# GRID CONNECTED SOLAR PHOTOVOLTAIC SYSTEM EFFICIENCY:

# CASE STUDY FOR LANDED RESIDENTIAL

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Dedication to my beloved mother, Lu Siew Ding whom support me, physically, mentally and emotionally, throughout my Master's study.

For my siblings and friends, appreciate your encouragement and help. To all my lecturers, you are my inspiration for today and future time. Thank you everyone and only the universal supreme can bestow just reward to all of you.

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# ABSTRACT

The purpose of this study is to evaluate the field test efficiency of grid connected solar PV system by simulation, field test results and real time data monitoring. The real behavior of modules by respect to the specifications was one of the greater uncertainties in the PV system performance evaluation. The reason is the mismatch of poor cell by the manufacturer during fabrication. The thesis demonstrates the performance analysis of solar module by using solar module analyzer, irradiance meter and inclinometer under different irradiation at site. The peak power produced is measured and compared with the manufacturing test report to ensure all the modules in the string will have power rating at the acceptable tolerance. The real time monitoring is implemented by using Solar-Log in order to obtain the absolute maximum performance from the solar energy system at all time. The real time data is recorded and compare with the PVSYST simulation results. Results obtained were compared to validate the efficiency of PV system. Finally, economic analysis of PV system is presented by using simple payback method to determine the return on investment (ROI).At the end of study, recommendation and suggested solution will be presented to increase the reliable and efficiency of photovoltaic (PV) system. By increasing the efficiency of PV system, more energy will be generated which contribute to a better return of investment (ROI). Hence, the renewable energy will becomes a viable and sound long term investment for companies, industries and also for individuals.

# ABSTRAK

Kajian ini dilakukan bertujuan menilai prestasi kecekapan untuk "*Grid Connected Solar PV*" dengan kaedah simulasi, ujian lapangan dan masa nyata data memantau. Tingkah laku sebenar untuk PV modul oleh berkenaan dengan spesifikasi adalah ketidaktentuan yang besar untuk PV system prestasi penilaian. Ini adalah disebabkan oleh sel-sel yang tidak sepadan teleh digambungkan oleh pengilang semasa pembuatan. Tesis ini menunjukkan analisa prestasi untuk kuasa suria modul dengan mengunakan kuasa suria peralatan, kuasa suria penilaian peralatan meter , cenderung suria peralatan meter dalam perbezaan sinaran suria di tapak kerja. Puncak kuasa yang dihasillan adalah diukurkan dan dibandingkan dengan pengilang laporan ujian untuk memastikan semua modul yang ditalikan mempunyai kuasa toleransi yang boleh diterima. Data memantau dalam masa nyata akan dilaksanakan dengan kaedah "Solar-Log" untuk mendapat mutlak maksimum prestasi dari sinaran suria dalam setiap masa. Data memantau dalam masa nyata akan direkodkan and berbanding dengan "PVSYST" simulasi. Hasil didapati akan dibandingkan untuk mengesahkan prestasi PV sistem. Akhirnya. ekonomi analisis akan ditunjukkan dalam kaedah mudah bayak balik pengiraan untuk menentukan jangka masa pulangan pelaburan. Di akhir kajian, cadangan penyelesaian praktikal akan ditunjukkan untuk meningkatkan prestasi PV sistem. Dengan peningkatan prestasi PV sistem, kelebihan tenanga akan dihasilkan dan akan mempercekatkan pulangan pelaburan. Oleh itu, tenaga yang boleh diperbaharui akan menjadi berdaya maju dan pelaburan yang bijak untuk syarikat,industri dan individu.

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| | | |
|---|---|---|
| PV | - | Photovoltaic |
| FiT | - | Feed In Tariff |
| R.O.I | - | Return of Investment |
| SEDA | - | Sustainable Energy Development Authority Malaysia |
| TNB | - | Tenaga Nasional Berhad |
| kwp | - | Kilowatt Peak |
| kwh | - | Kilowatt Hour |
| Pmin | - | Minimum Power |
| Pmax | - | Maximum Power |
| ACJB | - | Alternating Current Junction Box |
| DCJB | - | Direct Current Junction Box |
| Isc | - | Short Circuit Current |
| Voc | - | Open Circuit Voltage |
| SY | - | Specific Yield |
| CPV | - | Concentrated Photovoltaic |

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# CHAPTER 1

## INTRODUCTION

The grid connected solar photovoltaic (PV) system is installed at Setia Eco Park, Shah Alam. The system is called as on-grid system and is connected to the Tenaga Nasional Berhad (TNB) grid. The installed PV system harnesses the power of sunlight and produces electricity from sunlight through modules that are installed on the roof. The merit of the PV power is it does not produce noise or pollution; it is reliable, dependable and has no moving parts required. It is also renewable and thus very environmental friendly.

Case study on landed residential will be conducted for 13 unit of bungalows and 14 units of semi-detached. The PV modules are installed on the roof where the capacity installed for bungalow is 5kWp and for Semi-D is 4kWp. Below are the brief PV system installations:-

## 1.1 System Installation

### A Solar Panel

Each bungalow is retrofitted with 20 number of solar panel and the total of solar panels for bungalows is 260 numbers. In contrast, each semi-detached is retrofitted with 16 number of solar panel and the total of solar panels for bungalows is 224 numbers. Every solar PV panel will include solar cell, housing and aluminum structure. The solar PV panel is installed at the roof top of the building and it supported by hot deep galvanized structure to stand the PV panel. The PV panel that used in this system is BLD250-60M.

| Type | Solar Panel Per Unit | Total Solar Panel | Location |
|---|---|---|---|
| Bungalow (13 Units) | 20 | 260 | Retrofitted Roof Top |
| Semi-D (14 Units) | 16 | 224 | |

### B. Inverter

Inverter is used to convert DC supply from the PV panel to the AC supply. It is converted from DC to AC and will be connected with electricity grid (TNB).

| Type of House | Type of Inverter | Total of Inverter Per Unit | Total of Inverter | Location |
|---|---|---|---|---|
| Bungalow (13 Units) | STECAGRID 3600 | 1 | 13 | Inverter Room |
| Semi-D (14 Units) | STECAGRID 2000 | 2 | 28 | |

## C) Direct Current Junction Box (DCJB)

DCJB is stand for Direct Current Junction Box. The main part in this DCJB is DC Surge Protectors to protect the Photovoltaic modules and inverter against indirect lightning effect. It also has switch fuse 10mA to protect the SPD (Surge Protection Devices). DC junction box consists:

| Item | Type | Quantities | Location |
|---|---|---|---|
| 1 | DC SPDs 500PKT40-PV | 3 | Inverter Room |
| 2 | DC SPDs 500PKT40-PV | 6 | Inverter Room |

## D) Alternating Current Junction Box (DCJB)

ACJB is stand for Alternating Current Junction Box. The main part on the ACJB is the AC Surge Protectors to protect the inverters against indirect lightning effect and short circuit effect. As the connecting cable is within 10m, then it is necessary for SPDs to be installed on photovoltaic modules. ACJB consist of:

| Item | Type | Quantities | Location |
|---|---|---|---|
| 1 | AC SPDs 415PKT40 | 1 | Inverter Room |

**Remark:** The complete electrical circuit and installation of grid connected solar photovoltaic system is attached as per appendix.

## 1.2 BACKGROUND OF THE STUDY

The on-grid connected solar photovoltaic (PV) system is power systems energized by photovoltaic panels which are connected to the utility grid. Grid-connected photovoltaic power systems comprise of photovoltaic panels, solar inverters and grid connection equipment. The basic building block is the PV cell, which is connected to other cells to create larger units called modules. Modules are connected together to form panels or strings. The desired resulting voltage will determine the number of modules in a string. The number of strings will determine the capacity of the system. The finished panels are also called an array.

A grid-connected PV system uses sunlight that impinges the solar array to generate DC power. This DC power will be converting to AC power via the inverter and the AC power will be connected with electricity grid (TNB). The grid-connected PV system generates the power in the afternoon while the peak power demands are greatest in evening and to a less extent in morning. TNB as the distribution licensee is to buy the electricity produced from renewable resources from Feed-in Approval Holders (FiAHs) at the approved Feed-in Tariff (FiT) rate for a specific duration.

The merit of the research study is to evaluate and validate the performance of PV efficiency. This is done through simulation, field test result and real time data to achieve the reliable and efficiency of the photovoltaic system. By enhancing the PV system efficiency, it will reduce the payback period of the installation as compared to the initial capital cost of the PV system. Economic consideration is important parameters when making decision to purchase a grid connected PV system as the cost to establish or set up the PV can be expensive although the solar energy is free resource.

## 1.3 Problem Statement

PV module is manufactured with a specified power rating and tolerance. The modules shall provide the rated output. However, most of PV modules series didn't match the manufacturer nominal specifications. The real behavior of modules by respect to the specifications was one of the greater uncertainties in the PV system performance evaluation. The reason is the mismatch of poor cell by the manufacturer during fabrication. As the result, when the modules are installed in a string, it is very unlikely that all the modules in the string will be the exact power rating. As such, the module with the least power rating will affect the whole string.

## 1.4 Objective

The objective of this project:

a) To study the practical design of Solar PV system by providing detail calculation on the solar arrays outputs, inverter specifications and other relevant information on the solar energy system.
b) To evaluate the performance of efficiency based on simulation, field test results and real time data.
c) To present a simple payback and life cycle costing of PV grid connected system.
d) To recommend a practical method to increase the efficiency of a grid connected solar photovoltaic system for residential houses.

## 1.5 Project scope

a) To determine the cell/module efficiency and peak power produced under different irradiations and verify the field test results with the manufacturer testing report.
b) To measure and monitor the real time data and validate with simulation results.
c) To evaluate the performance of efficiency based on simulation, field test results and real time data.

## 1.6 Significance of the project

This project proposes the method and suggests solution in order to achieve the reliable and efficiency of the photovoltaic system. The benefit of the research study is to evaluate and validate the performance of PV efficiency by simulation, field test result and real time data.

By increasing the efficiency of the PV system access to the grid and setting a favorable price per unit of renewable energy the feed in tariff mechanism would ensure that renewable energy becomes a viable and sound long-term investment for companies industries and also for individuals.

## 1.7 Organization of the reports

**Layout of the Research**

The research will report the whole process and results of performed research in four chapters as listed below:

**Chapter 1:** Presents an introduction and background of the research, the problems and the main objectives of this study.

**Chapter 2:** Presents the previous relevant research, recent related work and current status of the topic.

**Chapter 3:** Presents the methods and strategies, which will be used in the research to achieve the specified objectives.

**Chapter 4:** Presents the results of implementation technique and analyze the data. These results are illustrated as tables, plotted curves and figures. A practical method is recommended and presented to enhance the efficiency particularly on the residential housing.

**Chapter 5:** Presents the summary of thesis and recommendation of future works.

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