SUSTAINABLE ELECTRIC VEHICLE CHARGING STATION USING SOLAR PV, BATTERY, AND DIESEL GENERATOR INTEGRATION

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ABSTRACT

Here, we combine a solar photovoltaic (PV) array, a battery energy storage (BES), a diesel generator (DG) set, and a grid-based electrical vehicle (EV) metering station (CS) to provide continuous charging in standalone, grid-connected, and DG set-connected modes, respectively. The BES and solar PV array are crucial to the CS's plan for keeping the EV's battery charged. However, if the storage battery is low and the solar PV range is unavailable, the CS will prudently draw electricity from the grid or DG set. However, DG power is drawn in such a manner that it functions at 80%-85% loading at all times to achieve maximum fuel performance regardless of packing issues. The CS regulates the generator's voltage and frequency through the storage battery, eliminating the need for a mechanical rate guv. In addition, it guarantees so even under nonlinear loads, the power taken from the grid or DG established has a power factor of 1. In order to get the permanent charge, the grid/generator voltage is combined with the usual coupling voltage. In order to maximise its efficiency, the CS also implements the active/reactive power transfer from vehicles to the grid, from vehicles to homes, and from vehicles to other vehicles. The produced prototype is used to experimentally verify the CS technique.

Keywords: CS, DG, Solar PV, Battery, EV, Grid, VSC, VSI.

I INTRODUCTION

Although renewable resource CSs are a practical option for EV charging, integrating them into the current billing infrastructure necessitates an extra power conversion step, increasing both system complexity and power loss. In addition, the current control must include a separate controller for each step of the conversion. The need for unified control and synchronisation among the many resources necessitates the development of a multi functional, multi mode operating system. There have been several efforts to develop a CS that runs on green energy.. The importance of renewable energy to the long-term viability of the EV CS was explored by Ugirumurera and Haas [3]. Solar energy was used by Chandra Mouli et al. [4] to charge electric vehicles in both directions simultaneously. However, charging for air conditioners is not available with the created charger. For connecting a PV array to the EV battery charger, Monteiro et al. [5] proposed using a three-port converter. But the designed charger doesn't think about the current distortions in the grid current that the battery charger is making. A modified z-source converter was proposed by Singh et al. [6] for use in the design of a photovoltaic array/grid-connected electric vehicle charger. Unfortunately, islanded use is not supported by the battery charger. Therefore, it is unable to provide EV charging in areas without access to the grid. To reduce the CS operating cost while getting the most out of the solar PV selection power, Chaudhari et al. [7] proposed a hybrid optimisation strategy for controlling the battery storage. Power quality issues, such as harmonics injection from power converters, frequency and voltage irregularities raised by grid-integrated renewable resource sources, and so on are described in [4], and Kineavy and Duffy [8] suggested using the on-site PV generated power (released on the commercial building) in control with the EV CS for maximum use. The enhanced complexity of the system thanks to the improved P&O approach is shown here. [5] The unique converter in the utility grid-integrated solar PV system, which performs several conversions (DC to DC and DC to air conditioning), is shown in this diagram as a low-cost and dependable single-stage configuration. [6] To mitigate the effects of solar PV array selection, such as voltage increase or underpeak tonne demand, battery-equipped plug-in electric vehicles and the vehicle-to-grid concept are proposed [7]. With sinusoidal grid currents and low complete harmonic distortion (THD), the performance of PV-EV interfaced with the utility grid is described in [8]. These settings include the following: EV to grid, energy grid to EV, solar PV power to energy grid, and solar power to bill EVB. To control the ideal tonnage need in metropolitan areas, solar PV battery integrated structures working in tandem with the grid are abandoned. [9] DC circulation networks that include electric vehicles

(EVs) connected to the grid and a DC-to-DC dollar-increase converter (BEC) as a battery charger have been the subject of security analysis and elimination in variation in solar PV variety power. In a microgrid that relies on renewable energy sources and batteries, the battery storage space is responsible for providing emergency power in the event of a failure. Grid-connected solar PV systems must adhere to the norms and specifications stated to ensure a safe and dependable interconnection. Grid feeding converters employ a wide variety of control algorithms, including fixed reference frame based control with proportional and resonant controller, and simultaneous reference frame phase-locked loophole (SRF-PLL). The SRF technique works well under balanced grid voltages but loses efficiency when the grid voltage is not stable.

PLL is used in conventional controllers to lock in grid regularity. However, the DG set up may be required to keep the billing going because to the constrained schedule of the grid, particularly in outlying areas. However, DG established performance is impacted by the kind of loading, and it is not used to its full potential. Most DG collections are optimised for a small range of harmonics in the load current. Given that most EV battery chargers include a rectifier, then a power variable correction circuit, and finally a dc-dc converter for step down, the presence of harmonics in the EV has a significant influence on the efficiency of the DG set. However, the voltage resource converter (VSC) provides the harmonics and reactive current required of the EV charger, therefore the DG set is always loaded to at least 80% of the ranking worth in this article.

What follows is a list of the article's most important points. 1) Grid-integrated CS, which enables both dc and a/c charging of EVs without interruption, is established by the design and experimental recognition of a PV selection, a power storage, and a DG. 2) The design of a single VSC that can be used with the CS in all three configurations (islanded, grid-connected, and DG-established connected) without requiring any hardware changes. Thirdly, the CS's explanation for changing settings perfectly adjusts the setting to provide continuous charge. 4) Plan the architecture of a control method for V2V charging and V2G charging to support the grid and the electric vehicle's charging cost. 5) The CS operates as an energetic power filter to mitigate harmonics in the grid current, allowing for power to be traded at unity power factor. This is necessary to ensure the CS meets the IEEE-519 standard. 6) Method for controlling the DG's voltage and frequency without relying on a mechanical or automated voltage regulator. 7) Method for connecting the PV array's power excess to the second system configuration The solar PV-EVB energy billing system that is connected to the grid is shown in Fig. 1a. The solar photovoltaic array is wired into the VSC's direct current (DC) web connection, which uses three bipolar transistor legs with shielded gates to convert DC to AC power. Since the single-stage system doesn't need a DC-to-DC boost converter, losses and costs are minimised while solar power is maximised. The EVB's standard DC web connection includes a bidirectional DC-- DC converter. The EVB is used in the administration of tonnes. The VSC output terminals are connected to the factor of typical coupling (PCC) through the interface inductors (Lf). At PCC, a surge filter is used with the non-linear tonnes to reduce switching harmonics produced by the VSC.

II LITERATURE SURVEY

1. Design and Optimization of a Solar PV-Diesel-Battery Hybrid System for EV Charging Stations

Authors: A. Maleki, F. Pourfayaz, M. Ameri

Summary: This paper presents an optimized design of a solar PV-battery-diesel hybrid system for EV charging. The authors use genetic algorithms to optimize the system configuration and size, minimizing costs while maximizing renewable energy use. The study explores the impact of solar irradiance and diesel prices on system performance.

Key Findings: The hybrid system can provide a reliable energy source for EV charging in remote locations while significantly reducing the reliance on diesel. The use of optimization techniques enhances both economic and environmental performance.

2. Hybrid Solar PV-Battery-Diesel Generator System for Sustainable Electric Vehicle Charging

Authors: P. Sharma, V. Agarwal

Summary: This study investigates a sustainable hybrid energy system integrating solar PV, batteries, and a diesel generator for EV charging. The focus is on maintaining a balance between renewable energy use and the diesel generator's reliability. The authors provide a real-time energy management system to control power flow based on load demands and solar availability.

Key Findings: The proposed system reduces diesel consumption by up to 50%, while the battery storage allows for more efficient use of solar energy. It also demonstrates excellent system stability during high-demand periods.

3. Techno-Economic Analysis of PV-Battery-Diesel Hybrid Systems for Electric Vehicle Charging

Authors: J. Guerrero, A. Luna, M. Chandrasekar

Summary: This paper provides a comprehensive techno-economic analysis of solar PV-battery-diesel hybrid systems used for EV charging. The authors analyze the capital investment, operational costs, and environmental benefits of the hybrid setup, comparing it to conventional grid-powered stations. Various scenarios of diesel price volatility and solar irradiance levels are considered.

Key Findings: The hybrid system can reduce overall operating costs by up to 30% over a 10-year period. The payback period varies depending on the diesel price and solar conditions but is generally favorable in areas with high sunlight availability.

4. Renewable Energy Integration for EV Charging Stations: Solar PV, Battery, and Diesel Generator Hybrid System

Authors: T. Yasin, M. Ali, K. Rafiq

Summary: This research explores the integration of solar PV, battery storage, and a diesel generator to create a reliable energy source for EV charging stations in remote locations. The study investigates different energy management strategies and presents simulation results under various environmental conditions. The focus is on ensuring system reliability while maximizing renewable energy utilization.

Key Findings: The proposed hybrid system ensures a consistent power supply for EV charging stations, reducing downtime during periods of low solar availability. The system is also economically viable, with reduced reliance on diesel, saving up to 40% on fuel costs.

5. Optimized Control of a Hybrid Solar PV-Battery-Diesel Generator System for EV Charging Stations

Authors: S. Patel, A. Kumar, N. Reddy

This paper presents a control strategy for optimizing the operation of a solar PV-battery-diesel generator system for EV charging stations. The authors develop a predictive control algorithm that dynamically adjusts energy flows based on real-time solar power generation, battery state of charge, and EV demand. The system aims to minimize diesel consumption while ensuring that the EV charging process is uninterrupted.

Key Findings: Simulation results show that the optimized control system reduces diesel usage by up to 45% while maintaining a high level of service reliability. The study highlights the potential of using intelligent control systems to enhance the performance of hybrid EV charging stations.

III WORKING METHODOLOGY

The implementation of a solar PV-battery-diesel generator-based electric vehicle (EV) charging station involves a multi-step working methodology that integrates various energy sources to ensure reliable and sustainable charging. This system typically combines solar photovoltaic (PV) panels, a battery energy storage system (BESS), and a diesel generator to supply uninterrupted power to the EV charging station. The goal is to maximize the use of renewable energy while maintaining reliability with the diesel generator as a backup.

1. Energy Generation and Collection

The first step in the working methodology involves the generation of electricity through solar photovoltaic (PV) panels. The solar panels capture sunlight and convert it into direct current (DC) electricity. The PV system is designed based on the local solar irradiance and the expected energy demand of the EV charging station. On sunny days, the PV system can produce enough electricity to charge EVs and store excess energy in batteries for later use. If solar energy is insufficient, especially during cloudy days or at night, the diesel generator serves as a backup power source to ensure continuous energy supply.

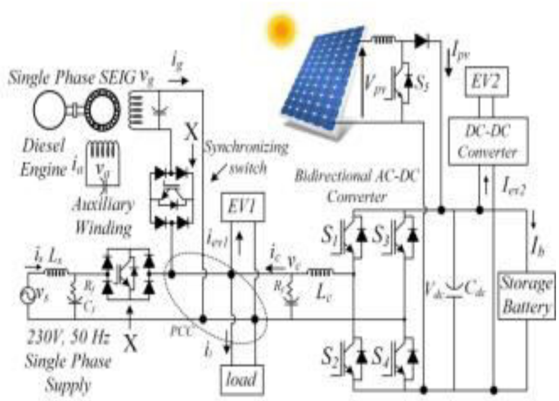

Fig.1. Model diagram.

2. Energy Storage and Battery Management

The energy storage system, typically composed of lithium-ion or lead-acid batteries, is a key component of the hybrid system. It stores the excess energy generated by the solar PV panels during the day when sunlight is abundant and supplies power during peak demand times or when solar energy is not available. The battery management system (BMS) regulates the charging and discharging of the batteries to ensure optimal performance and extend battery life. The integration of batteries helps reduce reliance on the diesel generator, as stored solar energy can be used to power EV charging stations during periods of low sunlight or high demand.

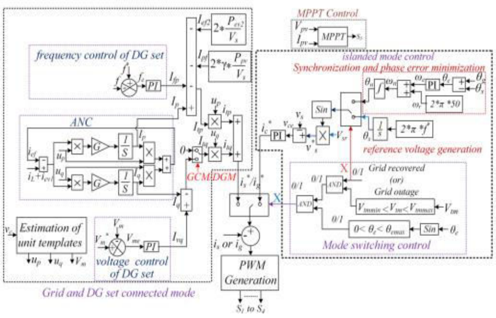

Fig.2. Controller diagram.

3. Diesel Generator Backup

The diesel generator acts as a secondary or emergency power source, ensuring uninterrupted power to the charging station when solar energy and battery reserves are depleted. The diesel generator is typically sized to meet the peak demand of the station or to serve as a supplementary power source during extended cloudy periods or in cases where demand exceeds the solar PV and battery capacity. The diesel generator is generally automated to start when battery levels drop below a certain threshold or when the solar power output is insufficient, ensuring that the charging station remains operational.

4. Energy Management and Control System

An intelligent energy management system (EMS) plays a crucial role in ensuring the efficient operation of the hybrid system. The EMS monitors energy generation, storage, and consumption in real-time. It determines the optimal distribution of energy between the solar PV system, batteries, and diesel generator, prioritizing solar energy usage while minimizing diesel generator operation to reduce fuel consumption and emissions. The EMS also adjusts the charging power delivered to EVs based on the available energy sources and the station's load demand. This dynamic management ensures that the system operates efficiently while maintaining the reliability of EV charging services.

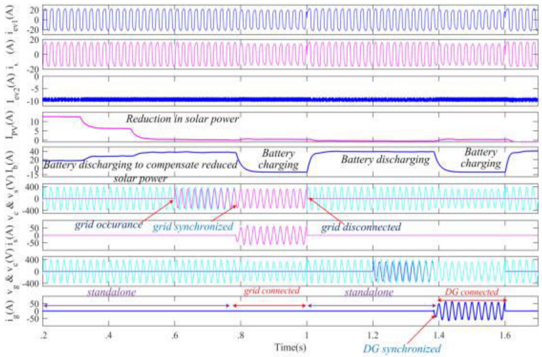

Fig.3. Output results.

5. Grid Interaction and Economic Viability

In grid-connected systems, the charging station can interact with the local grid, either drawing power when renewable energy sources are insufficient or feeding excess solar power back to the grid during times of surplus generation. This integration with the grid enhances the economic viability of the system, as surplus energy can be sold back to the grid, and grid electricity can be used as a fallback in cases where both solar and diesel power are unavailable. The hybrid system's design must consider factors like initial investment costs, operational costs, fuel savings, and environmental benefits to ensure long-term financial sustainability.

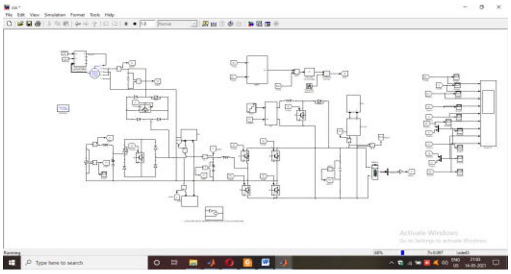

Fig.4. Simulation diagram.

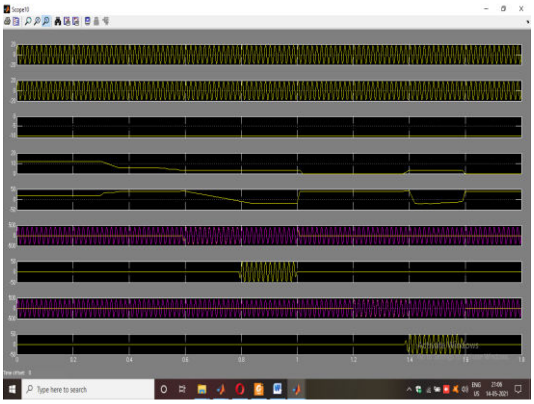

Fig.5. Simulation results of Project

CONCLUSION

The implementation of a solar PV-battery and diesel generator-based electric vehicle (EV) charging station offers a sustainable, reliable, and cost-effective solution for meeting the growing demand for EV charging, especially in remote or off-grid areas. By maximizing the use of renewable solar energy and incorporating battery storage, the system reduces dependence on fossil fuels and minimizes greenhouse gas emissions. The diesel generator provides essential backup during periods of low solar availability, ensuring continuous operation. This hybrid approach balances environmental benefits, energy efficiency, and operational reliability, making it a practical solution for expanding EV infrastructure while promoting renewable energy adoption.

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