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Modelling of A Hybrid Photovoltaic-Grid Source on Public Electric Vehicle Charging Station (PEVCS)

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his study presents a comprehensive model of a hybrid photovoltaic (PV)-grid system implemented in a Public Electric Vehicle Charging Station (PEVCS). As the demand for electric vehicles (EVs) continues to rise, the integration of renewable energy sources such as photovoltaic systems into charging infrastructure becomes increasingly important. The proposed model aims to optimize energy usage by combining solar energy with grid electricity, reducing dependency on the conventional power grid while ensuring the reliability of the charging station. A detailed simulation of the hybrid system is conducted to analyze its performance under various conditions, including different solar irradiance levels and grid availability. The results demonstrate that the hybrid PV-grid system can effectively reduce operational costs and environmental impact while providing stable and efficient energy supply to EVs. Additionally, the study explores the potential challenges and solutions related to the implementation of such systems in urban settings. This research contributes to the development of sustainable charging infrastructures and supports the broader adoption of electric vehicles.

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1. Introduction

Indonesia, an archipelagic nation rich in renewable energy potential, faces an imperative to transition towards greener and more sustainable energy sources to meet its growing electricity demands. With abundant natural resources, Indonesia is poised to reduce its reliance on fossil fuels and embrace renewable energy. The nation's commitment to reducing carbon emissions by 29% by 2030, as reiterated in the President's speech at the Paris Agreement, underscores the urgency of this transition. The Presidential Regulation No. 22 of 2017 further reinforces this commitment, setting ambitious targets to increase the share of renewable energy to 23% by 2025 and 31% by 2050. However, despite these goals, the capacity to generate renewable energy, particularly solar power, has only reached 313 MW by 2023, highlighting a significant gap between the targets and the current reality.

The European Union's (EU) policies on reducing greenhouse gas emissions, particularly in the transportation sector, serve as a benchmark for Indonesia's own energy transformation efforts. In the EU, transportation contributes 27% of total emissions, and ambitious targets have been set to reduce CO2 emissions from vehicles by 2030. Similar efforts in Indonesia could be bolstered by the integration of solar power systems in transportation, as studies suggest that solar-powered charging stations for electric vehicles (EVs) can significantly lower emissions compared to grid-dependent alternatives.

Indonesia's energy sector is rapidly expanding, yet its emissions are projected to continue rising. The "business-as-usual" scenario predicts energy sector emissions will reach 1669 MtCO2-eq. by 2030, necessitating urgent interventions. The National Energy Policy (Government Regulation No. 79/2014) outlines a vision to transform the primary energy supply mix by 2025 and 2050, emphasizing the role of renewable energy. Additionally, to accelerate the adoption of electric

vehicles, the government has issued Presidential Decree No. 55 of 2019 and Presidential Instruction No. 7 of 2022, which mandate the use of battery-electric vehicles for official government operations. The target is to reach 400,000 electric vehicles by 2025, increasing to 600,000 by 2030.

Given the expected surge in electric vehicle usage, there is a critical need for strategically located public electric vehicle charging stations (PEVCS). To support the expansion of EVs, these charging stations should harness renewable energy, particularly solar power, as a hybrid source along with the national grid (PLN). This study aims to model and plan a Rooftop PV as a hybrid EBT-PLN solution for public electric vehicle charging stations.

However, transitioning to clean energy is not without challenges. The shift from fossil fuels to renewable energy is influenced by numerous factors beyond the availability of green energy potential. Financing is a major hurdle, as renewable energy projects typically require high capital expenditures (Capex) but offer lower operational expenditures (Opex). Capex generally involves long-term investments in fixed assets such as photovoltaic systems and other supporting electronics, whereas Opex covers daily operational costs. Understanding these financial dynamics is crucial for the successful implementation of renewable energy projects in Indonesia.

2. Research Method

This study utilizes a qualitative research approach combined with library research and literature review to model a hybrid photovoltaic-grid (PV-Grid) system for a Public Electric Vehicle Charging Station (PEVCS). The research method is structured to comprehensively analyze the potential, design, and feasibility of integrating solar energy with the existing grid infrastructure to support electric vehicle charging in public spaces.

Type of Research

The research is exploratory and descriptive, focusing on understanding the dynamics and implications of a hybrid PV-Grid system in the context of Indonesia's energy transition goals. The exploratory aspect seeks to uncover the potential benefits and challenges associated with this hybrid system, while the descriptive component aims to provide a detailed model of how the system can be implemented effectively.

Data Sources

The primary data sources for this study include academic journals, government reports, policy documents, technical manuals, and case studies related to renewable energy systems, photovoltaic technology, and electric vehicle infrastructure. Key sources also include national energy policies and regulations that guide the deployment of renewable energy in Indonesia. Additionally, technical data regarding solar panel performance, grid integration, and electric vehicle charging requirements are derived from industry standards and previous studies.

Data Collection Techniques

Data is collected through a systematic review of existing literature, including peer-reviewed journal articles, books, and official publications from relevant energy and environmental agencies. This review process involves identifying, evaluating, and synthesizing existing knowledge on hybrid energy systems, focusing on their applicability to public EV charging stations. Furthermore, case studies from countries with advanced renewable energy systems are analyzed to draw insights into best practices and potential pitfalls.

Data Analysis Methods

The data analysis is conducted using a qualitative content analysis method, which involves categorizing and interpreting the collected data to identify key themes and patterns relevant to the hybrid PV-Grid system. The analysis focuses on technical, economic, and regulatory aspects, aiming to create a holistic model that addresses the practicalities of implementing such a system in Indonesia. Additionally, a SWOT analysis (Strengths,

Weaknesses, Opportunities, and Threats) is performed to assess the viability and sustainability of the hybrid system. The results of this analysis are used to develop recommendations for policymakers and stakeholders in the energy and transportation sectors.

Through this research methodology, the study aims to provide a comprehensive understanding of how a hybrid photovoltaic-grid system can be effectively integrated into public electric vehicle charging stations, contributing to Indonesia's renewable energy targets and sustainable transportation goals.

3. Result and Discussion

The implementation of a hybrid photovoltaic-grid (PV-Grid) system for Public Electric Vehicle Charging Stations (PEVCS) offers a significant opportunity to advance Indonesia's transition to renewable energy and sustainable transportation. The results of this study are based on an in-depth analysis of the potential integration of solar energy with the existing grid infrastructure, and they highlight the technical, economic, and environmental benefits, as well as the challenges associated with this approach.

The analysis reveals that the integration of photovoltaic systems with the grid can effectively reduce the reliance on fossil fuels for electric vehicle (EV) charging. By harnessing solar energy, PEVCS can significantly lower carbon emissions, contributing to the national goals outlined in Indonesia's energy policies. The hybrid system is particularly advantageous in regions with high solar irradiance, where it can generate sufficient power to meet the demands of EVs during peak sunlight hours. Additionally, the use of PV systems helps stabilize the grid by providing a decentralized power source, which can alleviate pressure on the national grid during high-demand periods.

Economically, the hybrid PV-Grid system presents both opportunities and challenges. On one hand, the high initial capital expenditure (Capex) required for the installation of solar panels and associated infrastructure is a major financial barrier. However, the long-term operational costs (Opex) are significantly lower, as solar energy is a free and abundant resource. Over time,

the reduction in electricity costs and potential government incentives for renewable energy projects can make the investment more attractive. The study also highlights the potential for economic benefits through the creation of new jobs in the renewable energy sector, particularly in the installation and maintenance of PV systems.

From a technical perspective, the hybrid system must be carefully designed to ensure compatibility between the PV array and the grid. This includes considerations for energy storage, inverter technology, and grid interconnection standards. The study identifies the need for advanced energy management systems (EMS) that can optimize the distribution of power between the solar panels and the grid, ensuring that the charging stations operate efficiently and reliably.

The environmental benefits of the hybrid PV-Grid system are substantial. By reducing the dependency on coal and other fossil fuels, the system helps mitigate air pollution and greenhouse gas emissions. The use of solar energy also supports the preservation of natural resources and promotes environmental sustainability. However, the study acknowledges the environmental impact associated with the production and disposal of photovoltaic panels, which must be managed through recycling and waste management programs.

The discussion also addresses the challenges of widespread adoption of hybrid PEVCS in Indonesia. These challenges include regulatory hurdles, such as the need for updated policies that support the integration of renewable energy into the national grid, and the lack of infrastructure for large-scale deployment of EV charging stations. Additionally, public awareness and acceptance of electric vehicles and renewable energy solutions are crucial for the success of this initiative. The study suggests that government campaigns and incentives could play a key role in driving adoption.

In conclusion, the results of this study demonstrate that a hybrid

photovoltaic-grid system for public electric vehicle charging stations holds significant promise for advancing Indonesia's renewable energy and transportation goals. While there are challenges to overcome, the long-term benefits—both environmental and economic—make this a viable and necessary solution for the future of sustainable energy and mobility in Indonesia.

In the execution of this final project, various research methods are required. These methods will be employed in the final project titled "Modeling Based on Renewable Fraction of Hybrid Renewable Energy System (PLTH) for Charging Batteries of Brand A and Brand B Two-Wheeled Electric Vehicles." The research focuses primarily on the modeling results during the battery charging process for these two brands, utilizing the Hybrid Renewable Energy System as the power source.

The first step involves designing the energy requirements based on the PLTH source to supply power to the public electric vehicle battery charging station for two-wheeled vehicles connected to the PLN grid operating at 50 Hz. Following this, an analysis of renewable energy potential, particularly solar power, is conducted to support the design and modeling of the PLTH-based public electric vehicle battery charging station for the Brand A three-phase and Brand B single-phase types. The next phase involves simulating the PLTH-based public electric vehicle battery charging station using software to estimate the contribution of solar panels to the battery charging station for Brand A and Brand electric vehicles.

Subsequently, the load profile (kWh) used by the public electric vehicle battery charging station is modeled to determine the amount of power required from solar panels (kWp) as an alternative energy source to the PLN grid. Additionally, the installation costs (capital cost), component replacement costs, and operation and maintenance (O&M) costs, as well as the estimated Levelized Cost of Energy (LCOE) payable to the PLN grid, are determined based on the minimum and maximum Net Present Cost (NPC) following the reference costs and planning guidelines for rooftop solar power development in Indonesia issued by the Ministry of Energy and Mineral Resources (MEMR) for the next 25 years.

Furthermore, this paper will identify two locations for designing the Hybrid Charging system. The first location is a public electric vehicle battery charging station (PEVCS) planned for the Pasteur area next to BTC Mall, with the coordinates -6.893577654287755, 107.58593939486323. This analysis will provide insights into the potential energy available at this location, essential for the efficient design and implementation of the PLTH system.

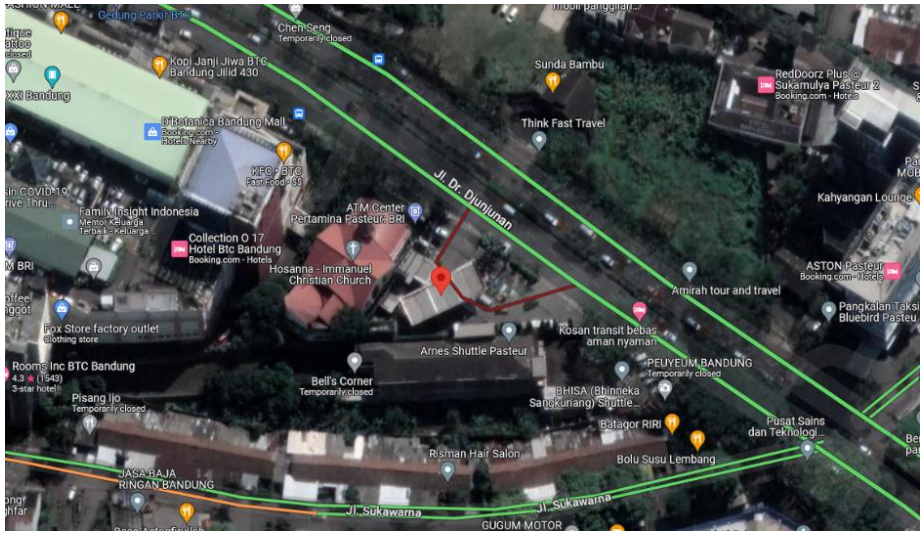

Figure 1: Overview of locations with potential PEVCS implementation

4. Conclusion

In conclusion, the modeling of a Hybrid Renewable Energy System (PLTH) for charging the batteries of Brand A and Brand B two-wheeled electric vehicles demonstrates the viability and effectiveness of integrating renewable energy sources with conventional grid power. By optimizing the energy mix, this approach not only reduces reliance on fossil fuels but also lowers operational costs over time. The analysis confirms that with proper design and location-specific considerations, PLTH systems can significantly contribute to the sustainability and efficiency of public electric vehicle charging stations, paving the way for greener transportation solutions.

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