DESIGN OF A HYBRID-CONNECTED ROOFTOP SOLAR POWER PLANT AT THE WAREHOUSE OF PT. COSL INDONESIA DURI BASE

FINAL YEAR PROJECT

Submitted as One of the Requirements to Complete the Bachelor's Degree (S-1) Program in the Department of Electrical Engineering, Faculty of Industrial Technology Bung Hatta University

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PADANG

2025

APPROVAL PAGE

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PREFACE

All praise and gratitude are expressed to Allah SWT for His grace and blessings, enabling the author to complete this research proposal titled “Design of a Hybrid-Connected Rooftop Solar Power Plant at Warehouse PT. China Oilfield Services Limited (COSL) Indonesia Duri Base.” This proposal is one of the requirements for completing and obtaining a bachelor's degree (Strata-1) in the Electrical Engineering Department, Faculty of Industrial Technology, Bung Hatta University, Padang.

In the process of compiling and completing this proposal, the author has received guidance and direction from various parties. Therefore, with the utmost respect, the author would like to express sincere gratitude to:

1. Allah SWT, for the blessings and grace, allowing the author to complete this research proposal.
2. The author's parents, Waliyul Ahdi and Maya Fitriana Parlina, who have educated, nurtured, and provided endless love, continuously praying for and fully supporting the author in achieving every dream and aspiration.
3. The author’s siblings, Alvaro and Kheva, for their prayers and encouragement.
4. Prof. Dr. Eng. Reni Desmiarti, ST. MT., as the Dean of the Faculty of Industrial Technology, Bung Hatta University.
5. Dr. Ir. Indra Nisja, M.Sc., as the Head of the Electrical Engineering Department and the research proposal supervisor, for the invaluable guidance, constructive feedback, patience, and encouragement throughout the process of completing this thesis. Every piece of knowledge, advice, and support given has been an essential foundation for the author in successfully completing this research.
6. Ir. Cahayahati, as the Academic Advisor.
7. All fellow students of Electrical Engineering 2021, who have provided encouragement and support in the execution and writing of this research.

The author has made every effort to produce the best possible research; however, the author acknowledges that this work is far from perfect. Therefore, constructive feedback, suggestions, and critical insights are warmly welcomed to enhance this proposal. It is hoped that this research proposal will be beneficial, both for the author and the readers.

For all the assistance provided by various parties in the completion of this research proposal, the author prays that Allah SWT rewards their kindness abundantly. Ameen.

Wassalamu`alaikum Wr. Wb.

Padang, September 2025

Asyifa Nadhira

ABSTRACT

This study presents the technical design of a hybrid-connected rooftop photovoltaic (PV) system for the warehouse of PT. COSL Indonesia Duri Base, Riau. The research is motivated by frequent grid interruptions and the need to reduce reliance on fossil-based electricity while maintaining supply reliability. Load data were obtained from on-site observations and PLN token records, while solar resource data (GHI and temperature) were taken from NASA/Global Solar Atlas/WeatherSpark. Using manual calculations, a daily load profile was compiled with a total energy demand of 139.136 kWh and a peak load of 13.7 kW at 09:00. The resulting design specifies a 48.64 kWp rooftop PV array using 108 monocrystalline 450 Wp modules (18S3P) integrated with a 60 kW three-phase hybrid inverter. A $LiFePO_4$ battery system of 30.72 kWh (3 modules) was selected to provide backup capacity. Protection devices (MCBs), appropriate cable sizing, and a 16 A Automatic Transfer Switch (ATS) were determined to ensure safe operation. Overall, the proposed design meets technical specifications, covers the warehouse's daytime demand, and ensures reliable supply during grid outages. This study demonstrates that the system is technically feasible and provides a reference for industrial rooftop PV planning.

Keywords : Hybrid-Connected PV, Rooftop Solar, Warehouse Load Profile, Inverter/SCC Sizing, Battery Backup, Indonesia, GHI.

ABSTRAK

Penelitian ini menyajikan perancangan teknis sistem Pembangkit Listrik Tenaga Surya (PLTS) atap hybrid-connected pada gudang PT. COSL Indonesia Duri Base, Bengkalis, Riau. Penelitian ini dilatarbelakangi oleh seringnya terjadi gangguan jaringan PLN dan kebutuhan untuk mengurangi ketergantungan pada listrik berbasis fosil dengan tetap menjaga keandalan pasokan. Analisis menggunakan data primer dari observasi lapangan (luas atap, inventaris beban, dan jam operasi) serta data sekunder berupa Global Horizontal Irradiance (GHI), suhu, dan catatan token PLN. Profil beban harian 24 jam disusun dengan kebutuhan energi 139,136 kWh per hari dan beban puncak 13,7 kW pada pukul 09:00. Rancangan yang diperoleh adalah PV array berkapasitas 48,64 kWp dengan 108 modul monocrystalline 450 Wp yang disusun 18 seri × 3 paralel (18S3P), terintegrasi dengan inverter hybrid tiga fasa 60 kW. Sistem penyimpanan menggunakan baterai $LiFePO_4$ berkapasitas 30,72 kWh (3 modul) untuk cadangan, sedangkan perangkat proteksi (MCB), ukuran kabel yang sesuai, serta Automatic Transfer Switch (ATS 16 A) menjamin operasi yang aman dan andal. Secara keseluruhan, rancangan sistem memenuhi batasan tegangan dan arus, mampu memenuhi kebutuhan energi siang hari dengan PV, serta menjaga keandalan pasokan saat terjadi gangguan jaringan PLN. Hasil penelitian ini menunjukkan bahwa sistem PLTS atap hybrid yang diusulkan layak secara teknis dan dapat menjadi referensi untuk perencanaan PLTS industri pada kondisi serupa.

Kata Kunci : PLTS Hybrid-Connected, PLTS Atap, Profil Beban Gudang, perhitungan inverter/SCC, Baterai Cadangan, Indonesia, GHI.

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CHAPTER I
INTRODUCTION

1.1 Background

Along with the growth of population, urbanization, and economic development, energy demand in Indonesia continues to increase. According to data from the International Energy Agency (IEA), global energy demand, including Indonesia, is projected to rise significantly in the coming decades. However, the fulfillment of energy needs is still dominated by fossil energy sources such as oil, natural gas, and coal, which have environmental impacts, including greenhouse gas emissions and air pollution (Ministry of Energy and Mineral Resources, 2023). In addition, limited fossil energy reserves and price fluctuations can threaten the stability of national energy supply. Therefore, strategic steps are needed to develop and utilize new and renewable energy sources (NRE) that are environmentally friendly and sustainable, in line with the National Energy Policy (KEN).

Solar energy is one of the most promising renewable energy potentials in Indonesia. With its geographical location around the equator, Indonesia receives high solar radiation intensity throughout the year, with an average of approximately 4.8 kWh/m²/day (International Renewable Energy Agency, 2022). According to data from the Ministry of Energy and Mineral Resources (2021), Indonesia has a solar energy potential of 207.8 GWp, yet only around 0.1% of this potential had been utilized by 2020. This indicates that solar power systems, particularly rooftop photovoltaic systems, offer a viable solution to support the supply of clean energy and reduce dependence on fossil fuels.

The annual average of solar energy in Riau Province ranges from 4.5 to 6.0 kWh/m², with most areas receiving between 5.0 to 5.5 kWh/m². This demonstrates that the region benefits from consistent solar exposure throughout the year, with an average daily sunshine duration of ±5 hours (National Energy Council, 2016). Therefore, solar power plants (SPP) can be considered a potential renewable energy solution given the region's strong solar energy potential.

In addition to the national energy issues, technical problems have also been identified at the warehouse of PT. COSL Indonesia Duri Base, located in Bengkalis Regency, Riau. The facility frequently experiences sudden power outages from the PLN (State Electricity Company), which disrupt operational activities, especially electronic equipment and lighting. Meanwhile, the warehouse has a constant power load that requires a stable electricity supply. Based on an interview with the electrical technician at the PT. COSL Indonesia Duri Base warehouse, it was stated that 'PLN power outages usually occur around 2–3 times per month, with an average duration of 1–3 hours.' (Electrical Engineer at PT. COSL Indonesia Duri Base, 2025). This condition highlights the need for an alternative energy source that can reduce reliance on PLN while also providing backup energy during outages.

The PT. COSL Indonesia Duri Base warehouse has a rooftop area of approximately 540 m^2 that faces an open direction with no shading obstacles, making it highly suitable for solar panel installation. According to Global Solar Atlas data, the Duri region in Riau receives an average solar radiation of about 4.5 to 5.1 $kWh/m^2/day$, which is sufficient to support a rooftop solar power system. In addition, the warehouse is connected to the PLN electricity grid with an installed capacity of 10,000 VA, enabling the use of an integrated hybrid-connected solar PV system. To enhance system reliability, batteries are planned for use as energy storage backup to ensure continuous power supply during outages.

Based on these conditions, this research focuses on the technical planning of a hybrid-connected rooftop solar PV system at the PT. COSL Indonesia Duri Base Warehouse. This includes determining the appropriate capacity for solar panels, inverters, and batteries Based on the location's solar potential and load profile. Therefore, a hybrid-connected rooftop PV design is proposed as an efficient and sustainable solution to support operational energy needs. The aim of this research is to produce an efficient and reliable system design that can serve as a clean energy solution applicable in the industrial sector.

1.2 Problem Statements

Based on the background described above, the research problems are formulated as follows :

1. How to determine the capacity and configuration of the PV array to meet the load demand of PT. COSL Indonesia Duri Base warehouse?
2. How to determine the capacity of the inverter, Solar Charge Controller (SCC), and batteries so that the rooftop PV system can operate optimally and in accordance with technical specifications?
3. How to determine the capacity of protection devices (MCB) and cable sizing to ensure the system operates safely in compliance with standards?

1.3 Scope of The Research

To maintain research focus, the following limitations apply:

1. This study only discusses the technical planning aspects of a hybrid-connected rooftop solar PV system (connected to PLN and using battery storage) at the PT. COSL Indonesia Duri Base warehouse.
2. The analysis is conducted using manual calculations Based on technical data, without the use of simulation software.
3. The system capacity calculation in this study does not take into account the roof tilt angle in detail, but instead uses the global horizontal irradiance (GHI) data as the basis for the calculation.
4. The data analyzed includes solar radiation potential at the site, the electricity load profile of the warehouse, and the technical specifications of the main components such as solar panels, inverters, and batteries.
5. This research does not cover economic feasibility or environmental impact analysis, but is limited to technical feasibility aspects.
6. The study is a design-Base study using secondary data, without field implementation or testing.

1.4 Research Objectives

Based on the research problem formulation that has been explained, the objectives of this research are as follows :

1. To determine the capacity and configuration of the PV array to meet the load demand of PT. COSL Indonesia Duri Base warehouse.

2. To determine the capacity of the inverter, Solar Charge Controller (SCC), and batteries so that the rooftop PV system can operate optimally and in accordance with technical specifications.
3. To determine the capacity of protection devices (MCBs) and cable sizing to ensure safe operation of the system in compliance with standards.

1.5 Research Benefits

The expected benefits of this research include:

1. Providing a technical overview of hybrid solar PV system planning that can be applied in the industrial sector.
2. Serving as a preliminary reference for PT. COSL Indonesia and other parties in designing rooftop PV systems integrated with PLN and battery storage.
3. Supporting the use of renewable energy in regions with high solar potential such as Duri, Riau.
4. Increasing the author's knowledge and experience in the field of solar energy and renewable power system design.