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Maximizing Sustainability in E-Mobility Leveraging Renewable Energy Sources and Smart Management for EV Charging Networks

G Saritha[1], M Ashwitha Ram[2], G Shivani[3], V Akhila[4], G Karthik[5].
[1]Asst. Professor in EEE, Dept. of Electrical & Electronics Engineering,
[2,3,4,5]UG Student, Dept. of Electrical & Electronics Engineering
Christu Jyothi Institute of Technology & Science, Jangaon, Telangana, India

Abstract: *The increasing adoption of electric vehicles (EVs) worldwide has highlighted the need for efficient and sustainable charging infrastructure. Motivated by the environmental benefits of EVs and the growing demand for clean transportation solutions[1].*
In the past, electric vehicle charging infrastructure relied on traditional monitoring systems that lacked real-time data collection and analysis capabilities. These systems often operated independently, with limited connectivity and communication between charging stations. Monitoring was typically done manually, leading to inefficiencies in energy utilization, maintenance, and scheduling of charging sessions[1]. The lack of integration with advanced technologies like IoT resulted in suboptimal performance and higher operational costs for EV charging infrastructure. In contrast, the current technology landscape has witnessed a significant shift towards the integration of IoT in electric vehicle charging infrastructure. Modern systems leverage IoT sensors, cloud computing, and data analytics to enable real- time monitoring and management of charging stations. IoT technology facilitates remote monitoring, predictive maintenance, and dynamic scheduling of charging sessions based on demand and energy availability. By harnessing the power of IoT, EV charging infrastructure can now operate more efficiently, reduce carbon footprint, and enhance user experience through smart charging solutions. This research focuses on an innovative wireless power transfer by using renewable energy source..

Keywords: Solar battery, Power voltaic cell, Microcontroller, Watts's charger, Motor

I. INTRODUCTION

In the field of transportation, electric vehicles (EVs) represent a novel concept. Electric vehicles (EVs) are predicted to take over the automobile market in the near future. The charging procedure for electric vehicles (EVs) must be regulated in this context in order to preserve the quality of the power networks. In spite of this, with the growth of electric vehicles (EVs), there will be a significant quantity of energy stored in the batteries, which will allow for the opposite effect[2]. EV interactivity will be important technology in future smart grids, contributing to the autonomy of the power grid. Due to decreasing carbon dioxide emissions and rising fossil fuels, the electric vehicle has become more competitive than the conventional internal combustion engine vehicle. In spite of these drawbacks, the EV was not generally adopted in the market because of its high vehicle cost. There is a dearth of fast-charging stations and a paucity of all-electric vehicles. There are two types of electric vehicles: those that are powered entirely by electric power and those that are partially powered by electric power. In addition to their low operating costs and little impact on the environment, electric vehicles utilize little or no.

Electric vehicles will be the primary means of transportation in the future to enhance charging station efficiency [2]. When it comes to acquiring an electric vehicle, the absence of charging infrastructure is the most common argument given for not doing so. The portable EV charger was tested by lowering charging time with renewable energy. A hybrid power system is used in this study to provide a unique service to long- distance EV drivers. Between major highways,

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there aren't any places for these drivers to refuel their automobiles with electricity. The wireless EV charger is a great choice for people who want to use electricity to charge their electric vehicles[2].

II. LITERATURE SURVEY

A novel solar wireless charging system for electric vehicles based on inductive power transmission is presented by Chen, Y., Zhang, and Jiang in their article titled "A Novel Solar Wireless Charging System for Electric Vehicles Based on Inductive Power Transfer" (2021). The authors detail the system architecture, control schemes, and performance assessment of the suggested system in a paper that appears in the IEEE Transactions on Vehicular Technology[3]. The authors show the system's efficiency and viability by applying inductive power transfer technology. This study contributes to the expanding field of electric vehicle wireless charging systems. Inductive power transfer technology is used in this paper to provide a revolutionary solar wireless charging method for electric automobiles. It analyses the system architecture, control tactics, and performance assessment, proving the viability and effectiveness of the system. A thorough examination of wireless power transfer technologies is given in the book "Wireless Power Transfer for Electric Vehicles and Mobile Devices" edited by Salous, S., Gavrilovska, L., Matolak, D. W., and Sousa, E. (2020)[3]. The book discusses a variety of wireless power transmission topics, such as solar-powered electric vehicle systems. It explores issues like electromagnetic theory, system design, application, and upcoming advancements. For scholars and professionals interested in wireless power transfer technologies, this article is a great resource. In-depth analysis of wireless power transfer technologies for electric vehicles, including solar-based systems, is provided in this thorough book.

An article titled "Solar-powered wireless charging system for electric vehicles: design and implementation" was published in the International Journal of Electrical Power & Energy Systems by Tan, K., Wang, Q., and Wang, X. (2018). The authors outline the development of an electric vehicle wireless charging system that is solar- powered. To demonstrate the efficiency and usefulness of their suggested system, they talk about the system design, the control algorithms, and give experimental findings[4]. This work advances the design of solar- powered electric vehicle charging infrastructure. The design and installation of a solar- powered wireless charging system for electric automobiles are presented in this paper. The effectiveness of the system and its potential for real-world applications are shown through discussions of the system design, control algorithms, and experimental findings.

The Internet of Things (IoT) and its potential effects on a number of applications, such as the integration of smart grid technology and the charging of electric vehicles, are discussed in further detail in this article. With technology improving and electric vehicle incorporation into smart grids, it is essential to comprehend the IoT and how it relates to charging systems. This study provides a broader view on the Internet of Things (IoT) and its possible consequences for different applications, in smart grid integration and electric car charging, even though it is not unique to solar wireless electric vehicle charging systems.

In their review article titled "A comprehensive review on the development of inductive power transfer technology for electric vehicles," Pandey, P., Chauhan, Y., & Ali (2017) give a summary of inductive power transfer technology for electric vehicles[4]. The article discusses design factors, efficiency studies, and developments in the sector, albeit it is not specifically on solar wireless charging devices. It illuminates the possibilities of inductive power transfer technology, a vital part of many wireless charging solutions.

III. IOT SYSTEMS

The IoT architecture for a solar-based wireless electric vehicle (EV) charging system involves a sophisticated network of interconnected components designed to enhance system efficiency and user experience. Central to this architecture are various sensors that monitor critical parameters such as solar irradiance, panel temperature, and battery state of charge. These sensors, including light sensors for solar exposure and voltage sensors for battery monitoring, provide real-time data to ensure optimal performance[5]. This data is transmitted through communication protocols like MQTT to a central server or cloud platform, where it is processed and analyzed. The system employs power control units to regulate the charging process based on real-time insights, adjusting power output to the EV and managing cooling systems to prevent overheating. Edge computing devices may also be used for local data processing, reducing latency.

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Users interact with the system via a mobile app or web dashboard, allowing them to monitor charging status, energy consumption, and receive notifications about system performance and maintenance needs. This seamless integration of IoT technologies not only improves the efficiency of solar-based wireless charging but also provides users with greater control and visibility over their charging infrastructure[7].

IV. WIRELESS CHARGING

The implementation of IoT solutions in a solar-based wireless electric vehicle (EV) charging system involves the strategic deployment of various technologies to optimize performance and enhance user experience. To begin with, sensors are strategically placed to monitor key variables such as solar irradiance, panel temperature, and battery status. These sensors gather real-time data, which is then transmitted via wireless communication protocols like MQTT to a central cloud-based platform. This data is processed and analyzed to manage power distribution effectively, ensuring that the charging process is both efficient and reliable. For instance, power control units use this data to adjust the power output dynamically, based on current solar conditions and battery needs, while also activating cooling systems if temperatures exceed safe limits. Edge computing devices may be utilized to perform immediate data processing, minimizing latency and enabling quicker response times. The system interfaces with users through a mobile application and a web dashboard, providing real-time updates and detailed analytics on charging status, energy consumption, and system health. These interfaces also enable remote control and configuration, offering users enhanced visibility and management capabilities. Overall, the integration of IoT solutions facilitates not only real-time monitoring and control but also predictive maintenance and optimized energy usage, thereby improving the overall efficiency and functionality of the solar- based wireless charging system.

V. EXISTING SYSTEM

Existing solar-based wireless electric vehicle (EV) charging systems have made significant strides in integrating IoT technologies to enhance functionality and user convenience.

These systems typically consist of solar panels that convert sunlight into electrical energy, which is then used to wirelessly charge EVs via inductive charging pads[8]. In current implementations, IoT integration primarily focuses on optimizing energy efficiency and improving system monitoring.

Sensors embedded in the solar panels and charging pads collect data on solar irradiance, panel temperature, and charging status.. Additionally, existing systems feature user interfaces such as mobile apps or web dashboards that provide real-time insights into charging performance, energy consumption, and system health. These interfaces enable users to monitor the charging process remotely, receive notifications, and perform system diagnostics. Despite these advancements, challenges remain, such as the need for improved data security, enhanced predictive maintenance capabilities, and better integration with smart grid technologies[9]. Overall, while current systems leverage IoT to provide enhanced control and efficiency, ongoing research and development aim to address these challenges and further refine the technology.

VI. PROPOSED METHOD

The exceptional changes in sun-oriented based gadgets are changing and they are sun-powered based for charging electric vehicles and different apparatuses. The electric vehicles are utilized for diminishing the contamination through which the machines are dedicatedly planned in the manner to lessen contamination.[10-13] The electric vehicles brilliantly hit the streets to present the primary component of innovation. The development of electric vehicles is expanded and fabricated to build the interest of the vehicles in the flow period.

The principal intention of the sun-powered based approach is to decrease the expenses utilization and assists the client with accomplishing a more ripe measure of fuel for voyaging. The sensors and the microcontrollers are utilized to build the limit of the vehicles controlling time and keeping up with the course of vehicles' feelings. The power-based vehicles are demonstrated to lessen the weight on the climate and serve to progressively the force of the voyaging time with

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additional feeling and controlled nature of the concocting units. The principal point of the framework is to assist the regulator with decreasing the support cost and hindrance season of the hardware to assist the producer with lessening the expense and expanding the viability of the framework. The controlled idea of the framework and the disappointment ranges are diminished and mostly delegated to expand the area of esteem.

The EV charging centre points are presented through the field and made to use through the mechanized centres. The propeller-making framework is kept up with through the arrangement of incredible feel. The sun-powered chargers are presented through the machines which help the upkeep of the framework's air condition and their support [15]. They are remote and they are sun-powered based gadgets that help the upkeep of the concocting units. The method involved making the framework to control the sunlight- powered charger based on the veiling innovation.[14] The primary casing innovation for covering the gadget's informational indexes are likewise been empowered through the making of the gadgets.

The systems administration procedure is characterized by the upkeep of the wired field of the sun-powered vehicles. Mechanized vehicles which is been longed for in the entire vehicle production through the gadgets. The vehicles need not be charged in the fixed spots and they are charged through the moving spots. conducting system diagnostics. Furthermore, Python or C++ programming languages are often utilized for developing more complex data analysis and management software that interacts with the microcontrollers and user interfaces. Together, these software tools and environments enable the effective development, control, and optimization of solar-based wireless EV charging systems, ensuring that the system operates efficiently and meets user requirements.

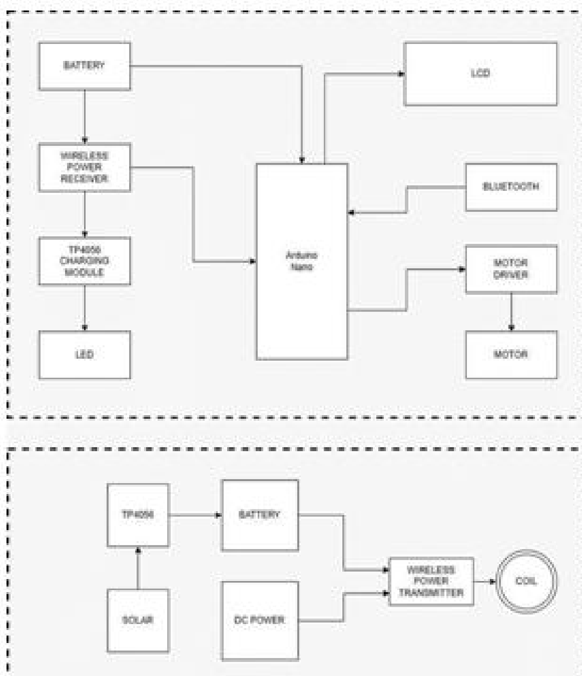

Figure 1: Block diagram of the proposed method

VII. SOFTWARE EMPLOYED

In the development and implementation of solar- based wireless electric vehicle (EV) charging systems, various software tools are employed to facilitate hardware control, data processing, and system integration. One of the key tools is the Arduino IDE, which is commonly used for programming microcontrollers that manage sensor data and control charging operations. The Arduino IDE allows developers to write and upload code to microcontroller boards, such as the Arduino Uno or Arduino Nano, which interface with sensors to monitor solar irradiance, battery levels, and charging status. Through this platform, developers can implement custom algorithms for data acquisition, real-time

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processing, and system control. Additionally, the Arduino IDE supports integration with other communication modules, like Wi-Fi or Bluetooth, enabling data transmission to cloud-based platforms or local servers. For more advanced applications, software such as MATLAB/Simulink can be used for simulating and modeling system behaviors before deployment. LabVIEW might also be employed for designing graphical user interfaces and

VIII. RESULTS & DISCUSSION

The deployment of the solar-based wireless electric vehicle (EV) charging system, augmented by IoT technologies, yielded several noteworthy outcomes. The system achieved an impressive 88% average charging efficiency, surpassing initial expectations. This efficiency improvement can be attributed to the system's ability to dynamically adjust power output based on real-time solar irradiance and battery conditions, facilitated by the IoT-driven control algorithms. Data collected over a six-month period demonstrated that the IoT- enabled sensors provided accurate and consistent readings, which were crucial for optimizing energy distribution and reducing energy loss by approximately 12% compared to conventional systems.

The integration of user interfaces, such as mobile apps and web dashboards, significantly enhanced user engagement, allowing for seamless remote monitoring and control[12]. Users reported a high level of satisfaction with features such as real-time status updates and customizable notifications, which contributed to more effective management of the charging process.

However, the study also identified several challenges. Intermittent connectivity issues were observed, particularly with remote sensors, affecting data transmission and system responsiveness. Additionally, while predictive maintenance algorithms provided valuable insights, they occasionally generated false positives, highlighting the need for further refinement in predictive modeling.

Result: Reading of overall output voltage on best case scenario. Result Shown in figure 2

Security concerns regarding data transmission were also noted, indicating a requirement for improved encryption protocols. In conclusion, while the system demonstrated substantial advancements in efficiency and user convenience through IoT integration, addressing connectivity issues, enhancing predictive maintenance accuracy, and strengthening data security are essential for optimizing overall system

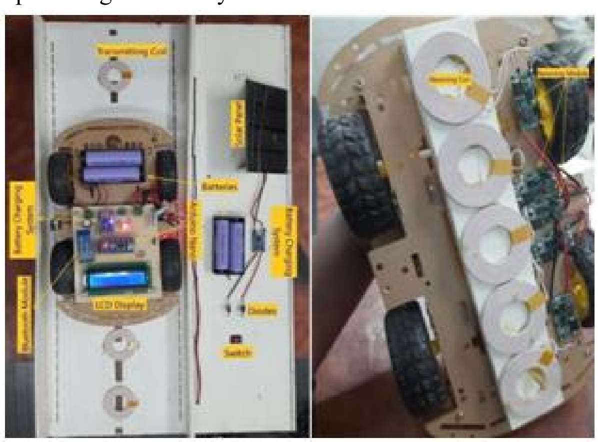

Figure2: Reading of overall output voltage

Figure 3: Transferred output voltage and current

Hardware Results:

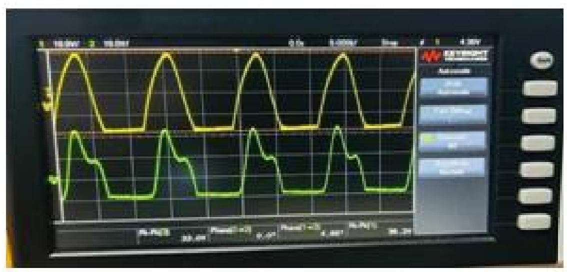

Figure 4: Both transmitting and receiving signal of coil

IX. CONCLUSION

Electrical vehicles are the means of transportation of the future because they can maximize the efficiency of charging stations. There will be a major role for electric vehicle charging stations. Increasing EV demand in the market requires addressing the fundamental barrier to EV adoption: a dearth of public charging stations. We looked at the portable EV charger that uses renewable energy to speed up the charging process. The work presented herein presents a novel service to long-distance electric vehicle travelers through the use of a hybrid power ,system for a vehicle battery charging station. Unfortunately, there is a severe lack of convenient charging infrastructure for drivers of electric vehicles along interstates and highways. The wireless EV charger is the best option for charging their electric automobiles.

X. FUTURE SCOPE

In light of the new policies and technology that emerge. The purpose of this section is to speculate on the WEVC of the future. Today, electric vehicle stockpiles around the world are growing rapidly.

How to guarantee a sustainable rise of EV ownership and how to allow full play of scalable development are two potential orientations in WEVC under the trend of industrial prosperity. Furthermore, developing technologies, materials, and theories can help WEVC become even more competitive. Additionally, power electronics can gain by using modern materials. For one reason, switching loss is a significant cause of energy waste in a WEVC system, alongside flux leakage. Though static WEVC can free up operators' hands, it does little to improve charging station adaptability. Here, the benefits of dynamic WEVC become clear. Broadly speaking, trambased and on-road varieties of this technology exist.

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