- and natural gas-fired power plants [2]. Biomass, wind, biogas (e.g., landfill gas/wastewater treatment digester gas), geothermal, and solar (photovoltaic, solar thermal) are the most prevalent renewable energy sources [3].

Installing a photovoltaic (PV) system on the roof or in the yard of a house may provide various benefits. Due to the fact that we produce our own power, our utility costs will decrease. Solar photovoltaic (PV) systems may last up to 30 years, offering long-term security against increased power rates that may be imposed as global energy markets develop [4]. A solar system may also raise the value of the property. Whether Grid-connected or stand-alone, the majority of residences throughout the globe have installed PV systems to reduce their electricity costs. A grid-connected photovoltaic (PV) system is one in which solar panels or arrays are connected to the utility grid by means of a power converter device, enabling them to operate in parallel with the grid [4].

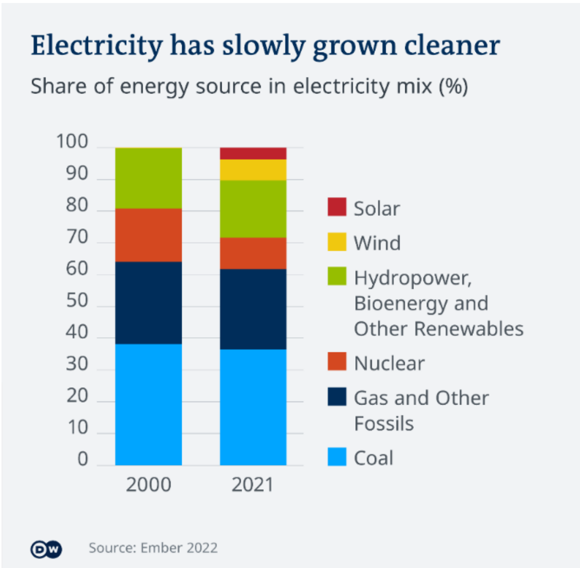

Figure 1.1 Renewable Energy Chart

Based on the above graph, solar installation has been a multimillion dollar industry. Many of them are motivated to implement by benefits such as Net Energy Metering Scheme (NEM), Feed in Tariff (FiT), Large Scale Solar (LSS), and Self Consumption (SELCO). The concept behind NEM is that the energy generated by the solar PV system will be utilized first, and any excess energy will be exported to TNB at the prevailing cost of displacement. The Feed-in Tariff (FiT) system in Malaysia requires Distribution Licensees (DLs) to purchase renewable energy from Feed-in Approval Holders (FIAHs) and establishes the FiT rate. During a predetermined time period, the DLs will cover the cost of renewable energy supplied to the electricity grid. Self-consumption, also known as SELCO, occurs when electricity is produced for personal use but cannot be exported to the grid. In order for a solar installer to approach a consumer, they must explain difficult-to-understand terms such as PVsyst, PVcase, PVSketch, and Sunny Design. This occurred because the simulator is so complex and has numerous parameters that the consumer did not understand.

1.2 Problem Statement

As demonstrated in the preceding section, the complexity of the simulator makes it difficult for solar installers to explain its operation to customers. This project's simplified design and user-friendliness make it easier for customers to comprehend the system. It additionally assists solar installers in communicating with their customers.

1.3 Objective

The main purpose of Excel-based GCPV System Design Apps is to create an application that is user-friendly and can be used either by customer or company. Below shows the objective of the project :

- To develop of excel based VBA application for GCPV system design.
- To design different power output produced by solar panel and solar inverter of solar system.
- To validate the accuracy the accuracy of the system by comparing the output of the design and calculation.

1.4 Scope of Project

- Visual Basic software in Excel are used in this project.
- Design of project based on Yingli YL400D-36B solar panel and Huawei SUN2000-2KTL-L1 solar inverter.
- This project is meant for design of a grid connected photovoltaic for domestic houses.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will provide a full summary of what has been written by researchers on various themes. The primary goal of this literature study is to learn about the information and concepts that have been established concerning Excel-based GCPV System Design Apps that focus on GCPV System design.

Furthermore, there are several materials available on the subject of Excel-based GCPV System Design Apps. The data was gathered from a variety of sources, including written papers and online publications.

This chapter will be divided into three sections: the fundamental GCPV system, GCPV System Design Methods, and Literature Review.

2.2 GCPV System Basic

Grid Connected Photovoltaic (GCPV) is an another system that can generates energy by using solar power. This system consist of DC solar panel, Inverter, AC Loads and Grid network. This system convert solar energy into electrical energy. Small power generators (GCPV systems) can be found in a variety of places, including homes, factories, and commercial buildings [4]. Photovoltaic (PV) systems, commonly referred to as solar electric systems, convert sunlight to energy. PV systems may be tailored to satisfy most electrical requirements, both large and small, because they are made up of separate modules. The size of a home PV system is measured in kilowatts (kW) of power, while the electricity generated by the system is measured in kilowatt hours (kWh). When systems stay plugged into the local utility, they are referred to be "grid connected." Most grid-connected PV systems do not include a battery backup system [5]. Off grid systems often employ battery backup, which supplies electricity when the sun isn't shining. At night, grid-connected systems rely on their utility for electricity.

Photovoltaic (PV) technology is gaining popularity globally. The worldwide PV energy harvest has more than quadrupled since 2010. Grid-connected photovoltaic (GCPV) systems come in three sizes: small scale, medium size, and utility scale [4]. Various configurations for GCPV systems are recommended based on system size, with each configuration being evaluated based on characteristics such as efficiency, reliability, expandability, and cost. PV panels put on the roof of a building within the same Premise shall be used for the solar PV installation [6]. PV systems have low maintenance requirements: they may require cleaning on occasion for maximum operation, and they frequently require a new inverter after 10-15 years [6]. Installing a monitoring device that records the PV system's power output is the best approach to guarantee it's operating properly [5].

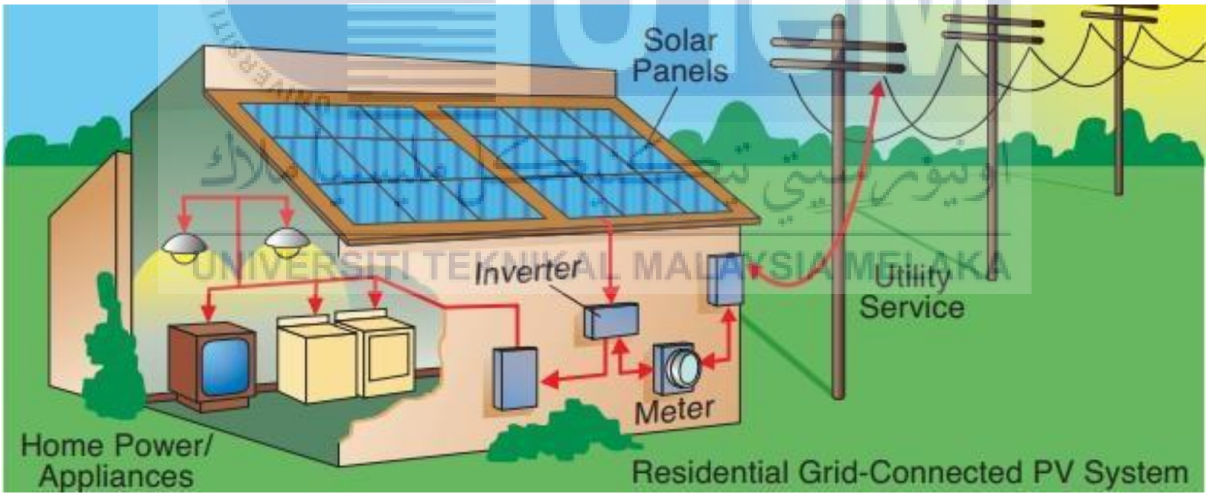

Figure 2.1 Basic PV System Installation

2.2.1 Component used in GCPV system

2.2.1.1 Solar Panels

Multiple semiconducting layers of silicon or another semiconducting material constitute the cells of a photovoltaic solar panel. This material conducts electricity when illuminated. The cells are capable of functioning on cloudy days without direct sunlight. However, energy generation rises as sun intensity increases [5]. Under strong sunlight, each solar panel in a solar PV system produces approximately 355 watts of electricity. Approximately ten panels comprise a typical system that generates direct current (DC) electricity.

There are emphasised and significant criteria for solar panels. The first factor is solar panel type. In this study work, three types of solar panels are utilised: monocrystalline, polycrystalline, and high-efficiency thin-film (HIT) solar panels. Monocrystalline solar panel refers to a solar panel composed of monocrystalline solar cells. The product derives its name from the very pure single-crystal silicon ingot used to construct the panel's cylindrical ingot. Due to the cell's single crystal design, electrons have more space to migrate, resulting in a more efficient electrical flow [7]. From the cylindrical ingot, wafers are sliced to form cells. To maximise the use of the cells, circular wafers are wire-cut into octagonal shapes. The unique look of these rooms is due to their octagonal shape. Next, polycrystalline or multicrystalline solar panels contain multiple silicon crystals per PV cell. Wafers for polycrystalline solar panels are produced by melting together multiple fragments of silicon. In this instance, the silicon crucible used to produce polycrystalline solar cells is cooled directly on the panel. The surface of these solar panels resembles a mosaic. They are composed of numerous polycrystalline silicon crystals and have a square form and brilliant blue color. Due to the numerous silicon crystals contained within every individual cell of polycrystalline panels, electron mobility within the cells is restricted. These solar panels capture solar energy and convert sunlight into electricity. The last type of solar panel is HIT type. In the past ten years, the manufacture of solar panels using heterojunction technology (HJT) has gained significant momentum [7]. The technology is now the greatest alternative for the solar industry to maximise efficiency and power production. HJT creates a high-power hybrid cell that outperforms the performance of the industry's standard technology by fusing the greatest aspects of crystalline silicon and amorphous silicon thin-film.

The quantity of solar cells is the following element to consider. A solar cell is any device that transforms light directly into electrical energy using the photovoltaic effect. Additionally known as a photovoltaic cell. The vast majority of solar cells are composed of silicon, which is available in amorphous (non-crystalline), polycrystalline, and crystalline (single crystal) forms, with increasing efficiency and decreasing cost [7]. Arrays of solar cells may be composed of numerous cells. These arrays, comprised of thousands of individual cells, can function as central electric power plants by gathering solar radiation to generate electricity for distribution to industrial, commercial, and residential clients. The maximum voltage of the system is the third parameter. Maximum System Voltage refers to the greatest root mean square (r,m.s.) line-to-line voltage that may be sustained under normal operating circumstances at any time and any point within the system. It excludes transient. Maximum reverse current of solar panels is the fourth parameter. Highest reverse current (IR) is the amount of currents flowing through a diode in reverse-bias mode when it is receiving the maximum rated inverse voltage (VDC). Current leakage is an alternate phrase. As a perfect diode would halt all current when biased in the opposite direction, the best value for this number would be zero. The fifth parameter is the output power at STC. Max Power at STC is the maximum power the panel is capable of producing when evaluated under Standard Test Conditions. Customers and solar industry experts refer to solar panel dimensions as Max Power at STC. Next parameter is open circuit voltage. In solar cell applications, "open circuit voltage" is a commonly employed term. Open circuit voltage (VOC) is the greatest voltage obtainable from a solar cell while no current is flowing. Due to the light-induced bias at the solar cell junction, the open circuit voltage is equal to the solar cell's forward bias. The maximum voltage is the eighth requirement. Maximum power voltage is the voltage that corresponds to the maximum power output of the module. Examine the maximum power current and short circuit current as the eighth factor. Maximum power voltage is the voltage that a module is able to produce at its maximum power level. While there is no voltage across the solar cell, the short-circuit current (ISC) flows through the cell (i.e., when the solar cell is short circuited). ISC results from the generation and accumulation of light-generated carriers. NOCT is the last parameter. The temperature reached by open circuited cells in a module under conditions of 800W/ m2 irradiance, 20°C ambient temperature, and 1 m/s wind speed, with the PV module tilted 45° and its back exposed to the breeze, is identified as the Normal Operating Cell Temperature (NOCT), which is a screening standard geared toward operating temperatures of solar cells (as opposed to conditions where panels are mounted on rooftops and heat builds up that under panel) [7]. Identical to PTC, NOCT situations are designed to simulate actual events. Numerous energy rating and output performance standards need it as a considerably more stringent requirement for estimating the average day's real available watts.

The first solar panel is Glass/Glass STKM -60 – 270Wp Monocrystalline module by Solar Electric. Glass/Glass is a technology by laminate PV cells between two glasses. This panel is a monocrystalline type. This solar panel have approximate around 20.5kg in weight and the dimension is 1673mm x 991mm x 5mm. the number of cells in the line is 60 which is 10 x 6. This panel can produce maximum system voltage 1000V DC with maximum reverse current 15A. rated maximum power at STC is 270Wp and Open Circuit Voltage is 38.40V.

The maximum Power Voltage that can be produced is 31.15V. Maximum Power Current that can be produced is 8.51A while the Short Circuit Current 8.97A. The NOCT value for this panel is 43.6°C.

Table 2.1 Mechanical & Electrical Monocrystalline Solar Panel

Type	Monocrystalline
Weight (kg)	20.5
Dimension (LxWxH) (mm)	1673x991x54
No. of cells in line	60
Maximum System Voltage	1000V DC
Maximum Reverse Current (A)	15
Rated Maximum Power at STC (Wp)	270
Open Circuit Voltage (Voc/V)	38.40
Maximum Power Voltage (Vmp/V)	31.15
Maximum Power Current (Imp/A)	8.51
Short Circuit Current (Isc/A)	8.97
NOCT	46.3°C

The second solar panel is Glass/Glass STKM -60 – 260Wp Polycrystalline module by Solar Electric. Glass/Glass is a technology by laminate PV cells between two glasses [4]. This panel is a polycrystalline type. This solar panel have approximate around 20.5kg in weight and the dimension is 1673mm x 991mm x 5mm. the number of cells in the line is 60 which is 10 x 6. This panel can produce maximum 1000V DC with maximum reverse current 15A. Rated maximum power at STC is 260Wp and Open Circuit Voltage is 37.90V. The maximum Power Voltage that can be produced is 30.70V. Maximum Power Current that can be produced is 8.60A while the Short Circuit Current 8.10A. The NOCT value for this panel is 46.3°C.

Table 2.2 Mechanical & Electrical Polycrystalline Solar Panel

Type	Polycrystalline
Weight (kg)	20.5
Dimension (LxWxH) (mm)	1673x991x54
No. of cells in line	60
Maximum System Voltage	1000V DC
Maximum Reverse Current (A)	15
Rated Maximum Power at STC (Wp)	260
Open Circuit Voltage (Voc/V)	37.90
Maximum Power Voltage (Vmp/V)	30.70
Maximum Power Current (Imp/A)	8.10
Short Circuit Current (Isc/A)	8.60
NOCT	46.3°C

The third solar panel is Photovoltaic Module HIT N330 module by Solar Panasonic. HIT have a novel hetero-junction cell structure composed of monocrystalline and amorphous layers of silicon [5]. This panel is a HIT type. This solar panel have 18.5kg in weight and the dimension is 1590mm x 1053mm x 35mm. This panel can produce maximum system voltage 600V DC with maximum reverse current 15A. Rated maximum power at STC is 330Wp and Open Circuit Voltage is 69.70V. The Maximum Power Voltage that can be produced is 58.0V. Maximum Power Current that can be produced is 5.70A while the Short Circuit Current 6.07A. The NOCT value for this panel is 44°C.