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Smart Electric Vehicle Charging Station Using Solar Power

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***Abstract*—Electric vehicle (EV) charging stations powered by renewable energy sources, such as solar power, can significantly reduce carbon emissions from transportation. In this paper, we propose a smart electric vehicle charging station that utilizes solar power to charge EVs. The proposed system integrates solar panels, battery storage system, and electric vehicle charging equipment to provide a sustainable and efficient charging solution. Additionally, a smart charging system optimizes the use of solar energy and manages the charging sessions to avoid peak demand periods. We describe the system design, implementation, and benefits of a solar-powered smart EV charging station.**

***Keywords*—solar panel, BMS, IOT, EV charging station.**

I. Introduction

With the increasing demand for electric vehicles (EVs), the need for electric vehicle charging stations is growing rapidly. However, the use of traditional electricity sources to power these stations results in significant environmental impact and contributes to the global carbon footprint. Therefore, the implementation of renewable energy sources, such as solar power, is becoming increasingly important.

The combination of solar power and electric vehicle charging stations offers a sustainable solution that can significantly reduce carbon emissions and promote the use of renewable energy sources. The integration of a smart charging system allows for efficient management of the charging process, optimizing the use of solar energy and avoiding peak demand periods. This paper proposes a smart electric vehicle charging station that is powered by solar energy and includes a smart charging system.

The paper is organized as follows: The first section provides an overview of the current status of electric vehicle charging stations and the use of solar power as a renewable energy source. The second section presents the proposed smart electric vehicle charging station and its components. The third section discusses the implementation of the proposed system. Finally,the conclusion summarizes the findings of this research paper and discusses the potential for future research.

II. Current Status of Electric Vehicle Charging Stations and Solar Power

The increasing demand for electric vehicles has resulted in a significant increase in the number of electric vehicle charging stations globally. According to the International Energy Agency (IEA), the number of publicly accessible electric vehicle charging points reached over 1.3 million worldwide in 2020. However, the majority of these charging stations rely on traditional electricity sources, such as coal and natural gas, which contribute to greenhouse gas emissions.

The implementation of renewable energy sources, such as solar power, can significantly reduce the environmental impact of electric vehicle charging stations. Solar power is a clean and renewable energy source that can be harnessed to provide electricity to charging stations. The use of solar power in electric vehicle charging stations not only reduces carbon emissions but also reduces the reliance on the traditional electricity grid, providing energy security.

III. Methodology

A. Block Diagram

- The grid-based photovoltaic charging system is an innovative future technology. The photovoltaic charging system is shown in the architecture, which was developed after various studies.
- The above design shows that a DC-to-DC converter and a DC-to-AC converter both produce two stages. The dc bus is more important since it interfaces with additional dc power devices, as well as the PV array and energy storage batteries of electric cars. The fact that the DC bus is meant to connect the PV array, the ESU, the EV battery pack, and other dc powered devices emphasizes its importance.

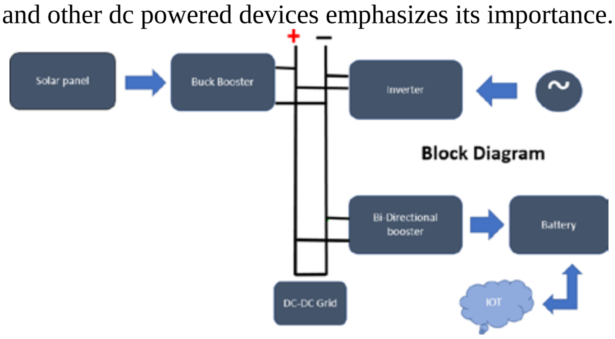

Fig. 1. Block Diagram

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- Standalone PV charging system: With an off-grid station, power is provided directly to the batteries of an electric car. Connection to the power grid An Energy Storage Device (ESD) unit is connected to the charging system to deliver electricity to the EV battery continuously during the night.
- We'll build an Internet of Things project in which the ESP8266 will track its own battery level using the BlynkIoT Cloud. We can monitor sensor data, battery charging/discharging status, battery voltage, and battery % in order to quickly recharge it. This is a simple method that makes use of a voltage divider circuit and the analogue input on the NodeMCU ESP8266 board.

B. Lab Setup

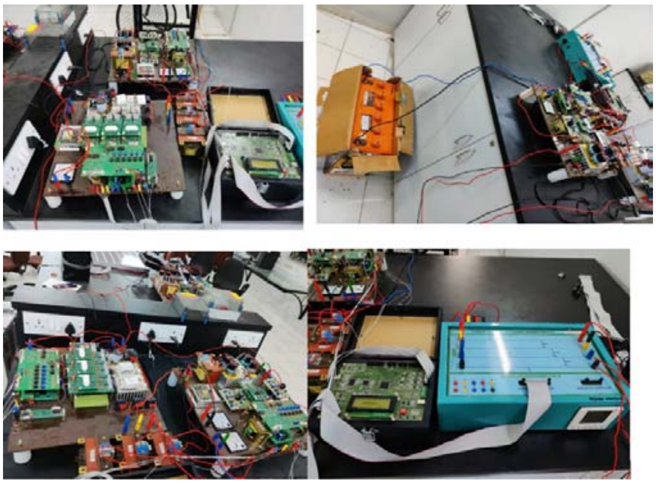

Fig. 2.Lab Setup.

- Solar panel

The solar panels are used to harness solar energy and convert it into electrical energy to power the EVCS. The number and capacity of solar panels depend on the expected charging demand, the geographic location, and the climate conditions.

- Energy Storage System

The energy storage system consists of batteries that store the excess solar energy generated during the day and use it to power the EVCS during the night or periods of low solar irradiance. The energy storage system also provides a buffer to balance the energy supply and demand, and ensure stable and reliable charging services.

- Energy Management

The energy management module is responsible for monitoring and optimizing the energy flows in the system. It uses real-time data from the solar panels, energy storage system, and EV charging stations to predict the energy demand and supply, and adjust the charging rates and schedules accordingly. The energy management module also ensures the safety and stability of the system by regulating the voltage and current levels, and preventing overloading or short-circuiting.

- EV Charging Stations

The EV charging stations are the primary interface be- tween the EVs and the EVCS. The proposed system supports different charging standards such as AC, DC, and fast charging, and can accommodate multiple EVs simultaneously. The charging stations are equipped with sensors and communication devices that enable real-time monitoring and control of the charging process.

C. Battery Management System

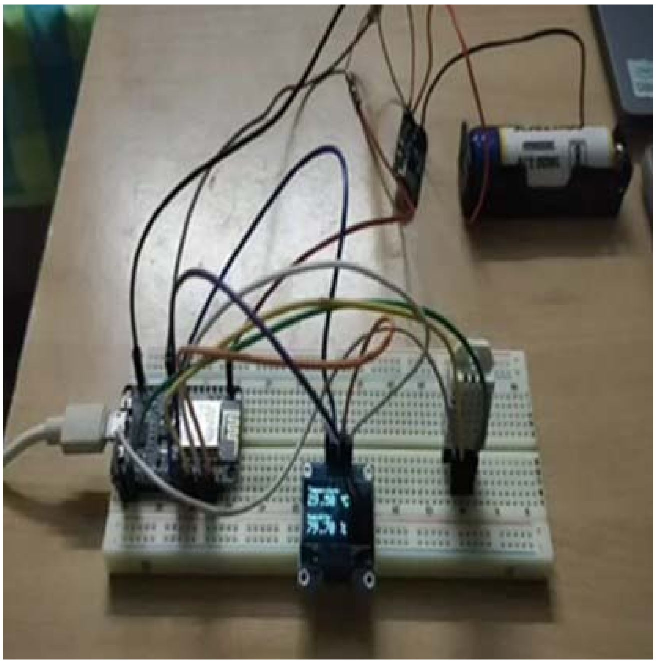

Fig. 3.Battery Management Setup.

- Smart Control System

The smart control system is the brain of the proposed EVCS. It integrates various advanced technologies such as IoT, AI, and cloud computing to optimize the system performance, enhance the user experience, and providevalue-added services. The smart control system consists of four main modules: energy management, charging scheduling, user interface, and communication and security.

- Charging Scheduling

The charging scheduling module is responsible for man- aging the charging sessions and optimizing the charging efficiency. It uses data from the EVs, such as battery capacity, charging status, and location, to prioritize the charging sessions and allocate the available energy re- sources efficiently. The charging scheduling module also provides real-time updates to the users about the charging status, estimated time of completion, and charging costs.

- User Interface

The user interface module provides a user-friendly and interactive interface for the customers to access the charging services and manage their accounts. It includes a mobile app and a web portal that enable customers to reserve charging spots, track the charging progress, and pay the charging fees. The user interface module also provides personalized recommendations and incentives

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based on the user's preferences and behavior.

IV. Implementation

Fig. 4.Mobile Dashboard.

The implementation of the proposed smart electric vehicle charging station involves several steps:

a) Feasibility Study: Evaluate the solar energy resource at the location, the expected demand for the charging station, and the required capacity of the battery storage system.

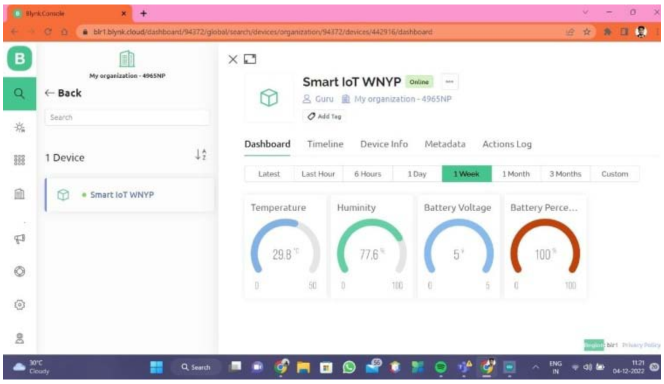

Fig. 5.Website Dashboard.

b) System Design: Develop a design that integrates the solar panels, battery storage system, and electric vehicle charging equipment. Determine the capacity of the solar panels and battery storage system needed to meet the expected demand for the charging station.

c) Equipment Selection: Choose the solar panels, battery storage system, and electric vehicle charging equipment that meet the project's requirements. Consider the efficiency, durability, and cost of the equipment.

d) Installation: Install the solar panels, battery storage system, and electric vehicle charging equipment according to the design specifications. Ensure that the installation follows safety regulations and industry standards.

e) Smart Charging Implementation: Integrate the smart charging system that manages the charging sessions, optimizes the use of solar energy, and communicates with the electric grid to avoid peak demand periods. The smart charging system can be implemented using a variety of technologies, including energy management systems, intelligent algorithms, and cloud- based platforms.

f) Testing and Commissioning: Test the charging station to ensure that it meets safety regulations and industry standards. Commission the charging station to operate efficiently and sustainably.

g) Monitoring and Maintenance: Monitor the performance of the charging station and maintain the equipment to ensure long-term efficiency and sustainability.

V. Benefits

a) Sustainable and Environmentally Friendly: The pro- posed system uses solar power, which is a renewable and clean energy source. It reduces the carbon footprint and contributes to mitigating the climate change effects.

b) Cost-effective: The use of solar power can reduce the operating costs of the EV charging station and increase the return on investment. The energy storage system can also reduce the peak demand charges and provide ancillary services to the electric grid. •

*c) Efficient and Reliable :*The smart control system can optimize the energy management and charging scheduling, and provide real-time monitoring and control of the chargingprocess. It ensures the efficient use of the available energy resources and the reliable operation of the system. •

d) Scalable and Flexible: The proposed system can accommodate different charging standards and protocols, and can be scaled up or down based on the demand and the availability of solar energy. It can also be integrated with other renewable energy sources and energy storage systems.

VI. Drawbacks

a) Initial Investment: The installation and setup of the EV charging station and the solar panels require a significant initial investment. The cost may vary depending on the size, capacity, and location of the system.

b) Weather Dependency: The efficiency and performance of the solar panels depend on the weather conditions, such as sunlight intensity, cloud cover, and temperature. The system may not generate enough energy during periods of low solar irradiance or extreme weather events.

c) Space Requirement: The installation of the solar panels requires a significant amount of space, which may not be available in some urban or densely populated areas.

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The charging station may also require additional space for parking and infrastructure.

d) Maintenance and Operation: The maintenance and operation of the EV charging station and the solar panels require specialized skills and knowledge. The system may also require periodic inspections and repairs to ensure the safety and reliability of the system.

VII. CONCLUSION

The project addressed the design and development of an IoT-based battery monitoring system for electric cars in order to ensure that online monitoring of battery performance decline was achievable. The objective is to establish the feasibility of the underlying premise of the notion. As part of the system development, the hardware for the battery monitoring device and a web-based battery monitoring user interface are being created. The system may offer information such as position, battery life, and time through the internet by integrating a GPS system to identify the coordinate and display it on the Google Maps application. The system may be developed further by integrating new capabilities. The technology may be utilized in smartphones by developing them.

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