

TECHNO-ECONOMIC ANALYSIS OF GRID CONNECTED PV-  
BATTERY SYSTEM IN SARAWAK, MALAYSIA

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TECHNO-ECONOMIC ANALYSIS OF GRID CONNECTED PV-  
BATTERY SYSTEM IN SARAWAK, MALAYSIA

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## **DEDICATION**

This project report is dedicated to my father, who taught me that the best kind of knowledge to have been that which is learned for its own sake. It is also dedicated to my mother, who taught me that even the largest task can be accomplished if it is done one step at a time.

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## ABSTRACT

Nowadays, energy use has become a very critical concern because of rapid increase in energy demand. The increased concerns for environmental impacts of conventional fossil fuels most importantly those related to global warming have been the major aspect driving the transformation towards green energy. However, the implementation of photovoltaic (PV) systems in Sarawak, East Malaysia, is still weak and has yet to be a common practice in Sarawak's construction industry. Furthermore, very limited research studies have been carried out to analyse the techno-economic feasibility of grid-connected PV-battery systems, especially in Sarawak. The main purpose of this study was to analyse the feasibility of grid-connected PV-battery systems to be implemented in towns of Sarawak, East Malaysia. This study also aimed to investigate the Levelized Cost of Energy (LCOE) and Net Present Cost (NPC), analyse the carbon emissions and determine the potentiality of the system. The proposed system will took into account several constraints such as the technical, economics and environmental impact of grid-connected PV battery system. The Hybrid Optimization of Multiple Energy Resources (HOMER) software was used to perform the simulation work to determine the economic and environmental effects and evaluate the feasibility of the proposed system in the towns of Sarawak. In addition, the technical features of the grid-connected PV-battery system were analysed using MATLAB/Simulink software.

## ABSTRAK

Pada masa kini, penggunaan tenaga telah menjadi kebimbangan yang sangat kritikal kerana peningkatan pesat dalam permintaan tenaga. Kebimbangan yang meningkat terhadap kesan alam sekitar bahan api fosil konvensional yang mengakibatkan pemanasan global telah menjadi aspek utama yang memacu transformasi ke arah tenaga hijau. Walau bagaimanapun, pelaksanaan sistem fotovoltai (PV) di Sarawak, Malaysia Timur, masih lemah dan masih belum menjadi amalan biasa dalam industri pembinaan Sarawak. Tambahan pula, kajian penyelidikan yang sangat terhad telah dijalankan untuk menganalisis kebolehlaksanaan tekno-ekonomi sistem PV-bateri bersambung grid, terutamanya di Sarawak. Tujuan utama kajian ini adalah untuk menganalisis kebolehlaksanaan sistem PV-bateri bersambung grid untuk dilaksanakan di pekan Sarawak, Malaysia Timur. Kajian ini juga bertujuan untuk menyiasat Kos Tenaga Bertingkat (LCOE) dan Kos Kini Bersih (NPC), menganalisis pelepasan karbon dan menentukan potensi system PV-bateri bersambung grid. Sistem yang dicadangkan itu akan mengambil kira beberapa kekangan seperti kesan teknikal, ekonomi dan alam sekitar sistem PV-bateri bersambung grid. Perisian Hybrid Optimization of Multiple Energy Resources (HOMER) digunakan untuk melaksanakan kerja simulasi untuk menentukan kesan ekonomi dan alam sekitar serta menilai kebolehlaksanaan sistem yang dicadangkan di bandar-bandar Sarawak. Selain itu, ciri teknikal sistem bateri PV bersambung grid juga dianalisis menggunakan perisian MATLAB/Simulink.

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## LIST OF ABBREVIATIONS

<b>PV</b>	Photovoltaic
<b>NPC</b>	Net Present Cost
<b>HOMER</b>	Hybrid Optimization of Multiple Energy Resources
<b>MATLAB</b>	Matrix Laboratory
<b>AC</b>	Alternative Current
<b>DC</b>	Direct Current
<b>LCOE</b>	Levelized Cost of Energy
<b>COE</b>	Cost of Energy
<b>IRR</b>	Internal Rate of Return
<b>ROI</b>	Return of Investment
<b>UTM</b>	Universiti Teknologi Malaysia
<b>CO<sub>2</sub></b>	Carbon Dioxide
<b>GCPV</b>	Grid-connected Photovoltaic
<b>SOC</b>	State of Charge
<b>DOD</b>	Depth of Discharge
<b>MOSFET</b>	Metal Oxide Semiconductor Field Effect Transistor
<b>IGBT</b>	Insulated Gate Bipolar Transistor
<b>US</b>	United States
<b>NREL</b>	National Renewable Energy Laboratory
<b>NASA</b>	National Aeronautics and Space Administrative
<b>POWER</b>	Prediction of Worldwide Energy Resources
<b>VSI</b>	Voltage Source Inverter
<b>CSI</b>	Current Source Inverter
<b>PCC</b>	Point of Common Coupling
<b>PLL</b>	Phase Lock Loop



<b>PWM</b>	Pulse Width Modulation
<b>STC</b>	Standard Test Condition
<b>PV</b>	Photovoltaic
<b>NPC</b>	Net Present Cost
<b>HOMER</b>	Hybrid Optimization of Multiple Energy Resources

# CHAPTER 1

## INTRODUCTION

### 1.1 Research Background

The use of renewable energy has been growing rapidly in recent years. The unstable price of fossil fuel and greenhouse gases emission caused by conventional electricity has contributed to the introduction of latest technology by using clean and natural energy sources such as solar energy. As of today, approximately 85% of greenhouse gases have been emitted from fossil fuels such as oil, natural gas and coal for electricity generation has led to global warming. The two main challenges of global power systems are providing a sustainable electricity supply and ensuring minimal environmental impact. The conventional electricity needs to integrate with latest technologies to overcome the challenges [1].

Among many renewable energy technologies, solar photovoltaic (PV) technology is the most well-known, clean and sustainable energy harvested from sunlight. However, due to its high capital investment in the past, the implementation of PV system is not common in many countries. With the growth of PV technology, the reduction cost of PV has demonstrated the potential of PV to be installed either on residential or commercial basis worldwide. In Malaysia, the government has announced the target of 20%

renewable energy mix by year 2025. Hence, various programmes and policies has been introduced to empower the renewable energy especially solar energy. The implementation of solar energy is a good way to mitigate global warming by reducing the emission of carbon dioxide and other greenhouse gases. Solar energy is one of the most promising clean and natural energy sources available in future of this world. The technology of PV has been continuously developed in many applications and, today, it has been largely used in supplying the electrical grid power [2, 3].

## **1.2 Problem Statement**

The implementation of PV panels in Sarawak, East Malaysia, is weak and not a common practice in Sarawak's construction industry. Furthermore, very limited research studies have been carried out to analyse the techno-economic feasibility of grid-connected PV-battery systems, especially in Sarawak. Although residential areas and commercial buildings can be installed with PV panels without or with battery backup storage along with the grid to continuously supply uninterrupted power, such feasibility has yet to be analysed. It is necessary to analyse the feasible of using the PV system in Sarawak, Malaysia to reduce energy costs and environmental impacts.

### **1.3 Research Objectives**

The main objective of this project was to analyse the feasibility of the grid-connected PV-battery system in the towns of Sarawak, East Malaysia that will continue the supply of an uninterrupted power to residential and commercial buildings which is safe, environmentally friendly and economically viable. There objectives were as follows:

- To evaluate the feasibility of grid-connected PV-battery system on residential and commercial building of Sarawak
- To determine the economic and environmental effects through Levelized Cost of Energy (LCOE)
- To analyse the technical features of the proposed grid connected PV-battery system in Sarawak.

### **1.4 Research Scope**

This project investigated the feasibility of grid connected PV-battery system in Sarawak. In this project, the economic and environmental analysis of a grid connected PV-battery system was performed using Hybrid Optimization of Multiple Energy Resources (HOMER) software, and the technical analysis was performed using Matrix Laboratory (MATLAB)/Simulink software. Three residential and commercial locations chosen in this project were in Kuching,

Sibu, and Miri. The project was simulation based and was solely done by using HOMER and MATLAB/Simulink software.

## **1.5 Research Contributions and Significances**

The main research contributions of this project are as follows:

- Production of clean and affordable energy
- Reduction of energy usage / waste usage
- Increase economic growth / new business opportunity
- Strengthen the green technology innovation in Malaysia
- Environment conservation for future generation

## **1.6 Thesis Organizations/Outline**

This report consists of 5 chapters, as follows:

- **Chapter 1** is the introduction for this project which mainly discuss the background of this project. All the objectives, scope and the research contributions are discussed in this chapter.
- **Chapter 2** is the literature review which is a review of conference papers, journals and theses related to this project. Some of the past works regarding this project have been reviewed and discussed in this chapter.

- **Chapter 3** contains the research methodology in this project, including the research method to analyse the grid connected PV-battery system. The procedures will be shown in block diagram and research planning for this overall project will be shown in Gantt chart.
- **Chapter 4** discusses all the simulation results based on the objectives as well as analysis and its justification. Besides that, benchmarking also will be conducted by comparing and verifying the simulation results with other journals and articles.
- **Chapter 5** presents the overall conclusions for this project. Some recommendations and suggested for future work will be also discussed and reviewed in this chapter.

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