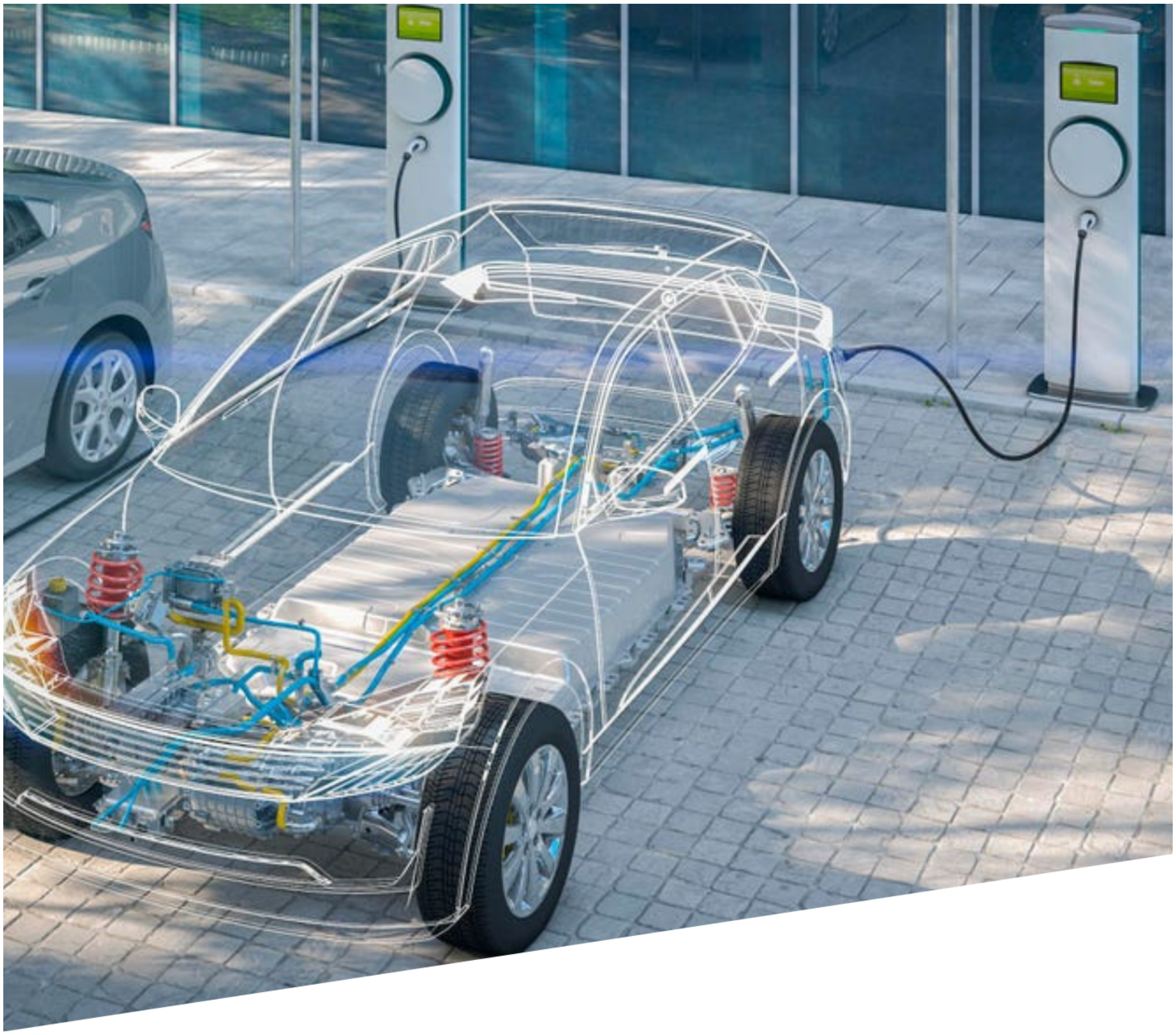

FABRICATION OF CONTINUOUS WIRELESS ENERGY TRANSMISSION ON THE RUN FOR ELECTRIC VEHICLES

RISHABH JAIN

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Abstract:

Between 1832 and 1836, Scotsman Robert Anderson created the first electric car. When electric vehicles came into existence, they promised to be a sustainable alternative in the automotive industry, thereby completely revolutionizing the industry. Subsequently, extraordinary minds, researchers, and companies such as Tesla, BMW, Nissan, Audi, Mercedes etc. added various revolutionary ideas to the development of electric vehicles. Within a small period, the automotive industry has seen a great transition, not only confirming its rate of expansion, but also its sustainability.

In recent times, we have seen the slow growth of EVs for which various factors are responsible: slow charging being the primary one. This paper studies these problems and develops a mechanism to wirelessly charge electric vehicles (WPTS) without any stoppage, thereby drastically reducing the charging time of EVs to nearly zero. Along with WPTS, a multipurpose, sustainable power source has also been proposed to provide energy to facilitate the mechanism to efficiently charge the vehicle's battery.

Keywords:

Electric Vehicles, EV Charging, Wireless Charging, WPTS, Dynamic WPTS, Continuous Wireless Energy Transmission, Sustainable Power Source

Objective:

Through this paper, we wish to do in-depth research on Electric Vehicles and propose a solution that would efficiently reduce/ abolish charging times of electric vehicles and also bring down their high costs.

We propose a system where an electric vehicle charges while it is on the road using copper coils present beneath the road to induce a current in the battery. Through this, we would be able to reduce the battery size, eradicate any kind of stoppage due to insufficient charge and also make electric vehicles a more sustainable option in the future.

Introduction:

More than 2,36,802 electric vehicles were sold in FY 2020-21 compared to 27,11,457 regular combustion vehicles. The average cost of an EV is approximately 20 lacs compared to just 7-10 lacs for a regular combustion vehicle. Electric Vehicles compared to their counterparts require 98% more time to get fully charged.

Electric Vehicles are the future of transportation. Not only are they a more sustainable option, but also an environmentally friendlier option as opposed to their counterparts - Conventional Induction Vehicles (CIV). Over the course of time, the global demand for electric vehicles has seen a significant rise due to obvious reasons: government encouragement and reduced greenhouse gas – CO_2 and CO – emissions being one of the most influential ones. Various countries of Europe and the USA have conducted multiple studies and reached the conclusion that the automobile sector is responsible for more than 25% of the total greenhouse gas emission. Vehicle owners to-date tend to purchase conventional induction vehicles due to the fear that the autonomy of EVs is not sufficient to guarantee an obstacle-free ride and require charging more often than CIVs.

Electric Vehicles can either be charged using a wired or wireless charger, which consist of pads that are required to be placed on both the vehicle as well as the charging station. The basic scientific concept of Electromagnetic Induction is used in the latter in order to induce current which in turn charges the battery of the vehicle.

Problem of Current EV Charging:

Although EVs provide multiple environmental benefits, their growth has been stagnant. Although people know about the benefits of EVs, they still prefer to purchase a conventional induction vehicle (CIV). This is primarily, as not only EV manufacturers but also the government has not been not able to create appropriate amounts of awareness and help customers build trust for EVs. People are not yet confident if the vehicle will survive long term like CIVs, if they would require hefty maintenance, if they had enough range, and above all if charging them was easy and economical. Furthermore, the lack of charging stations left consumers ambiguous about the ease of charging, causing them to foresee EVs as a whole. Even if the problem of fewer charging stations is solved, an increased number of charging stations will cause the voltage quality, purity, and harmonics to be compromised to a great extent, thereby affecting the electric grid.

Proposed Concept:

A concept wherein, an electric vehicle is charged on the run without any stoppage. Thus, making the process of charging electric vehicles easier, economical, and convenient.
Furthermore, a green, revolutionary, and innovative solution to produce energy for charging has also been proposed.

Implementation:

I. Charging Mechanism

The charging of electric vehicles occurs due to the Dynamic Wireless Power Transmission System (WPTS). The system uses rudimentary concepts such as Mutual Electromagnetic Induction to induce current using two copper coils. One coil is placed on the road, called the primary coil, just under its surface, and the other is placed on the lower chassis of the vehicle, called the secondary coil. The primary coil is connected through conducting wires to an AC power source as shown in Fig. 1. As electricity passes through the primary coil, the coil develops a magnetic field around it. As, both the coils are close to each other, a magnetic field is created around the secondary coil as well. At any given point when electricity is passing through the primary coil, the electricity is converted into a magnetic field (as shown in Fig. 2) which in turn induces electricity in the secondary coil as per Faraday's Law of Induction. This electric energy is then transported to the vehicle's battery using conductive wires and thus, the charging process is completed without the need for the vehicle to halt or slow down at any given time. (Working Diagram Shown in Fig. 3)

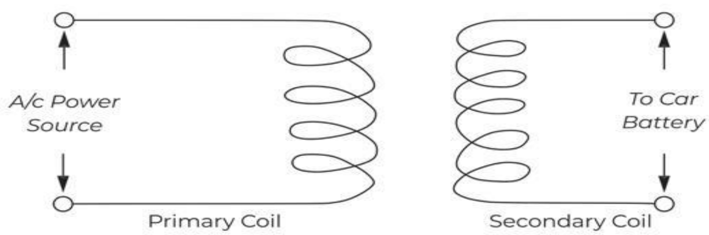


Fig. 1. Mutual Inductance

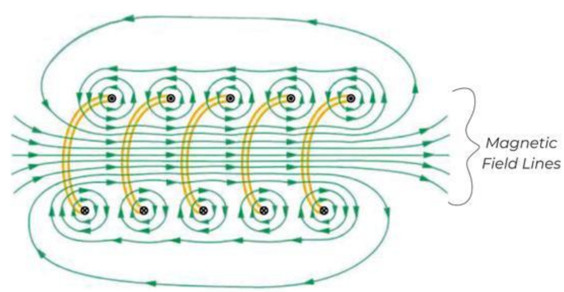


Fig. 2. Magnetic Field Due to Section of Solenoid

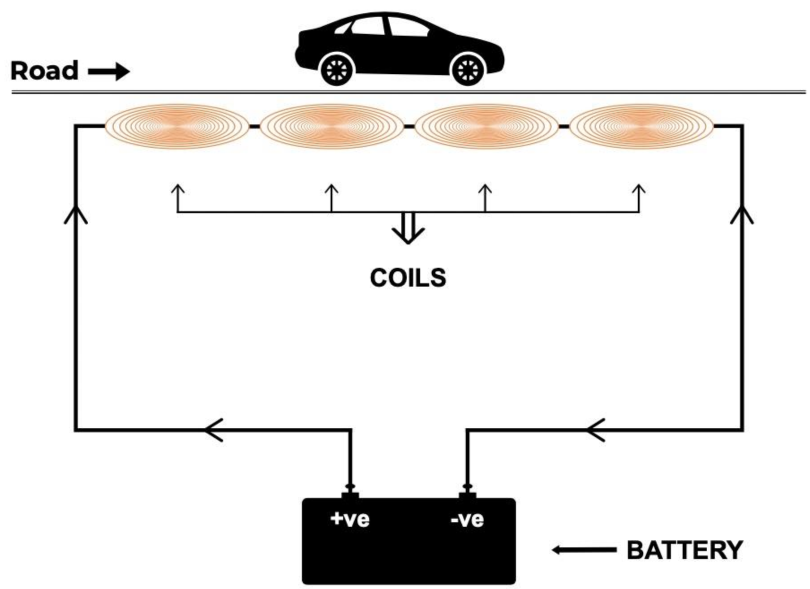


Fig. 3 : Working Diagram of Wireless Charging of EVs

II. Sensors

It is essential to ensure that when no vehicle is on the road, the system does not consume or waste any kind of energy. Keeping the above in mind, ultrasonic sensors are placed on either side of the road. These sensors detect any kind of object on the road by emitting soundwaves. Once the sound wave strikes a surface, the sound waves are reflected back on the sensor. Using the time taken by the soundwaves to return, the distance between the object and sensor can be easily calculated. If the ultrasonic sensor detects an object, it sends a signal to activate the passive infrared sensor (PIR Sensor) which in turn differentiates between a vehicle and any other object by using temperature difference. The heat radiated by vehicles is much higher (75°C - 105°C) as compared to other objects or even mammals (36°F - 42ºF). If the PIR sensor detects a temperature above 70°C, it will then close the circuit thereby, allowing energy to flow through and charge the vehicle's battery. On the contrary, if no object is detected by the ultrasonic sensor, the activation of the PIR sensor is not needed and the circuit remains open, not allowing energy to pass through.

III. Sustainable Power Source

Surprisingly, the power required for charging the vehicle can be derived from the vehicle itself. A system consisting of a flywheel, ratchet, axle, and dynamo can be used to derive the energy. The flywheel is placed on the surface of the road or speed breaker in a way where only two-fifths of the wheel is visible outside and the other three-fifth is below the ground. The flywheel is in direct contact with the ratchet which then moves as the vehicle passes over the flywheel. The ratchet is connected to the dynamo using an axle. As the ratchet moves, the axle is brought into motion which is used by the dynamo to convert this mechanical energy into electrical energy using the process of Electromagnetic Induction.

This produced energy can be stored in a battery using conductive wires.

It must not be overlooked that the amount of electricity generated by the dynamo will be variable as it receives variable amounts of energy from the car (car travels at different speeds, thereby each car causes a different angular displacement in the flywheel). This variable flow of current can cause problems in the battery. To eliminate this a voltage regulator must be fitted between the dynamo and battery; it would help stabilize the amount of electricity flowing into the battery. (Working Diagram Shown in Fig. 4)

Furthermore, energy can also be derived using solar panels and installing hydroelectricity plants.

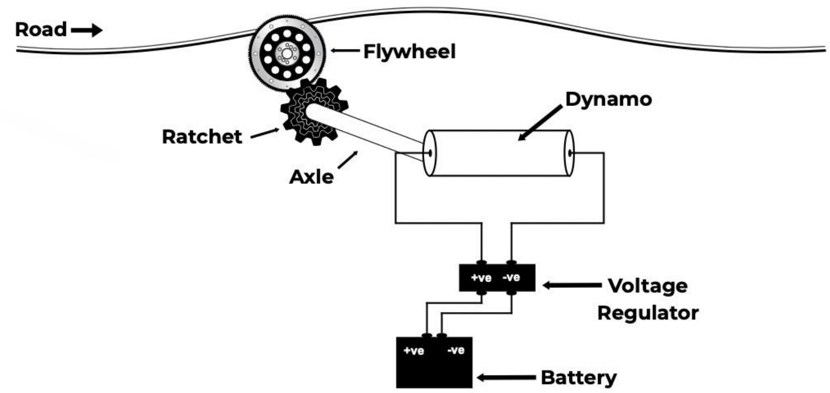


Fig. 4 : Working Diagram of Sustainable Power Source

Chronological Working of All Integrated Circuits & Components:

As power is supplied in the system, a circuit converts this 12V power into 5V power for a microcontroller (Arduino Nano). This microcontroller is connected to IR sensors and individual relays (one relay for each IR sensor). As the IR sensor detects the movement of a vehicle, it sends a signal to the microcontroller. The microcontroller then sends a signal to the relay for that specific coil for which the IR sensor is responsible. The relay is connected to the main circuit which contains CE 4847 IC, it acts as a delay counter. A transistor then completes the circuit by supplying current to one terminal of the coils. The other terminal of the coil gets current from its respective relay module. The relay module only supplies current to the coil whose IR Sensor had sent the signal to the microcontroller. Now as the vehicle moves over this coil, the vehicle's coil has current induced in it due to Faraday's Law of Induction.

Drawbacks of the Proposed System along with Solutions:

"One of the basic rules of the universe is that nothing is perfect. Perfection simply doesn't exist…. Without imperfection, neither you nor I would exist."
- Stephen Hawking

The proposed system is not perfect. To lay down the extensive network of copper coils and wiring, which connects these coils to the power source, a great amount of technical as well as economic resources will be required. Furthermore, it will be difficult to ensure that ultrasonic sensors are not stolen and roads are not dug up by people to obtain these coils in order to sell them and get some extra money.

To solve economic problems related to capital, the government must undertake appropriate resource allocation, as it would provide a clear idea of how resources must be used in a way that they produce maximum output efficiently. India has always been home to remarkable scientists, researchers, and engineers be it Dr. APJ Abdul Kalam or Satish Dhawan; senior engineers paired with young homegrown talent can provide the appropriate technical assistance. To protect the sensors from being stolen, barcoding can be done and a chip can be installed within the sensor, which would produce an alarm whenever the chip is moved through a distance of more than 20 - 30cms. For the coils, they can be dyed in a color to match that of asphalt (the topmost black layer of the road) which would help camouflage the coils.

Calculations:

An average electric vehicle requires 1 kWh of energy to cover a distance of 1 km.
Assuming the car is going on a highway at an average speed of 100 km/hr.
Let the radius of the coil under the road be 1m, number of revolutions be 3000, electric current flowing through the coil be 100A, and the distance between center of two coils be 0.5m.

B= $\frac{\mu_0 NI}{2r}$

B=$(4\pi \times 10^{-7} \times 3000 \times 100)/(2 \times 0.5)$
B= 0.37 T

A= $0.1\, m^2$

$\phi = BA$
$\phi = 0.037\, Tm^2$

Let time to cover distance between center of two coils = 0.03s at speed of 16.67 m/s or 60 km/hr.
Energy generated by coil for 1 coil=

E= $\frac{d\phi}{dt}$= $\frac{0.037-0}{0.03}$= 1.234V

Energy= $E \times I$
Energy= 1.234×1
Energy= $1.234\, J$
Energy= $3.4 \times 10^{-7}\, kWh$
Energy for 2000 coils i.e. 1 km = $6.8 \times 10^{-4} kWh$
Energy Generated by Primary Coil= Energy gained by car
(neglecting energy lost during conversion)
Therefore, car gains $6.8 \times 10^{-4} kWh$ of energy per km.

Conclusion:

The proposed system overcomes most of the problems faced by the customers while choosing EVs. The smart charging system eliminates the worry of charging the vehicle. It further helps EV manufacturers to cut down their costs, as the battery installed can now be much smaller in size. Furthermore, the battery life can be extended to a great extent as the depth of discharge is less and shallow charge-discharge cycles are used.

Automobile manufacturers will also be able to use battery optimization to fully utilize the stretch of road where dynamic wireless charging is available, just like what modern smartphones have.

Although it may solve many problems regarding charging of EVs, it also calls upon further study/research as the amount of electric current produced is quite low as shown on the previous page. The amount of energy produced is not able to compensate for the loss of energy while the car is running i.e. 0.125 kWh per km.

Motivation:

Being fascinated by technology, mechanics, cars, and any and everything that worked with electricity, the author always liked innovating new things, breaking them apart, and understanding their mechanisms. One day while discussing with his father about electric vehicles, it dawned upon him, the problem of high charging time and high costs.

The author then decided to find a solution to it. As he went on the net finding solutions, no feasible, economically, and environmentally friendly solutions were available. Once when his brother asked him about induction, he realized that he could use induction to make wireless charging cars just like wireless charging phones.

This experience offered me insight into researching existing technology by taking factors like environmental impact, social pressure, and government policies into account.

Interview of Mr. Shashank Srivastava

(Executive Director, Sales & Marketing, Maruti Suzuki India)

Link of Interview: https://bit.ly/3DqTXvO

In an interview conducted, Mr. Shashank Srivastava (Executive Director, Sales & Marketing, Maruti Suzuki India) clearly states that the main reasons for slow growth of the EV sector are range anxiety among consumers, high acquisition cost of electric vehicles, due to high battery costs (batteries constitute around 50% of an EV's cost), and lack of charging infrastructure. Furthermore, Mr. Srivastava also stressed upon a few ways by which EV acquisition costs can be cut down - localization of components plays a major factor as it reduces their costs. Although localization may seem simple it is yet more complicated. In order to encourage localization, volumes of components demanded must be high whereas on the other hand for volumes to be high, localization must be available leading to a never ending paradox. Localization can still be achieved for transmission components used mutually in both CIV's and EV's. A way by which range can be extended is by increasing the rating of batteries. An increase in the rating will therefore lead to an increased battery weight which in turn would require more power from the engine, thereby reducing efficiency leading to decreased range instead of increasing it. Nonetheless, it is essential to find the right balance of rating and size of battery (efficiency) in order to maximise range.

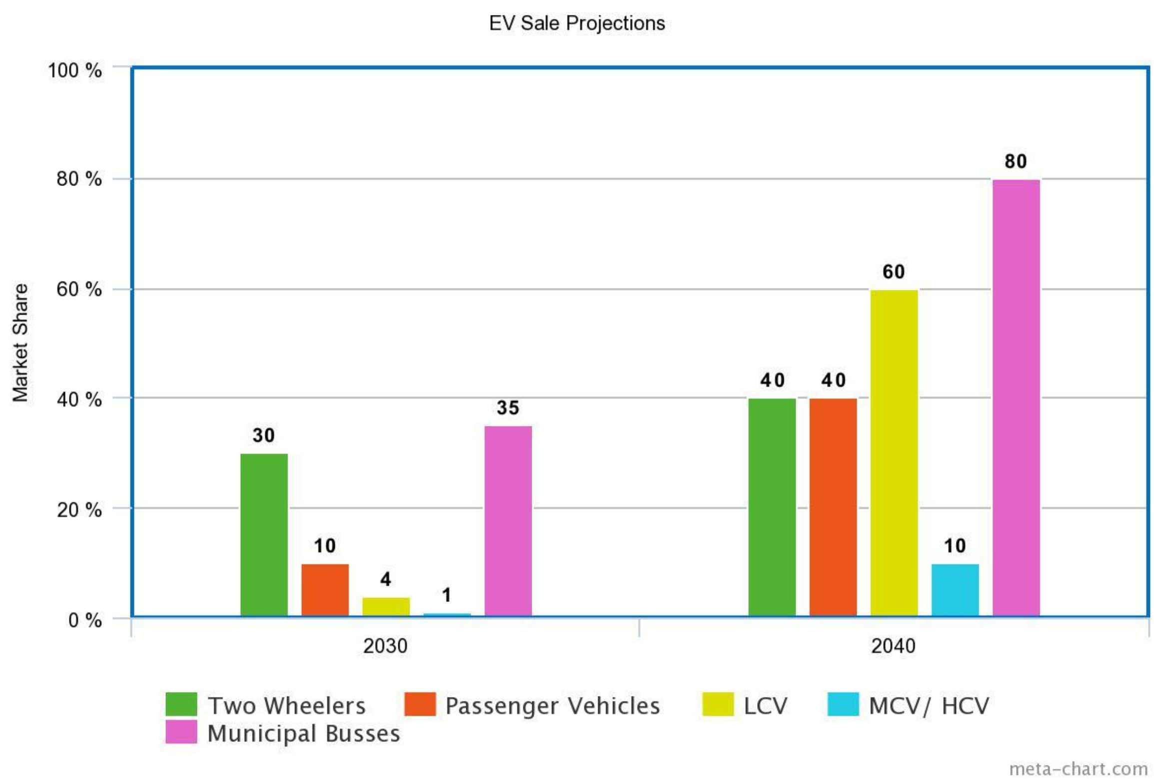
Mr. Srivastava also highlighted a few advantages of electric vehicles which include low charging cost i.e Rs. 7-12 per kWh (Rs 1.2 per km) as compared to regular combustion vehicles which go around Rs 5 per km. Even if fast charging is used for EVs, still the price per kilometer is comparatively lower at Rs. 2-3 per km.

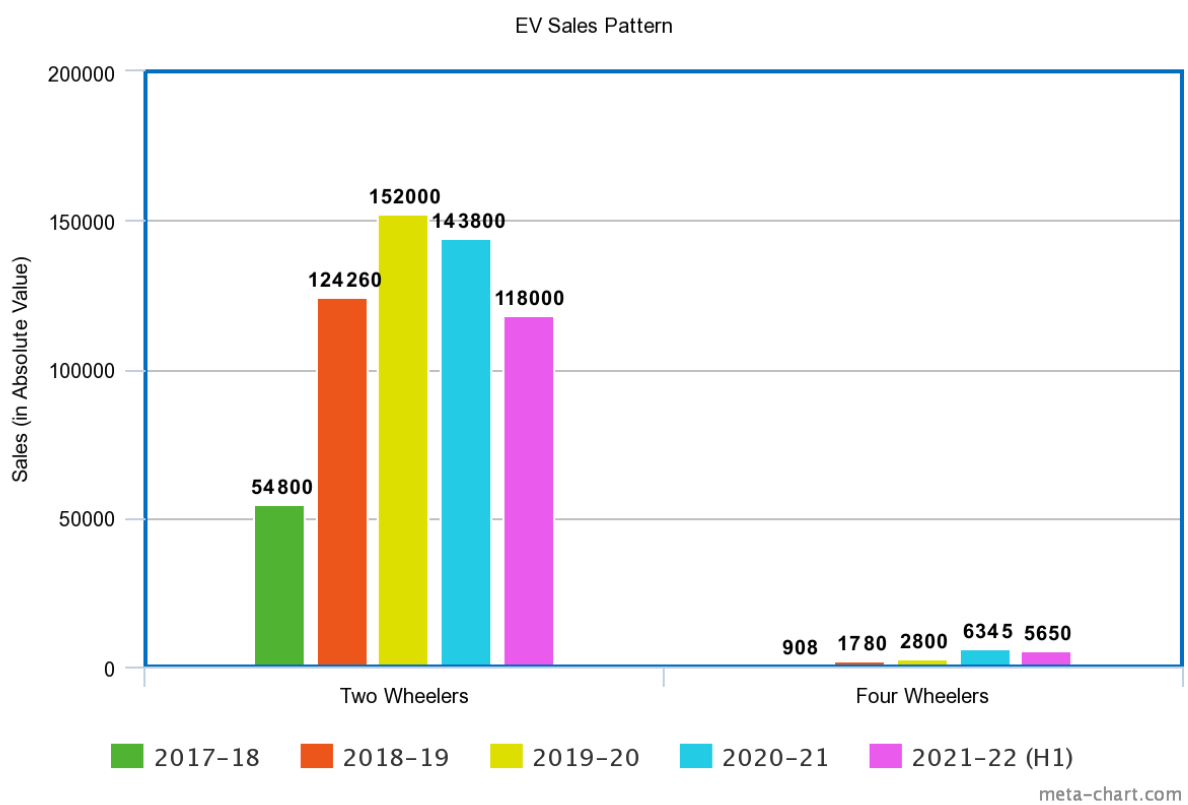
Finance plays a major role in the purchase of vehicles. More than 80% of the people prefer to finance their vehicles. Although finance companies such as Bajaj Finance are ready to finance electric vehicles, they require a much higher down payment and interest rates as their resale value is ambiguous.

Finance of EVs includes the evaluation of the car in two phases - battery and the non battery component. The battery is assumed to be replaced therefore making its resale value negligible, the non battery component is analyzed separately.

Another reason for high interest rates and downpayment is the resale territory of EV’s is quite constricted due to absence of charging facilities in rural and sub-rural areas.
He also briefly touched upon the convenience and reduced costs offered by wireless charging of EVs as no cables, meters, or adapters need to be installed. Wireless charging also prevents cables and adapters from being stolen and meters being manipulated.

<u>**Some Statistical Drawings Regarding Sales of Electric Vehicles:**</u>





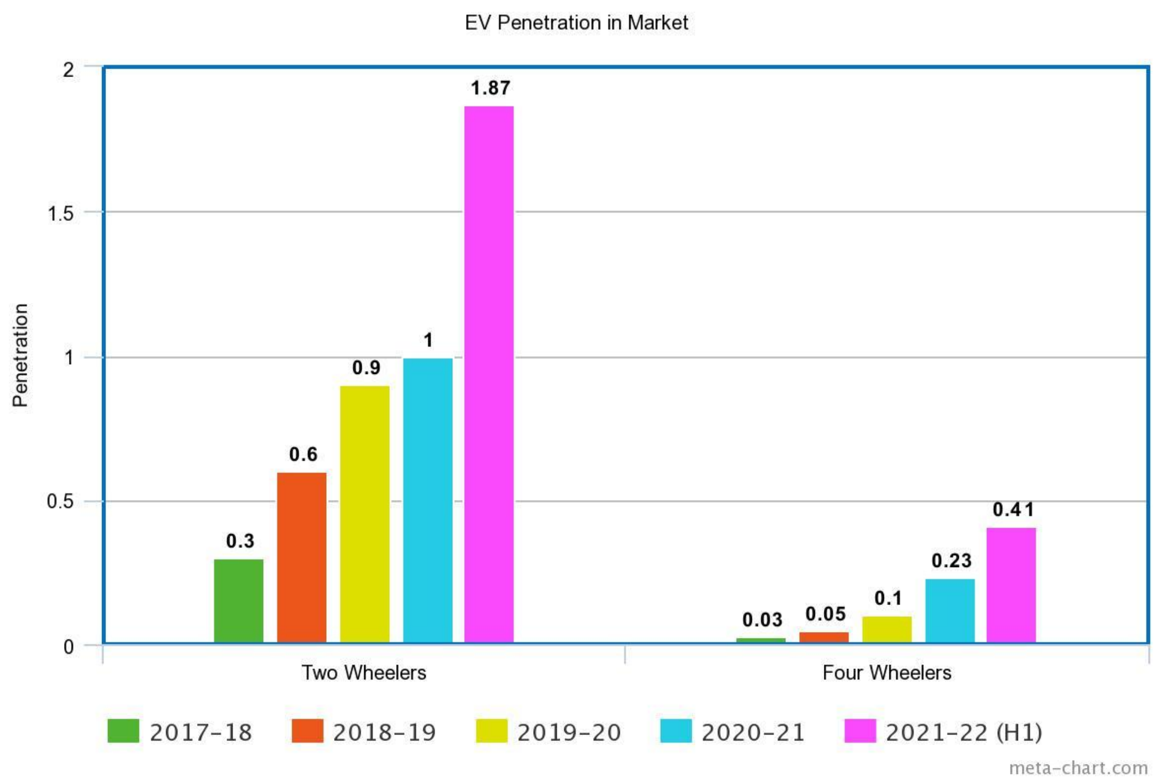
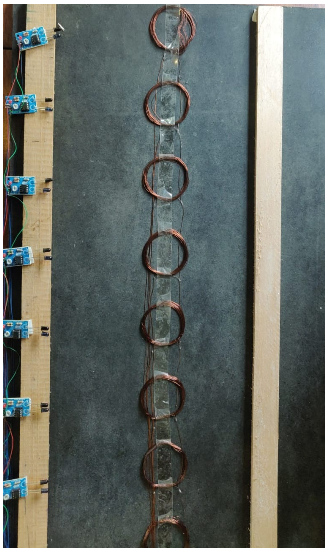
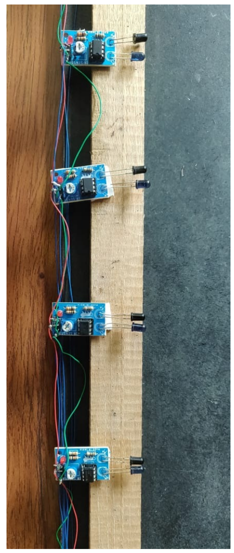

EV Penetration in Market
Penetration
2
1.5
1
0.5
0
1.87
1
0.9
0.6
0.3
0.41
0.23
0.1
0.05
0.03
Two Wheelers
Four Wheelers
2017-18
2018-19
2019-20
2020-21
2021-22 (H1)
meta-chart.com

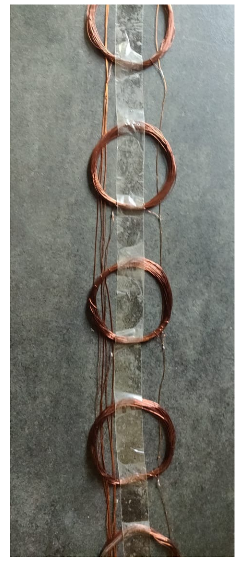
Photo Gallery:



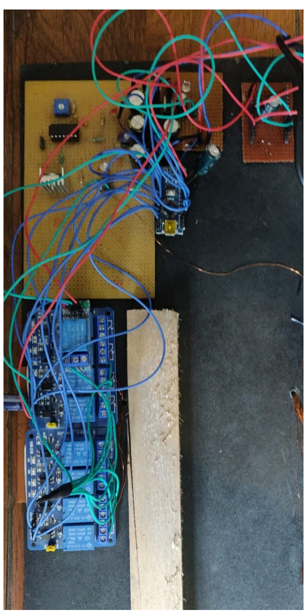
Coil with Sensor (Placement)



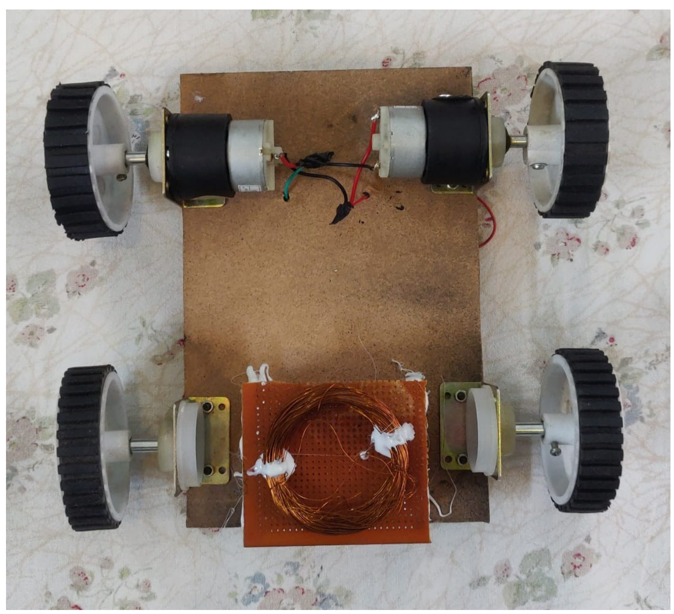
IR Sensors



Copper Coils



Control Center



Secondary Coil on Lower Chassis of Car

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