Advanced Battery Charging of EV's Using Hybrid Energy Sources and Monitoring with IOT

Sunil Kumar Chaudhary, Aryan Prasad, Praveen Kumar, Gargi Verma, Anurag Singh and Anushka Gupta

April 14, 2024

Advanced Battery Charging of EV's using Hybrid Energy Sources and Monitoring with IOT

Sunil Kumar Chaudhary
Dept. of Electrical Engineering
GCET
G. Noida, Uttar Pradesh, India
sunilkumarchaudhary@galgotiacollege.edu

Aryan Prasad
Dept. of Electrical Engineering
GCET
G. Noida, Uttar Pradesh, India
aryanp72127@gmail.com

Praveen Kumar
Dept. of Electrical Engineering
GCET
G. Noida, Uttar Pradesh, India
praveenchaudhary0777@gmail.com

Gargi Verma
Dept. of Electrical Engineering
GCET
G. Noida, Uttar Pradesh, India
gargi.verma757@gmail.com

Anurag Singh
Dept. of Electrical Engineering
GCET
G. Noida, Uttar Pradesh, India
anuragsingh510969@gmail.com

Anushka Gupta
Dept. of Electrical Engineering
GCET
G. Noida, Uttar Pradesh, India
anushkagupta99369596@gmail.com

***Abstract*— This article describes the design of a charging system that may be installed in an electric car to effectively charge the battery and minimize its dependency on the grid. This is accomplished with the use of renewable energy, such as wind as a source and solar as a source. After charging of battery IOT is used to monitor, regulate, and operate the battery, ensuring that it operates at its best capacity and follows the proper patterns for charging and discharging. For the assurance of smooth charging of battery IOT integrates with various sensors such as current, voltage and temperature sensors for the display of these information. The incorporation of IOT helps user to identify and read the real time data of different parameters of battery which helps the user to charge the battery according to conditions which ultimately increases the efficiency of the battery. By implementing the above charging and battery management system we reduce the dependency on grid which is very helpful and beneficial in reducing the pollution and conservation of electricity hence making it environment friendly.**

***Keywords*— IOT, Charging and discharging, Hybrid system, Overheating protection.**

I. INTRODUCTION

The global usage of electric vehicles (EVs) is increasing at a rate that makes it necessary to expand the infrastructure for charging EVs in bunch. Conventional EV charging systems mostly rely on grid energy, which might be heavily dependent on fossil fuels depending on the area, negating the environmental advantages of EVs. Sources of renewable energy, particularly solar as a source and wind as a source [1], have become viable options for decarbonizing the electrical grid and, therefore, the infrastructure needed for EV charging. In addition to being in line with international sustainability objectives, the incorporation of these renewable energy into EV charging systems provides a means of lowering the transportation industry's carbon footprint.

The charging of an electric vehicles draws on different strengths and weaknesses of solar and wind energy systems during the charging process. Solar electricity which is predictable and of wide availability can be gathered by PV(Photovoltaic) panels [2] deployed at charging stations or the other adjacent bodies near the stations.

Even though wind energy is more freckle [2], [3], it may turn out to be an additional resource together with solar energy, in the regions with high-altitude wind streams and when solar energy doesn't bring high efficiency levels. With an appropriate combination of renewable energy sources, EV recharging can provide a constant and sustainable energy amount, however, because of the character of the intermittently intermittent situation, creative practices to conduct energy management and storage are required.

This paper aims to evaluate the factuality, relevance, and inflation number viability of using solar and wind energy for EV charging. The hardware necessities such as energy generation, storage and conversion components of integrating renewable sources in EV charging [4] are elaborated that form the core of the EV charging system. Furthermore, the paper considers the question of inaccuracy of forecasts of weather and percentages of generation, e.g. a hybrid system that is a mix of solar and wind energy [5] aimed to electrify the electric cars which would be an environmental-friendly and reliable way. This research promotes the wider shift towards cleaner energy consumption in the transport sector and adds to the continuing discussion on sustainable transport infrastructure by analysing present technology, case studies, and possible future advancements.

The ultimate aim of this research is to add to the current conversation on integrated renewable energy sources and sustainable mobility [4], [5]. The goal of the study is to provide a roadmap for a cleaner, more sustainable transportation future by evaluating the environmental advantages, economic feasibility, and technological viability of using wind and solar energy to charge electric cars.

II. LITERATURE REVIEW

Bikash Kumar Parida, Aashish Kumar Bohre (2022) [1]. It comprises hybrid sources such as solar, wind, battery and biomass which connected to grid, the motive of this paper is to provide reasonable cost of energy. Two loads comprise the system under analysis in this paper: a domestic load [1] and a load related to electric and rechargeable automobile chargers, like PV and Wind [1].

Aaqib Raza, Mazhar H. Baloch, Irfan Ali, Waqas Ali, Muhammad Hassan, Abdul Karim (2022) [2]. This document offers hybrid source integration solutions for charging systems that support both all-electric and plug-in hybrid electric vehicles (PHEVs and EVs) [2]. Through sensor connectivity, utilizing artificial intelligence (AI) and the Internet of Things (IOT) [2], [3] makes it possible to enable real-time monitoring and autonomous driving capabilities. AI is essential to automating EVs since it can solve issues with parking, battery charging, and traffic, which will eventually lead to the development of smart cities from their urban infrastructure.

G. Chandrasekaran; N. Rathika; M. Venkatesh; S. Sujatha; T. Kanthimathi (2023) [3]. Using a hybrid energy source that combines batteries and super capacitors provides a pollution-free, clean energy source. A new bidirectional converter that combines buck and boost functions shows promise in lowering costs, eliminating voltage stress, simplifying circuitry, and improving system performance.

Naresh Kumar K, P. Badrinath; S. Vickraman, G. Satheesan (2022) [4]. There has been a significant global trend in recent years toward electric vehicles, which are valued for their increased comfort and affordability as compared to conventional fuel-powered automobiles. However, the development of charging infrastructure has lagged behind the increase in production of electric vehicles, particularly in regions with high rates of adoption. To simplify monitoring battery levels and SMS updates, users prefer using IOT platforms. This program aims to facilitate environmentally friendly transportation by cutting down reliance on fossil fuels and reducing greenhouse gas emissions [3], [4].

N. V. A. Ravikumar, Ramakrishna S. S. Nuvvula, Polamarasetty P Kumar, Noor Hanoon Haroon, Umakant Dinkar Butkar, Alighazi Siddiqui (2023) [5]. This study, therefore, investigates the intersection of electric vehicles (EVs), renewable energy sources (RES), and the internet of things (IOT) [6], [7] in order to enhance sustainable transportation and energy management. It also examines the challenges facing EVs as well as their potential to mitigate carbon emissions and reduce urban pollution. There is a need for battery improvements, charging infrastructure advancements and Vehicle-to-Grid (V2G) capabilities are [5] that have to be made before full EV integration into the grid can take place. This paper explores how electric vehicles might relate to renewable solar, wind or hydro power [3], [4] tactics such as demand response and energy storage being examined.

III. HARDWARE COMPONENTS

Solar Panel: Sustainable power generation is made possible by solar panels, which capture the sun's plentiful energy and use photovoltaic cells to turn it into electricity Specifications of the solar panel that we have used are, Maximum power-5.0W, open circuit voltage-21.03V, short circuit current-0.32A, maximum power voltage-17.00V, maximum power current-0.30A, maximum system voltage-600V [8], [9]. All these above values measured at STC: 25 °C temperature. These solar panels, which are made of linked solar cells, collect sunlight and produce direct current (DC) power. This DC electricity may then be transformed into useful alternating current (AC) electricity for use in household, business, and industrial settings.

Arduino Uno: The AT-mega328P microprocessor is generally used by the well-known Arduino Uno microcontroller board as shown in Fig.4. Because of its adaptability and ease of use, this Arduino.cc creation has become more and more popular in educational and hobbyist projects. The board has a number of features, there is 32 KB of memory on the Arduino Uno. It has 1 KB of EEPROM and 2 KB of SRAM (an EEPROM library is needed to read or write to this) [6]. It has 16 MHZ clock speed to perform particular task faster than the other controllers. Arduino Uno receives the data from the sensors such as battery voltage, wind voltage, solar voltage and battery temperature. It has USB connectivity means we can easily connect Arduino with PC as a result communication between the Arduino and PC becomes easy. The Arduino Uno powered by USB, if we provide external power then we can give supply between 6 to 20 volts but Arduino only works on 5 Volts. Out of 14 digital pins we can used 6 pins as PWM output and 6 pins used as an analog pin.

Operating voltage	5Volts
Input voltage	6-20Volts
Digital I/O pins	14
Analog i/p pins	6
Flash Memory	32kb
SRAM	2kb
EEPROM	1kb
PWM pins	6
CLK Speed	16 MHz

Table 1 Specifications of Arduino UNO

Node-MCU_ESP8266: A widely used and popular microcontroller board called NodeMCU8266 is frequently utilized in Internet of Things (IOT) applications as shown in Fig., such as battery monitoring systems. Because of its integrated Wi-Fi connectivity, the ESP8266 Wi-Fi chip, on which it is based, is perfect for our applications that call for remote monitoring or control. NodeMCU8266 is used in battery management systems to track the voltage, current, and temperature of the battery [10]. It then sends this information to a cloud-based platform or a central control system for additional analysis.

Operating Voltage	3.3Volts
Input Voltage	7-12Volts
Digital I/O Pins	16
Analog Input Pins	1
SPIs	1
UARTs	1
UARTs	1
Flash Memory	4 Mb
SRAM	64 kb
Clock Speed	80 MHz

Table 2 Node-MCU_ESP8266 Specifications

LCD Display: Liquid crystal molecules are controlled by electric fields in Liquid Crystal Display (LCD) technology to create pictures on a flat display. LCD displays are made up of a grid of many pixels, each of which has liquid crystal components that are managed by thin-film transistors (TFTs). Pins are often used for power, data, and control connections on these displays. Pins for data inputs (D0-D7), control signals (RS, RW, and EN), power supply (VCC and GND), and backlight control (BL+ and BL-) are examples of common pins. The data shown on this led screen is solar voltage, wind voltage, voltage delivered by battery and temperature of battery.

Buck Converter: A buck converter, are used as a step-down converter [10], [11], is a kind of DC-DC power converter that effectively lowers an input voltage that is higher than the output voltage. Two controllers that we have used i.e. Arduino UNO and Node MCU ESP8266 required 5V and 3.3V of supply respectively. So it is necessary to step down the supply voltage. It uses pulse-width modulation (PWM) to operate a switching transistor in order to adjust the output voltage. An inductor and capacitor network's energy flow is regulated by the transistor's on/off switching during operation. Because of its high efficiency and small design, the buck converter is frequently used in battery chargers, power supplies, and LED drivers.

Battery Pack (Li-ion): The high energy density, extended cycle life, and lightweight design of lithium-ion battery packs have completely changed the energy storage industry. From electric vehicles (EVs) to portable devices, these adaptable power sources are widely used in a wide range of sectors. Lithium-ion battery packs are a stable source of energy storage for wearables, laptops, smartphones in consumer electronics. Furthermore, lithium-ion battery packs are the foundation of electric cars in the automotive industry.

Relay Module: The purpose of the ADIY 1 channel 5v relay module is to switch just one powerful Arduino device. It contains a relay with a maximum 10A rating per channel at 30VDC or 250VAC. The relay module has two LEDs that show where the relay is located. The relay has three broken out channels that are connected to screw pin terminals. The channels are designated as follows: normally closed (NC), ordinarily open (NO), and common (COM). Three pins are located on the opposite side of the module: an input pin IN that controls the relay, a ground pin, and a VCC pin that powers the module. The input pin is active low, which means that pulling it low will activate the relay while pulling it high will cause it to become inactive [11]. The features and specifications of the relay module are, Supply voltage – 5V, Relay maximum current – 10A, Logic Signal voltage – 3.3V or 5V, Quiescent current: 2mA, Current when the relay is active: ~70mA, Relay maximum contact voltage – 250VAC or 30VDC [11].

Temperature Sensor: The DS18B20 sensor is a programmable digital temperature sensor designed to communicate using the 1-Wire method, making it compatible with various systems. It operates within a voltage range of 3V to 5V and the temperature range are from -55°C to +125°C [11], [12], ensuring versatility in different environments. With an accuracy of ±0.5°C, it provides reliable temperature readings. User can freely alter output resolution from 9-bit to 12-bit and even more based on specified requirements. It's 64-bit unique address allows the multiplexing, which in turn lets multiple sensors to be connected to just one microcontroller. The alarm options that are programmable will also increase its effectiveness for temperature detection purposes. It is possible to get it in many packages such as To-92, SOP and waterproof versions. For these reasons, the DS18B20 sensor provides users with the convenience of fitting it in different devices and conditions.

Dynamo Motor: Dynamo motor familiar with the name of dynamo or generator also can be used to step down the mechanical energy and convert it into electric power. It is a fundamental law of physics, which describes the phenomenon in which a changing magnetic field induces an electric current into the conductor. Whilst the coil rotates, it interacts with the magnetic lines of force, thus arousing an electric current in the wires according to Faraday's law of electromagnetic induction. This is how electric current can make different electrical appliances operate and also can be accumulated in batteries for later use. Dynamos fits into many bits. They are used as emergency radios, on hand cranks and for small-scale power generation. They serve as a source of electricity where grid power is not available or suitable.

Voltage Sensors: Voltage sensors are a vital part of different renewable applications which have different functions that are specific for different purposes. In the solar scenarios, these sensors detect the output voltage of the solar panels thus it becomes possible to conduct monitoring of the constant performance and also detection of voltage fluctuations or irregularities. Therefore, the application of voltage sensors in wind energy systems is also critical for controlling the voltage generated by the turbine's generator within the working thresholds. Voltage sensors in the battery systems also turn out to be an effective tool for battery voltage level measurement as they alert users to overvoltage or under-voltage instances. In the end, voltage sensors become indispensable in ensuring the excellence, safety, and reliability of renewable energy systems in different setups.

IV. HARDWARE MODEL AND CIRCUIT DIAGRAM

The hardware model prototype is shown in fig.1. The solar panel is fitted at top of the vehicle and the wind turbine are fixed at the front top of EV. The digital display shows different parameter of the EV like, voltage of solar, voltage of wind turbine, voltage of battery and the temperature of the battery as shown in the fig. 1. In the below figure OL stands for overload, we can move this rotary switch to vary the load, in this vehicle the load is fixed which is 4 motors but this switch helps to increase or decrease the load. The green light represents that battery is successfully charged by solar as a source.

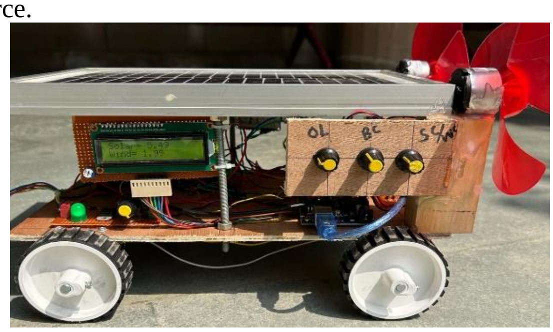

Fig. 1 Hardware Model

The block diagram is shown in fig.2 having control mechanism led by an Arduino-based controller to effectively charge a battery bank by integrating solar and wind energy sources. The solar panel and wind turbine charging circuits are the first in the system, and they are both outfitted with the parts that are required to govern the flow of energy into the battery bank, including regulators and charge controllers. The battery bank serves as an energy reservoir, storing the collected energy from both sources for later use.

The Arduino-based controller, which is at the heart of the system and controls multiple tasks that are crucial to the operations of the system, is the main device in the system. It monitors that the battery is at safe voltage and temperature parameters. Through regulation of a relay circuit that takes care of the direction of power from the solar panels and wind turbine into the battery, the controller also regulates the charging process. Arduino talks to the relay through signals, it runs or stops the charging based on set parameters and thresholds on the pre-programmed code.

The Arduino will be connected with an LCD display to show the consumers the operation in real-time. This element gives viewers a visual aid for following the system condition and exhibit certain information such as temperature, battery voltage and solar and wind energy level.

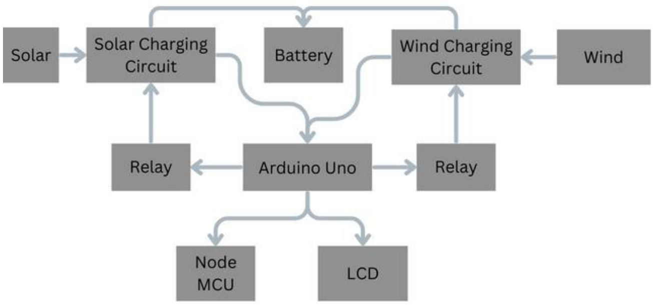

Fig.2 Block Diagram

From one perspective, the method will depend on the capability of the Node-MCU to create an internet for the system and connect it to the itself infrastructure of IOT. This data from the Arduino including the energy rate and battery condition can be sent to the faraway IOT app or AI platform through the Wi-Fi interface of the Node-MCU. Possibly the ESP8266 chip has the easy-to-connect feature through built-in Wi-Fi. With that fact, it is the perfect opportunity for our projects that the long-distance monitoring or control is required. Convenience/ease of: the system is enhanced by the ability to monitor and administer it remotely from the equipment because of this. All things considered, combining solar and wind energy sources with advanced control and monitoring tools provides a reliable and sustainable way to power a range of applications.

V. Results

The IOT (Internet of things) shows different parameters of EV like solar voltage, wind voltage, temperature of the battery, percentage of battery, solar current and output load to the EV. Fig.3(a) shows the solar voltage at a particular time. In our EV we have used 11.2 volt of battery. The IOT shows voltage up-to 20volt. The intensity of light during day time are at peak. The voltage may day to day, time to time and season to season. The current voltage of solar are 2.89 volt at a particular time.

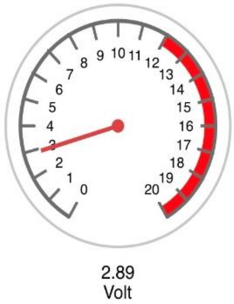

Fig.3(a): Solar Voltage

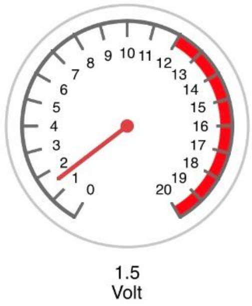

Fig.3(b): Wind Voltage

The wind voltage obtained at a particular time is shown in Fig.3(b). We use a battery with an 11.2volt capacity in our wind-powered systems. Up to 20 volts of wind voltage are shown by Internet of Things (IOT) sensors. The peak wind intensity usually occurs at specific periods of the day, which might vary from dawn to dusk and across different seasons. The wind voltage is currently 1.5 volts. Furthermore, wind patterns can fluctuate due to a variety of factors, including geography and local weather, which can affect the voltage produced by wind turbines.

Fig.3(c) shows the outside temperature at a particular moment in time. We use a battery in our electric vehicle (EV) that has a standard voltage of 11.2 volts. We can monitor temperatures as high as 100 degrees Celsius thanks to our Internet of Things (IOT) technology. There are daily, hourly, and seasonal fluctuations in temperature. Right now, the outside temperature is 31 degrees Celsius. Moreover, the thermal management system of our EV dynamically controls heating and cooling processes to improve battery life and performance, guaranteeing optimal performance in a range of environmental circumstances.

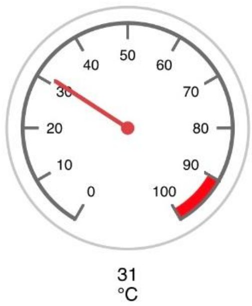

Fig.3(c): Battery Temp

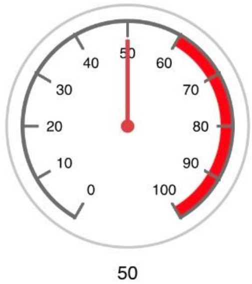

Fig.3(d): Battery Percentage

The battery percentage status at the same designated time is shown in the following Fig.3(d). The battery life of our electric car is adjustable between 0% and 100%. We continuously monitor and control the battery's charge level using our integrated Internet of Things (IOT) platform. Variations in usage patterns, charging cycles, and environmental factors can all affect the battery percentage. The battery percentage is at 78%. The battery management system of the EV uses predictive analytics for optimization balancing the battery longevity and efficiency both in charge and during discharge.

As per the time table the instant performance of the solar panels installed in the plant is represented in Fig. 3(e). In order to enhance the energy storage ability of our electric vehicles, we harness solar radiation through the help of solar panels. Sunlight can be captured at different intensities by its angle as its energy hits into the panels, and environmental conditions like weather, can all be the reasons of the lower output of the solar panels. Theoretically, it is as high as 768 mAH for the solar. Based on the fact that our EV's monitoring system has REAL-TIME integration, then it continuously tracks the performance of our solar cells to generate the highest use of the energy that we have captured and utilized. Last but not least, these modernized algorithms also try and predict patterns in solar generation curbing the need for controlling electric reactive power, thus contributing to more sustainability and efficiency.

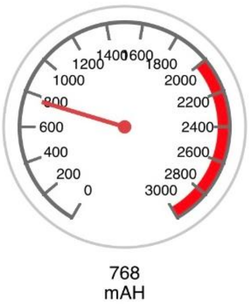

Fig.3(e): Solar Current

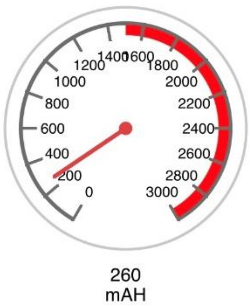

Fig.3(f): Output Load

The electric vehicle systems power usage status, at the specified time is displayed in Figure 3(f). Output load indicates the amount of power consumed by components in the car such, as lights, auxiliary systems and motors. This load can vary based on driving conditions, activities and external factors. Currently the output load is recorded at 6.8 kilowatts. To ensure performance and efficiency our vehicles built in monitoring and control systems constantly monitor and adjust the output load. Utilizing real time data analysis enables load management techniques that enhance system reliability and resource allocation efficiency.

VI. CONCLUSION

This project provides the construction of a prototype of a battery management system with IOT and charging system which uses hybrid energy sources such as solar as a source and wind as a source. It is an efficient and a reliable system that provides all the charging and managing of batteries requirements without depending on the grid. The prototype is completed, assembled, and passed through testing successfully. The results prove that BMS is able to tightly monitor and enable the cell balancing of battery pack in addition to providing a number of safe features to guard against damage. Validation and verification tests have indeed proved the system's energy independence, making it possible to charge highly efficiently using a combination of hybrid energy sources and therefore reducing electric vehicles dependency on the grid.

To expand the capabilities in the charging system architecture, future developments might contain effective power management from different sources as well as smart AI algorithms, which are most advanced. Overall, the project's charging system prototype has proven a sharp uptick in battery charging. Therefore, it might be a reliable and effective battery solution which does not pollute the environment.

VII. FUTURE SCOPE

A prime area that remains to be explored is innovation in the EV charging system which will adopt the use of solar and wind energy and smart cities which will be using Internet of Things (IOT) and which is going to be an area with lots of applications. Push with technological progress in the renewable field, we have wind power plants with much better turbines or solar panel manufacturing at reasonable pricing. This way we can have the best energy sources and the most affordable system.

Also AI and ML algorithms could be involved into the energy management adjustment and schedule the charge based on the real-time and user personal data which able to make use of IOT predictive power. Moreover, software components, at the same time, may be deployed in a more flexible and compatible way to cover more pilots and easy to hybrid in of existing infrastructure, which may be used.

REFERENCES

[1] Bikash Kumar Parida, Aashish Kumar Bohre, “Optimal Sizing of PV, Wind and Biomass based Grid Connected Hybrid Renewable Energy Systems for Rural Areas in Presence of EVs”. 2022 2nd International Conference on Emerging Frontiers in Electrical and Electronic Technologies (ICEFEET), 2022.

[2] Aaqib Raza, Mazhar H. Baloch, Irfan Ali, Waqas Ali, Muhammad Hassan, Abdul Karim, “Artificial Intelligence and IoT-Based Autonomous Hybrid Electric Vehicle with Self-Charging Infrastructure”. 2022 International Conference on Emerging Technologies in Electronics, Computing and Communication (ICETECC), 2022.

[3] G. Chandrasekaran; N. Rathika; M. Venkatesh; S. Sujatha; T. Kanthimathi, “Electric Vehicle Based Hybrid Energy Storage System using IoT”. 2023 Second International Conference on Smart Technologies for Smart Nation (Smart Tech Con) 2023.

[4] Naresh Kumar K; P. Badrinath; S. Vickraman; G. Satheesan, “Charging Station for E-Vehicle using Solar with IoT”. 2022 International Interdisciplinary Humanitarian Conference for Sustainability (IIHC) 2022.

[5] N. V. A. Ravikumar, Ramakrishna S. S Nuvvula, Polamarasetty P Kumar, Noor Hanoon Haroon, Umakant Dinkar Butkar, Alighazi Siddiqui, “Integration of Electric Vehicles, Renewable Energy Sources, and IoT for Sustainable Transportation and Energy Management: A Comprehensive Review and Future Prospects”. 2023 12th International Conference on Renewable Energy Research and Applications (ICRERA) 2023.

[6] K. Kumari. KS, L. Chitra, J. M. Abraham, N. Joseph and Y. K. TK, "The Role of IOT & AI in Battery Management of Electric Vehicles," 2023 International

Conference on Signal Processing, Computation, Electronics, Power and Telecommunication (IConSCEPT), Karaikal, India, 2023.
[7] M. Bharathi, K. Geetha, P. K. Mani., G. N. Samuel Vijayakumar, K. Srinivasan and K. R. Kumar, "AI and IoT-based Electric Vehicle Monitoring System," 2022 Sixth International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud) (I-SMAC), Dharan, Nepal, 2022.
[8] S. Singh, P. Chauhan and N. J. Singh, "Feasibility of Grid-connected Solar-wind Hybrid System with Electric Vehicle Charging Station," in Journal of Modern Power Systems and Clean Energy, vol. 9, no. 2, pp. 295-306, March 2021.
[9] M. Shatnawi, K. B. Ari, K. Alshamsi, M. Alhammadi and O. Alamoodi, "Solar EV Charging," 2021 6th International Conference on Renewable Energy: Generation and Applications (ICREGA), Al Ain, United Arab Emirates, 2021.
[10] A. Verma and B. Singh, "Integration of Solar PV-WECS and DG Set for EV Charging Station," 2020 IEEE International Conference on Power Electronics, Smart Grid and Renewable Energy (PESGRE2020), Cochin, India, 2020.
[11] Z. Amjadi and S. S. Williamson, "Power-Electronics-Based Solutions for Plug-in Hybrid Electric Vehicle Energy Storage and Management Systems," in IEEE Transactions on Industrial Electronics, vol. 57, no. 2, pp. 608-616, Feb. 2010.
[12] A. M. Alsomali, F. B. Alotaibi and A. T. Al-Awami, "Charging strategy for electric vehicles using solar energy," 2017 Saudi Arabia Smart Grid (SASG), Jeddah, Saudi Arabia, 2017.