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Solar Based Wireless Electric Vehicle Charging System

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Abstract: *In today's world there are more outcomes in environmental change due to the overutilization of petroleum products in this manner prompting a genuine effect on the climate? So there is a need for a substitute answer for lessen the consumption of such non – sustainable assets. One such exertion made in the field of Freeways is the advancement of "Solar Freeways" which can be an elective arrangement. Sun oriented streets consolidate various arrangements in one – it can assist us with improving the creation of power utilizing sun based boards, to give a computerized stage to our future country's ventures like Smart Cities, and to work with the arising electric vehicles that supplant the petroleum driven vehicles and substantially more.*

Motivated by the fact that there are numerous amount of clean and sustainable energy we receive from roadways, the following study puts forward some of the event and application of an innovative charging method for the renewable energy driven electric cars, buses by using the roadway and also implementation of revolutionary nanotechnology along with the latest best in the house power electronics and power system analysis tools. A small scale prototype model was made by our team to attest the working of smart inductive charging process. Our project team was successful to improve the working of the model by improving the use of the preinstalled solar panels and also implement its use on the very concept we are trying to improve.

On the vehicle, there will be the use of coils which are experimentally made for the flow of charges that are needed to provide charge to a moving electric vehicle (EV). The detailed strategy is presented in this report. Electric vehicles have now hit the road worldwide and are slowly growing in numbers. Apart from environmental benefits electric vehicles have also proven helpful in reducing cost of travel by replacing fuel by electricity which is way cheaper. Well here we develop an EV charging system that solves with a unique innovative solution. This EV charging of vehicles without any wires, No need of stop for charging, vehicle charges while moving, Solar power for keeping the charging system going, No external power supply needed. The system makes use of a solar panel, battery, transformer, regulator circuitry, copper coils, AC to DC converter, Atmega controller and LCD display to develop the system. The system demonstrates how electric vehicles can be charged while moving on the road, eliminating the need to stop for charging. Thus the system demonstrates a solar powered wireless charging system for electric vehicles that can be integrated in the road.

Keywords: Battery, Micro controller, Transformer, Microprocessor, Electric Vehicle

I. INTRODUCTION

The on-going climate condition has led to research and development of electric vehicle over the past decade. The increasing global warming has causes awareness among the people to switch to electric vehicles. The time required to wait at charging station while the battery is being charged will be reduce by the considerable amount of time when the charging will be done on road while driving the vehicle. Even though electric vehicles are an alternative, there need to be development in its charging system to make it the prime option for transport for this purpose; the charging system should be developed. Dynamic charging systems are more reliable user friendly and time is efficient. Also, the battery

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size can be reduced and range can be improved. This charging system can also be implemented in the travel routes, traffic signal, bus station. The rise of electric vehicles (EVs) signals a promising shift towards sustainable transportation, offering a solution to combat climate change and reduce reliance on fossil fuels.

However, challenges persist in the charging infrastructure, with conventional stationary charging stations causing significant waiting times for vehicle owners. This hinders the seamless integration of EVs into mainstream transportation systems. To address this issue, our project aims to develop an innovative solution the Solar Wireless Charging System in Electric Vehicles. By harnessing solar energy and wireless transmission technology, this system revolutionizes the EV charging landscape, enabling on-the-go charging to minimize downtime and enhance overall efficiency. Electric Vehicles represents a new concept in the transport sector around the world. It is expected that the market share of EVs will exponentially grow, comprising 24% of the U.S. light vehicle fleet in 2030, representing 64% light vehicle sales in this year.

In this context, the EVs battery charging process must be regulated to preserve the power quality in the power grids. Nevertheless, with the proliferation of EVs a considerable amount of energy will be stored in the batteries, raising the opportunity of the energy flow in the opposite sense. In the future smart grids, the interactivity with the EVs will be one of the key technologies, contributing to the power grid autonomous operation. The concept of the on-board bidirectional charger with V2G and V2H technologies is introduced. The electric vehicle has become more competitive when compared to the conventional internal combustion engine vehicle due to lower carbon dioxide emission and raising fossil fuels. However, the EV was not widely adopted into the market due to some limitations such as high vehicle cost limited charging infrastructure and limited all electric drive. EVs are vehicles that are either partially or fully powered on electric power. Electric vehicles have low running costs as they have fewer moving parts for maintenance and are also very environmentally friendly as they use little or no fossil.

II. PROBLEM STATEMENT

Electric vehicles have now hit the road worldwide and are slowly growing in numbers. Apart from environmental benefits, electric vehicles have also proven helpful in reducing the cost of travel by replacing fuel with electricity which is way cheaper.

However electric vehicles have 2 major disadvantages:

- Long charging time – 1-3 hours required for charging
- Non-availability of power for charging stations in off-city and remote areas.
- The power is converted to AC using a transformer and regulated using regulator circuitry. This power is now used to power the copper coils that are used for wireless energy transmission.
- A copper coil is also mounted underneath the electric vehicle. When the vehicle is driven over the coils energy is transmitted from the transmitter coil to the EV coil.
- Please note the energy is still DC current that is induced into this coil. Now we convert this to DC again so that it can be used t charge the EV battery.
- We use AC to DC conversion circuitry to convert it back to DC current. Now we also measure the input voltage using an Atmega microcontroller and display this on an LCD display.
- Thus the system demonstrates a solar-powered wireless charging system for an electric vehicle that can be integrated into the road.

III. OBJECTIVES

- Harness Solar Energy for EV Charging: - Develop a system that effectively utilizes solar power to charge electric vehicles, reducing dependence on traditional grid electricity and promoting the use ofrenewable energy sources.
- Energy Conversion and Storage:- Efficiently convert solar energy into electrical power using a DC to DC converter. Store the converted energy in batteries to ensure consistent power supply, even during low sunlight conditions or at night.

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- Integration of Microcontroller for System Control:- Use an Arduino Uno microcontroller (or a similar system) to control and monitor the charging process, ensuring optimal system performance and automation.
- Real-Time Feedback to Users: - Provide real-time data to users, such as charging status, battery levels, and system performance, through an LCD display or other user interfaces.
- Wireless Charging Implementation: - Design the system to facilitate wireless energy transfer using copper coils, enabling electric vehicles to be charged while in motion or parked without the need for physical connectors.
- Reduction of Environmental Impact: - Minimize the carbon footprint by reducing the reliance on fossil fuels for charging electric vehicles, thereby contributing to cleaner, greener transportation solutions.
- Optimize System Efficiency and Cost-Effectiveness: - Ensure the system is both energy-efficient and cost-effective by utilizing high-quality components and minimizing power losses during energy conversion and transmission.
- Scalability and Flexibility:- Design the system to be scalable, so it can be used in various settings— ranging from small residential installations to large-scale commercial or public charging stations.
- Address Challenges in Solar Energy Usage: - Overcome challenges related to the intermittent nature of solar power, such as energy storage and conversion, to ensure consistent and reliable charging for electric vehicles.

IV. BLOCK DIAGRAM

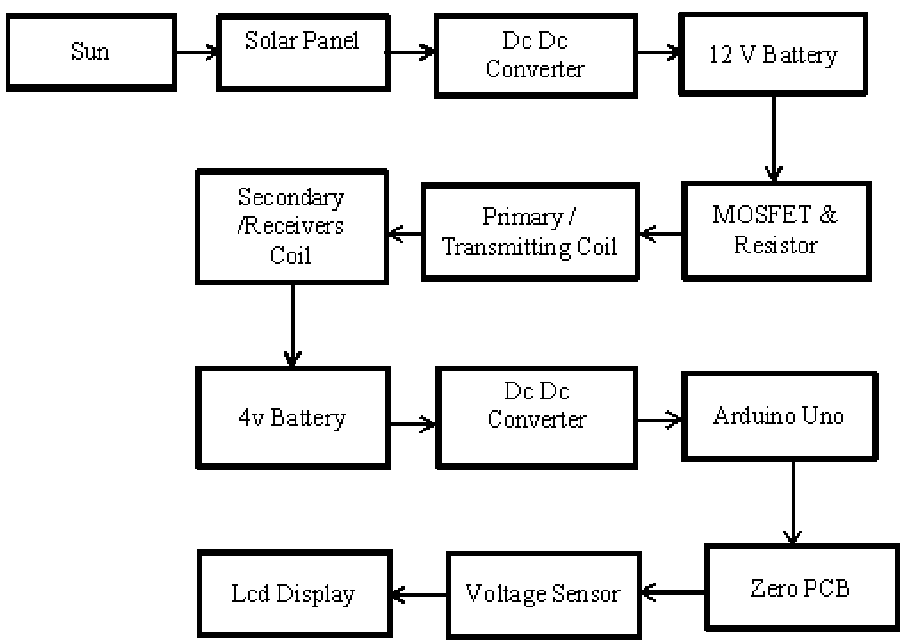

Fig.1 Block diagram of wireless EV charger

V. CHARGING INFRASTRUCTURES FOR ELECTRIC VEHICLE

The charging infrastructures rely on the relations between driving needs, charging equipment usage, EV stock, and technical capabilities. Population density, driving range, and charging behavior are specific factors that have direct implications on the geographical location of the EV supply equipment and on the charging rates, for electric low-duty vehicles. Two charging modes, slow and fast charging are presented in this paper, which denotes the charging rate for an EV.

Slow charging is mostly rated at 3 kW, but in reality, it is ranged between 1.8 kW and 6 kW. Charging time depends on the charging rate and the EV energy capacity, thus, a full charge takes 6–12 h for 3 kW. Slow chargers are common for most EVs, they can be found everywhere, e.g., at home, workplace, and public places. EV users tend to charge at home overnight for long charging.

Fast charging is typically rated from 7 kW up to 22 kW (single or three-phase 32A), where charging an EV with 40 kWh capacities takes 4–6 h with 7 kW and 1–2 h with 22 kW. The majority of fast chargers provide AC charging, however, some infrastructures are equipped with 25 kW DC chargers with CHAdeMO connectors. Fast chargers can be found in public places, such as shopping centers, car parks, workplaces, supermarkets, train stations, and airport parking.

The sizing and characteristics of PV-powered EV charging stations depend on the PV installation (parking shade or building-integrated PV), solar irradiation potential, stationary storage, and the adopted business model. The viability of well-designed PV-powered EV charging stations depends on social acceptance, PV benefits, and the business model.

Private chargers stand for 90% of global EV chargers in 2019, as profitability, convenience, and various supports and incentives are the main motivations of the universality of private chargers. The preferred locations are home and private workplaces to charge the EV. The infrastructure for home charging is a compatible electric socket and charger plug, which already exists in homes. Nearly 60% of EV users have access to private chargers in China based on The China EV Charging Infrastructure Promotion Agency recent report in 2019. The EVs consume approximately 75% of energy from private charging at home and at the workplace, in the United States, United Kingdom, and the European Union.

VI. CHALLENGES

EV development has many advantages and environmental benefits, but it still remains the challenges and barriers to the sustainable growth of EVs:

Battery limitation: Cells of the battery will decline gradually after the charging or discharging process. It means that the battery useable capacity is decreased. The battery aging is longer, the charging/discharging process, voltage, and temperature have to control. However, the fast charging/discharging process leads to the battery cell's ugliness. In order to predict the battery life, an equivalent series resistance Evaluation of solar powered charging station and electric vehicle technologies www.ijres.org 35 | Page parameter is used to estimate. When the charging/discharging process is performed and extreme depth, the equivalent series resistance parameter will increase under low battery temperature and extreme Battery State of Charge (SOC).

High investment cost: the initial investment cost of the solar power charging station is high for hardware and software infrastructure. EVs connect with the power grid system by bidirectional battery charger system. Besides, the charging/discharging process for EVs has energy loss, it means that financial benefit reduces.

VII. MATHEMATICAL CALCULATION

How to Calculate Solar Panel kWh

Determine the Size of One Solar Panel

Multiply the size of one solar panel in square meters by 1,000 to convert it to square centimeters.

Example: If a solar panel is 1.6 square meters, the calculation would be **1.6 ×— 1,000 = 1,600 square centimeters.**

Consider the Efficiency of One Solar Panel

Multiply the converted size by the efficiency of one solar panel, represented as a decimal.

Example: If the panel’s efficiency is 20%, (it means 20% of the total wattage) the calculation would be **1,600 ×— 0.2 = 320 W.**

Consider Sun Hours

Multiply the efficiency-adjusted size by the number of sun hours in your area per day.

Example: If your area receives 4.5 sun hours, the calculation would be **320 ×— 4.5 = 1,440 Wh.**

Convert to kWh

Divide the result by 1,000 to convert watt-hours to kilowatt-hours (kWh).

Example: **1,440 ×· 1,000 = 1.44 kWh per day**

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VIII. BENEFITS OF SOLAR CHARGING STATION

- **Sustainability:** By utilizing solar power, the SCS significantly reduces carbon emissions associated with EV charging. It harnesses clean, renewable energy, thereby contributing to a greener transportation ecosystem.
- **Cost-Effective:** Over time, the SCS offers cost savings compared to traditional charging stations, as it generates its own electricity and reduces reliance on grid power. Additionally, it benefits from government incentives and tax credits for renewable energy installations.
- **Grid Independence:** The inclusion of energy storage systems allows the SCS to operate independently from the grid, providing reliable charging services even in remote locations or during power outages.
- **Scalability:** The modular design of the SCS allows for easy scalability, enabling the addition of more PV panels and charging stations to meet growing demand.
- **Smart Management:** The SCS incorporates advanced monitoring and management systems, allowing operators to optimize energy use, track station performance, and provide real-time data to users through smartphone apps or online platforms.

BENEFITS (ACCORDING TO THE INDIAN CONDITIONS)

One of the bigger purposes for introducing electric vehicles is controlling our oil imports and attaining zero emissions, but right now almost all the electric vehicles that are getting charged are using electricity from gird and in India, 80% of the electricity is made of non-renewable energy sources (Fossil fuels), and again if we are using the same energy to recharge our EV instead reducing carbon emission it'll create more pollution than what ICE vehicles would have created (Making electric vehicle in itself emits a lot of pollution too). So, running electric vehicles over grid-based electricity is a very temporary solution for reducing carbon emissions.

Now, we must find a permanent solution to overcome this situation, and that is 'renewable energy.' Few of the sources of renewable energy present now are Wind energy, Biogas, Hydropower plants, solar energy, etc. But all of them are either have less energy density or not compatible with the present market demand. But technology is constantly improving, and the most lucrative renewable energy source, for now, is "solar power" because it's affordable for a large chunk of the population, good in energy density, and its production emits low carbon into the atmosphere. However solar has its own disadvantages too but overall, it's a good energy source to look after for renewable energy.

Not stretching it further but here are some quick points that talk about the benefits of solar charging stations:

Reduces carbon emission (Not removed completely). A vehicle charged with solar-powered electricity emits 0.6 kg of carbon into the atmosphere whereas a gasoline-driven vehicle would emit 13 kg of carbon for every 100km ride.

Charging cost will reduce. Solar power costs nearly 1.5 rupees for every kWh of electricity.

India will reduce its dependency on fossil fuels for driving electric vehicles

The load on the grid reduces.

IX. MERITS AND DEMERITS OF WIRELESS CHARGING SYSTEM

Merits

- **Environment-Friendly** - The biggest and best reason to use an electric vehicle is that it is environment-friendly. Vicious gases are not release that leads to pollution in air as against the fossil fuel powered cars.
- **No Fuel or Gas Cost** - Since electric vehicle need no fuel or gas to power them, and user can steep rise in price of these commodities. Mainly all we need to plugged-in and ready to go for another 100 miles.
- **Convenient** – The wireless electric vehicle is easy to recharge. From this, we have no longer need to run for the fuel station for charging the car. Even we can use regular electric socket for charging an electric car..

Demerits

- **Quieter** – Electric car cut noise pollution as they have fewer moving part than a conventional vehicle. They are much quieter when in operation. An electric car is very quiet and very smooth compared to a petroleum powered internal com bustion engine vehicle.
- **Dynamic** – The electric car will charge while moving there is no need to stop the car, it saves our time

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X. COMPONENTS SPECIFICATIONS

Name Of The Component	Specifications
Solar Panel	-Type: Monocrystalline or Polycrystalline Power Output: 250W to 400W per panel Voltage: 30V - 40V (STC) Efficiency: 15% - 22% Dimensions: ~1.65m x 1m for 300W panel
Battery	Type: Lithium-ion or Lead-acid Capacity: 100Ah to 200Ah Voltage: Commonly 12V or 48V Cycle Life: 500-2000 cycles (Li-ion),300-800 cycles (Lead-acid)
Transformer	Type: Step-up or Step-down Power Rating: Matches or exceeds system requirements (e.g.,500W) Voltage: Input/output depends on application (e.g., 12V to 240V)
Voltage Regulator	Type: Linear or Switching Regulator Output Voltage: 5V, 12V, or 24V Current Rating: Supports load requirements (1A - 5A)
Receiver Coil	Diameter: Similar to transmitter coil (10-20 cm) Number of Turns: 10-30 turns Frequency: Matches transmitter frequency
Transmitter Coil	Diameter: 10-20 cm Number of Turns: 10-30 turns Frequency: 100-200 kHz
Microcontroller	Model: ATmega328 or ATmega2560 Operating Voltage: 5V Flash Memory: 32KB (328) or 256KB (2560) Clock Speed: 16 MHz Analog Inputs: 6-16 (depending on model)
AC to DC Converter	Type: Bridge Rectifier or Switching Power Supply Input Voltage: 220V AC Output Voltage: Typically 12V DC or 48V DC Power Rating: 500W or higher
LCD Display	Type: 16x2 Character or Graphic LCD Operating Voltage: 5V Interface: I2C or Parallel Backlight: LED backlit

Solar Panel

Solar energy is transformed into electrical energy by solar panels. They make advantage of the photoelectric effect theory, which states that when light strikes a solar panel, electrons are emitted. Silicon cells are used to make solar panels. Since silicon has an atomic number of 14, when light strikes a silicon cell, two of its outermost electrons are present. This starts the flow of electricity that I started. Two separate sales structures exist for silicon. both single-crystalline and multicrystalline Monocrystalline solar panels are produced in silicon wafer format from the final silicon block. In the same way that monocrystalline silicon cells are more effective but more expensive than polycrystalline ones, polycrystalline silicon cells are likewise silicon cells made through melting many of the silicon crystals together.

Batteries (Power Supply)

Batteries are particularly useful as a power supply in situations where a stable source of power is not available or where mobility is important. To use a battery as a power supply, the device being powered must be designed to use the specific type of battery being used. The device must also be designed to operate within the voltage range and current output capabilities of the battery. When using batteries as a power supply, it is important to monitor the battery level and recharge or replace the battery when necessary. Over time, batteries can lose their capacity to hold a charge and may need to be replaced. Overall, batteries are a versatile and convenient way to provide power in a wide range of applications where a portable or backup power source is needed.

Step Up Transformer

The low voltage (LV) and high current from the primary side of the transformer are converted to the high voltage (HV) and low current value on the secondary side of the transformer by a step-up transformer. Known as a step down transformer, this is how it works in reverse. The transformer in daily definition is a piece of stationary electrical machinery which can converts electrical energy from primary side windings to magnetic energy which is located in the magnetic core of the transformer and then back to electrical energy (on secondary side). There are numerous uses for step-up transformers in transmission lines and electrical systems. Although the voltage and current numbers are typically different, the operating frequency and nominal power are roughly identical on the primary and secondary transformer sides due to the transformer's high efficiency.

Transmission Coil

This coil is employed to transfer power to the wireless power receiver coil in car system. This gets power from Grid and solar panels. The transmitting coil is 28 gauge and 32 gauge.

Receiving Coil

The fundamental components of the receiver section are the receiving inductor coil, the bridge rectifier, the voltage regulator, and the rechargeable battery. Bridge rectifiers are used to convert the AC signal received by the coil into a DC signal. The voltage produced by the bridge rectifiers is unregulated and needs to be changed into a regulated constant voltage.

DC Battery

The electric vehicle battery or hybrid electric vehicle's electric motors are mainly powered by a re-chargeable battery which is known as electric vehicle battery also referred to as a traction battery. They are made especially for high electric charge (or energy) capacity lithium-ion batteries. Mainly lighter and smaller batteries are more preferable because they reduce the weight of the vehicle and also increase its performance. We can distinguish electric vehicle batteries by their high power-to-weight ratio, energy density and from their specific energy. From their high energy density weight, lithium polymer batteries and lithium-ion are the most popular battery types in electric vehicles. Most of the batteries we can also include for charging the electric vehicles are nickel- cadmium, lead-acid and nickel-metal hydride (valve-regulated lead acid and many more lead batteries). Batteries can store electricity in the form of coulombs or ampere hours, with the total energy often measured in kilowatt-hours (kWh). As compare to energy storage methods, they have high energy mass, batteries like lithium-ion are currently implanted in the majority of portable gadgets and electric vehicle, including mobile and laptops. They also have highly power-weight ratio, high-temperature performance, high energy efficiency, and less self-discharge

ATMEGA Controller

A 32K 8-bit microcontroller based on the AVR architecture is the Atmel ATmega328P. At 20MHz, a lot of instructions are processed in a single clock cycle, yielding a throughput of almost 20 MIPS. The ATMEGA328-PU is compatible with our 28 pin AVR Development Board and is available in a PDIP 28 pin package. The computer, on the other hand, is made to accomplish all general-purpose activities on a single device, such as running software to perform

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calculations, storing multimedia files, or accessing the internet through a browser, whereas microcontrollers are made to execute only certain tasks. A straightforward, inexpensive, low-powered micro-controller is frequently required for a variety of applications and autonomous systems. The Arduino Uno, Arduino Pro Mini, and Arduino Nano models are perhaps the most popular examples of this chip's use in development environments.

LCD Display

A flat panel display, electronic visual display, or video display that makes advantage of the light-modulating capabilities of liquid crystals is known as a liquid-crystal display (LCD). From liquid crystals light cannot be emitted. There are LCDs that can show random images (as on a general-purpose computer display) or fixed graphics that can be shown or hidden, including pre- programmed words, numbers, and 7-segment displays like those found in digital clocks. They both make use of the same fundamental technology; however different displays have larger elements whereas random images are made up of a lot of tiny pixels. The major wide-ranging applications for LCD display can include computer monitors, televisions, mobile phones, instrument panels, cockpit displays in aircraft, and signs and many more. In this project, the LCD displays the voltage % of charging and discharging of electric vehicle.

XI. FUTURE SCOPES

- **Integration with Smart Cities: -** Embedding solar charging into city infrastructure for seamless EV charging.
- **Dynamic Charging: -** Potential development of road-embedded wireless charges pads for on-the-gocharging.
- **AI Integration: -** Utilizing AI to optimize charging processes for maximum efficiency and battery longevity.
- **Sustainability Drive: -** Solar-powered charging contributes to reducing transportation's carbonfootprint
- **Smart Grid Integration: -** Improved energy management and load balancing through decentralized energy systems.
- **Wireless Power Transfer Efficiency: -** Enhanced charging speeds and reduced energy losses through advanced materials & designs.
- **Battery Technology Advances**: - Development of high-density and fast-charging batteries for better integration with solar systems.
- **Building-Integrated Photovoltaic (BIPV):**- Aesthetic solar installations that also serve as EV chargers.
- **Vehicle-to-Grid (V2G):**- Enabling EVs to supply energy back to the grid, optimizing renewable energyuse.
- **Supportive Policies and Incentives: -** Government initiatives promoting renewable energy adoption.
- **Autonomous Vehicle Integration: -** Wireless charging solutions for autonomous EVs to simplify operations.
- **Community Micro grids: -** Shared charging infrastructure in urban areas for multiple EVs.
- **Smart Sensors and IoT: -** Monitoring environmental conditions to optimize solar panel performance.
- **Power Electronics Research: -** Development of efficient converters and inverters using advanced semiconductor materials.

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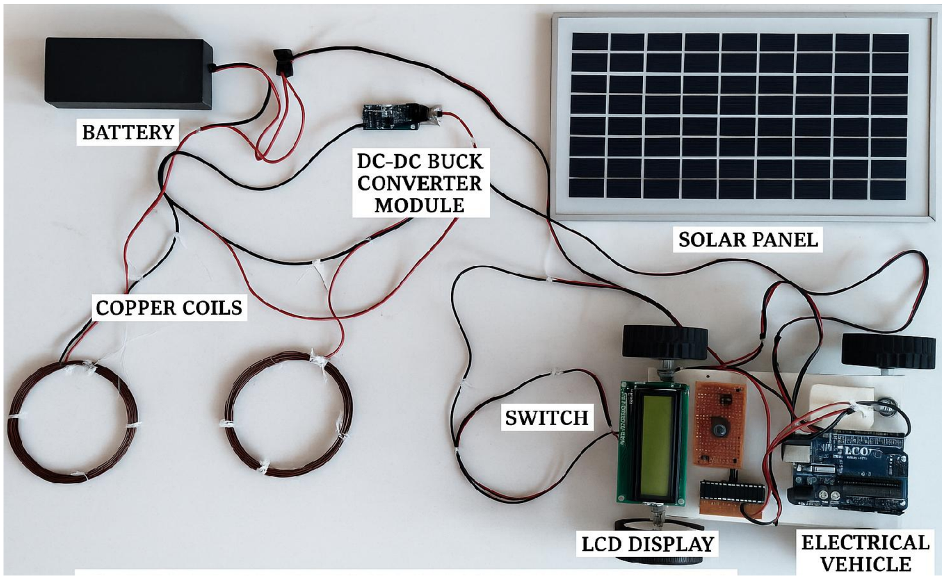
HARDWARE MODEL



OUTPUT

Component	Expected Output Value
Solar Panel	4.5V – 5.5V DC (depending on sunlight)
Battery (if used)	3.7V – 4.2V Li-ion / Li-Po (nominal)
Buck/Boost Converter	Regulates to 5V DC (stable output)
Primary Coil Output	~5V AC peak at ~20–100 kHz
Secondary Coil Output	~4V – 5V AC (induced), rectified
Rectifier Output	~4.5V DC (after diode drop)
Arduino Uno Supply	5V DC (via regulator or USB boost)
LCD Display	Displays voltage/status at 5V
DC Motors (if small)	3V – 6V DC (runs if receiving ≥4.5V)

XII. CONCLUSION

This paper reviews the EV types, the charging technologies, the solar charging system, and other aspects related to EVs. The development of solar power and EV sectors will decrease CO2 emissions and fossil fuel consumption. The solar power system only operates in the daytime, so it is a restriction of this system. EVs have clean, efficient, and noise-free compared with internal combustion engines. EVs are connected with the smart power grid system for charging the battery and the grid support. This method can combine renewable energy sources to decrease fossil energy consumption. Real-time communication is an advanced and complex technology that estimated the challenges and limitations for the charging EVs such as communication delays, routing protocols, and cyber security. To the EVs operates effectively, the charging/discharging process of the battery must be controlled, because the charging/discharging frequency is performed continuously. Besides, the solar power charging station infrastructure need to select strategic locates favorable for EVs charging. The fast charger needs to develop for the benefits of the users because it will reduce the charging time. There are various developed potentials for the EVs industry section; for

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example, there are different algorithms for utility in the EVs such as deterministic, fuzzy logic, and optimization genetic algorithms. Therefore, the studies of EVs should provide interesting topics for future research

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