



# The Basics of Electric Vehicle Technology

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**Abstract:** Growing oil prices and rising carbon emissions are the two key issues facing the world's main transportation systems. As a result of their lack of greenhouse gas emissions and dependence on oil, electric cars (EVs) are becoming increasingly popular.

Due to the transportation sector's harmful emissions and various OEM investments, there is a growing worry about the need for more affordable and efficient electric vehicles in the years to come. The adoption of EVs in India may be influenced by several variables, including improvements in technology, falling car prices, government policy support, incentives for buying new cars, parking benefits, and well-developed public charging infrastructure.

The major challenges automobile sector needs to address today are.

- (i) how to reduce impacts on climate change and
- (ii) how to lower dependence on oil fuel.

Several strategies are being considered for addressing these issues. These include switching over to eco-friendly biofuels, improved engine design and use of electric vehicles. Biofuels have the potential to decarbonize the transport sector. In the early 2000, it was projected that biofuels would be the answer to the issues of fuel security and emissions.

However, the sustainability and the anticipated reduced emissions from biofuels have been questioned in recent years in connection with food versus fuel trade-offs, carbon accounting and land use. EVs hold the promise of reducing carbon emissions from transport sector significantly. cars will be electric by 2030 and in France and Britain; sales of petrol and diesel cars will be banned by 2040.

## I. Introduction & Brief Description

The developments in EVs are covered in detail in this article, along with trends in battery technology, charging techniques, and research issues. It explains the various parts of an electric car, including the motor, battery, charger, steering, and brakes.

### What is an Electric Vehicle?

An electric vehicle is a vehicle that uses one or more electric motors for propulsion, rather than relying on an internal combustion engine (ICE) powered by gasoline or diesel. EVs use electricity stored in batteries to power an electric motor, which then drives the wheels. The electric motor converts electrical energy into mechanical energy, allowing the vehicle to move. Unlike traditional vehicles, EVs produce zero tailpipe emissions, making them an environmentally friendly option.

Let's put it this way, a car that runs on conventional fuel (petrol/diesel) comprises essential components such as engine, transmission, fuel tank, etc. Now, coming to an electric vehicle, the engine is replaced by an electric motor and the fuel tank is replaced by the battery pack. Transmission remains the same, although all-electric vehicles have a simpler arrangement of gears.

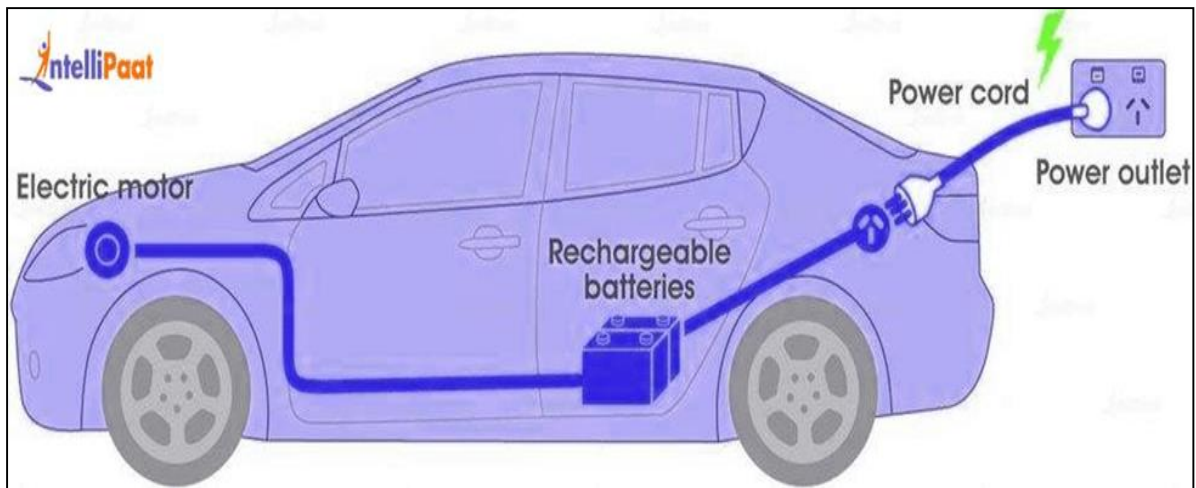


Figure 1: Electric Vehicle

### Key Components of Electric Vehicles

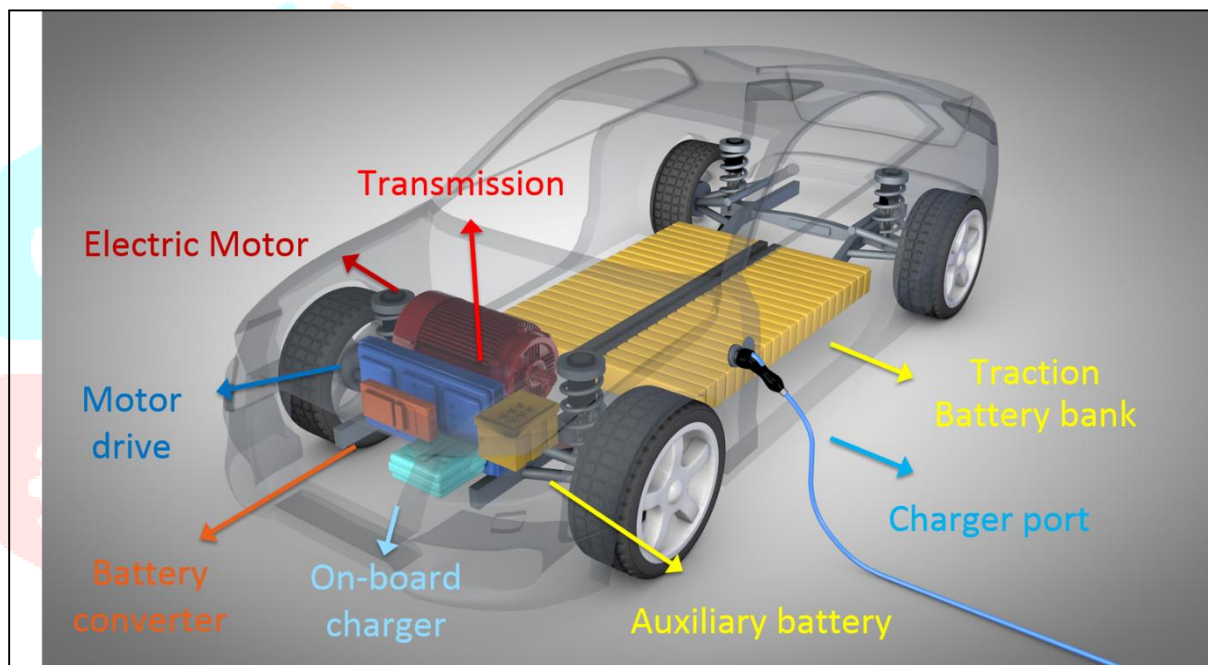


Figure 2 : Key Components of Electric Vehicles

### Battery Pack

The battery is the heart of an electric vehicle. It stores the electrical energy used to power the motor. Most EVs use lithium-ion batteries because of their high energy density, long lifespan, and relatively lightweight design. The size of the battery pack, usually measured in kilowatt-hours (kWh), directly impacts the vehicle's driving range. The larger the battery, the longer the vehicle can travel on a single charge.



Figure 3: Battery Pack

## Electric Motor

The electric motor is what propels the EV. There are different types of motors used in electric vehicles, including:

- AC (Alternating Current) Motors: These are commonly used in modern EVs because of their efficiency and simplicity.
- DC (Direct Current) Motors: These are found in older or smaller electric vehicles. They are simpler but generally less efficient than AC motors.

The motor receives electricity from the battery and converts it into mechanical energy, which turns the wheels. Depending on the EV, there may be one motor driving all four wheels or separate motors for each axle.



Figure 4: Electric Motor

## Inverter

The inverter is an essential component that converts direct current (DC) from the battery into alternating current (AC) to power the electric motor. Since batteries store electricity in DC form, the inverter ensures the motor can run using AC, which is more efficient for motor operation. In addition to converting DC to AC, the inverter also helps control the speed of the motor and the torque it produces.

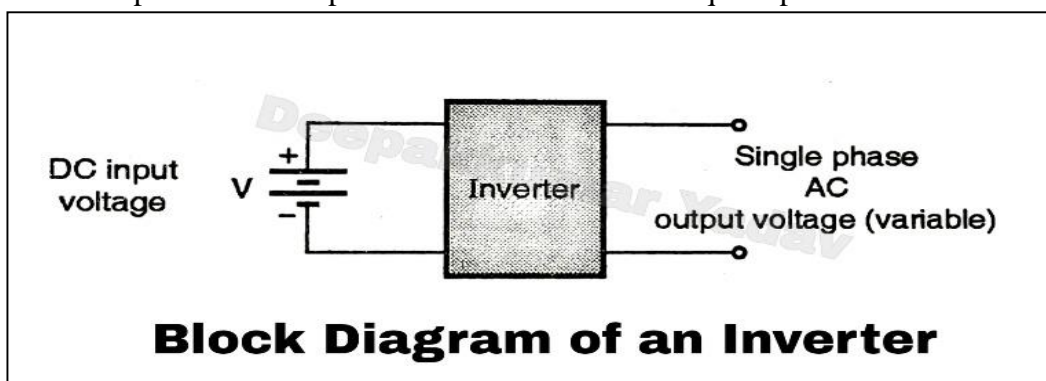


Figure 5: Inverter

## Drivetrain

Electric vehicles typically have a simpler drivetrain compared to internal combustion engine vehicles. Traditional vehicles require complex systems like a multi-speed transmission, differential, and driveshaft to transmit power from the engine to the wheels. In contrast, EVs often use a single-speed transmission or even a direct-drive system, which delivers power straight to the wheels with fewer moving parts. This simplicity reduces mechanical losses and increases overall efficiency.



Figure 6: Drivetrain

### Onboard Charger

The onboard charger converts the electricity from the charging station (AC) into a form that can be stored in the battery (DC). It also monitors battery levels to prevent overcharging, which can degrade battery performance. The onboard charger plays a key role in determining how fast an EV can recharge.

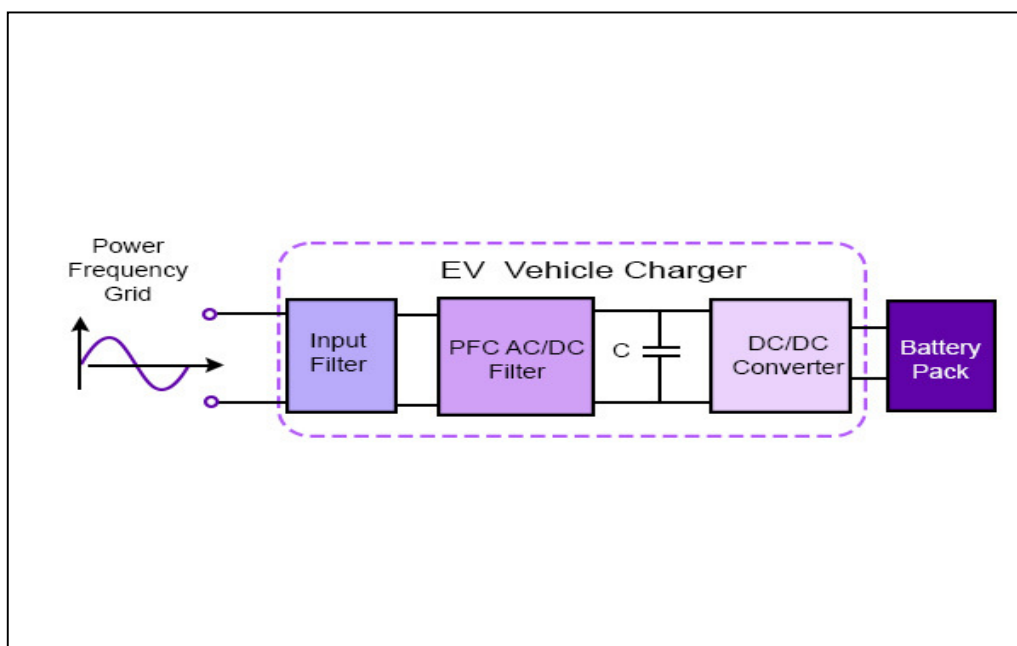


Figure 7: Onboard Charger

### DCDC Converter

In electric engineering, a DC-to-DC converter is a category of power converters, and it is an electric circuit which converts a source of direct current (DC) from one voltage level to another.

In EV numerous components, (the ECU, cameras, lights, etc.) operate on power from the low-voltage lead battery. The lead battery becomes low on power to feed when left uncharged. It needs to be charged with power from the lithium-ion battery.

Now, high-voltage DC power from the lithium-ion battery needs to be converted into low-voltage DC power with which the lead battery is charged, and the DC/DC converter makes this conversion. Low-voltage DC power resulting from the conversion allows various components in the EV to operate with proper voltage supplies.

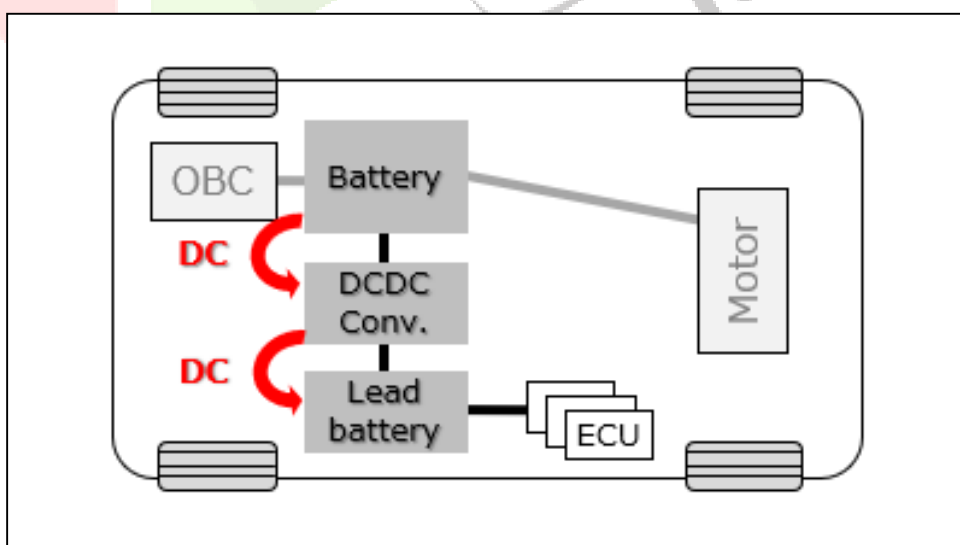


Figure 8: DCDC converter

## Regenerative Braking System

EVs are equipped with regenerative braking systems, which recover energy when the vehicle decelerates or brakes. In a traditional vehicle, braking generates heat, which is lost energy. In an electric vehicle, regenerative braking captures some of this energy and uses it to recharge the battery, improving overall efficiency and extending the vehicle's range.

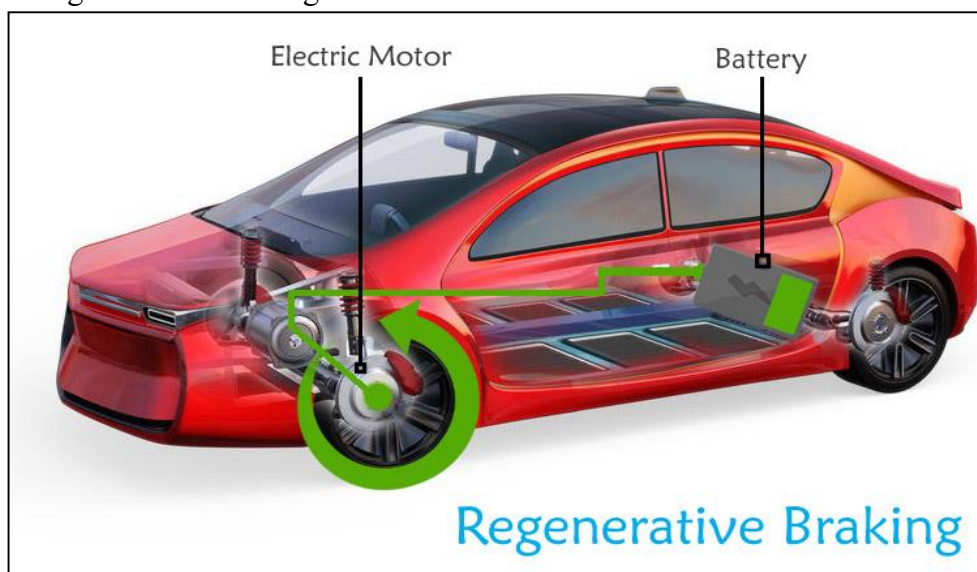


Figure 9: Regenerative Braking

## Charging Port

EVs have charging ports that allow them to connect to external power sources for recharging. These ports can be designed to support different types of charging speeds, from standard home charging to high-speed fast charging at public charging stations.



Figure 10: Charging Port

## ECU:

The controller is like the nerve centre of the human body. EVs must coordinate and control each subsystem through a vehicle control system to achieve the best performance of the vehicle.

An Electronic Control Unit (ECU) is a small computer that manages the electrical systems of an electric vehicle (EV). It acts as the vehicle's brain, using software to control a variety of features. The ECU receives input from sensors throughout the vehicle and makes real-time decisions to optimize the vehicle's performance.



Figure 11: ECU



### Battery Management System

A battery management system (BMS) is a critical component of electric vehicles (EVs) that monitors and controls the battery to ensure it operates safely and reliably.

A BMS helps to:

- **Protect the battery:** Prevents the battery from operating outside of its safe range
- **Monitor the battery:** Estimates the battery's state of charge (SoC) and state of health (SoH)
- **Optimize the battery:** Improves the battery's life and capacity through cell balancing.
- **Maximize the vehicle's range:** Optimally uses the energy stored in the battery.
- **Report operational status:** Communicates with external devices.

A BMS uses various monitoring techniques to maintain the battery's voltage, current, ambient temperature, and other parameters.

It also communicates with the onboard charger to control the battery pack's charging.

Some BMSs use wireless communication protocols to enable system enhancements through over-the-air (OTA) updates. This allows automotive OEMs to ensure the BMS's functionality and performance are intact.

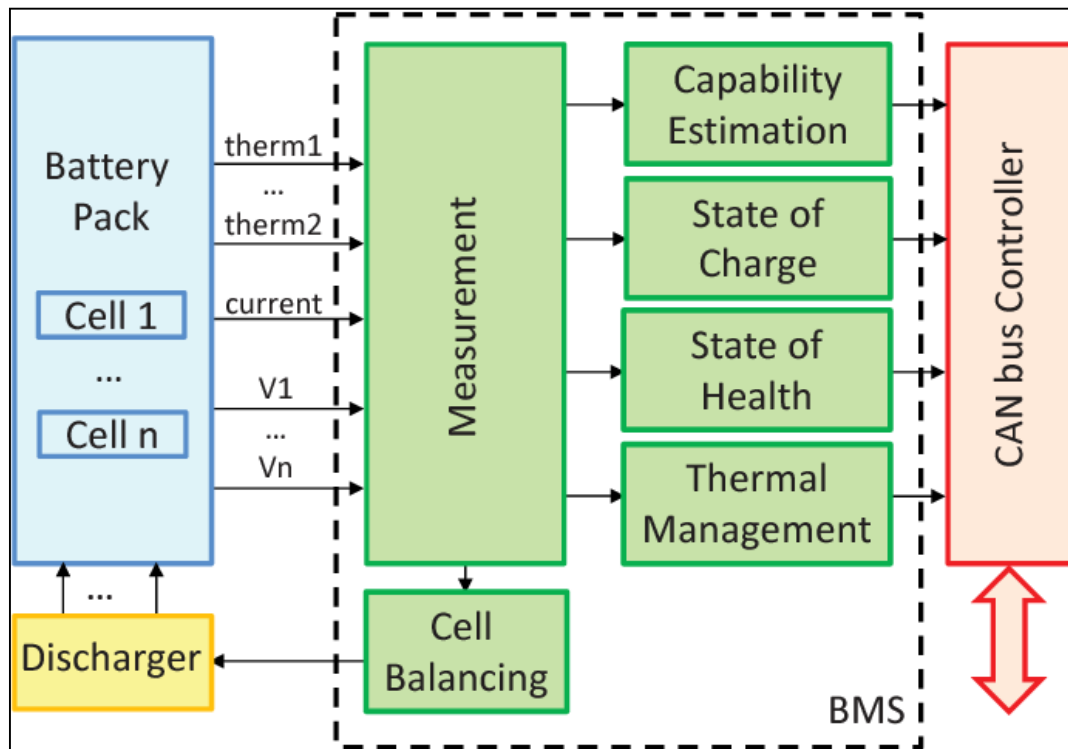


Figure 12: BMS

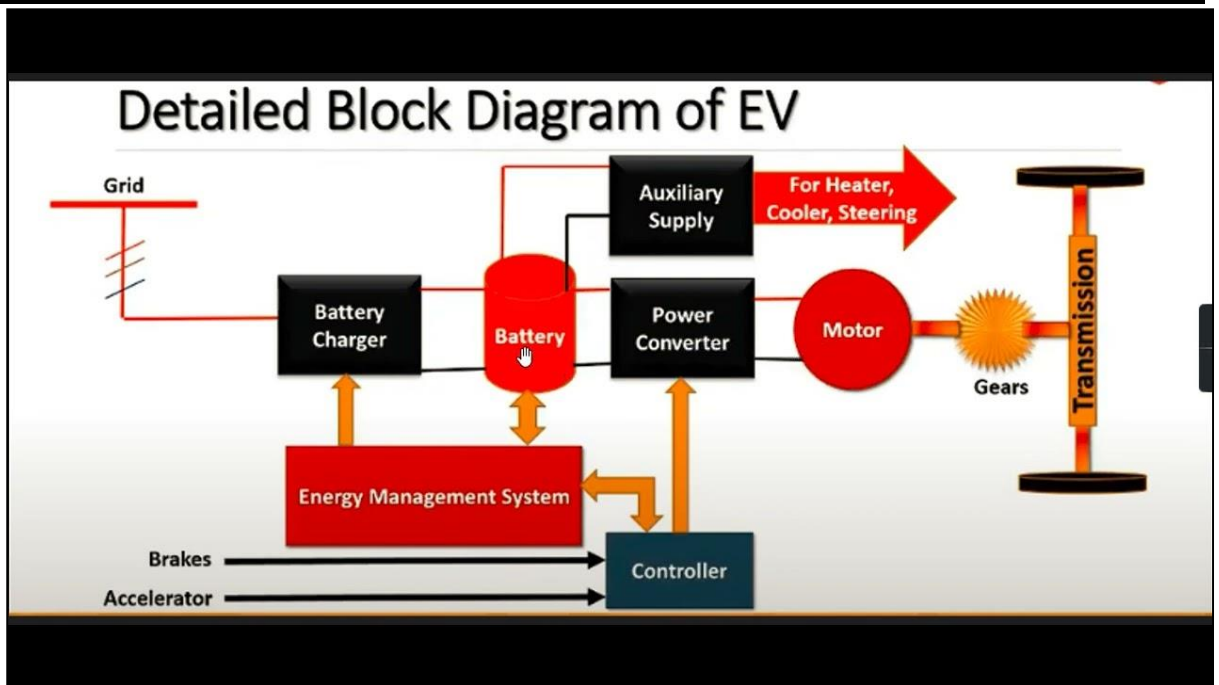
### Electric cars: How do they work?

Electric cars work on the principle of transforming electric energy into mechanical energy, which is then used to obtain kinetic energy and enable motion in a vehicle. EVs feature an electric motor instead of a conventional fuel engine. Thus, electric energy replaces conventional fuel (petrol/diesel). The electric motor converts the electric charge into mechanical energy.

Refer to the below points to understand how an electric vehicle works.

- A controller manages the flow of electrical energy to the motor. The controller modulates the flow of electricity depending on the signals received from the accelerator pedal.
- The battery pack stores electrical energy when you charge the battery. The stored energy is used to power the electric motor and other accessories/components.
- The electric motor receives power from the battery and converts it into mechanical energy.
- The transmission transfers the mechanical energy from the motor to drive the wheels.
- Some EVs produce regenerative braking energy. The energy produced during braking or deceleration of the vehicle is sent back to the battery pack.
- The battery pack can be charged via the charging port. The onboard charger converts AC (Alternating Current) to DC (Direct Current).
- You can charge the battery by connecting an external power source to the vehicle's charging port.
- An EV is also equipped with an auxiliary battery to power the vehicle's accessories and other equipment. The auxiliary battery is recharged via a DC-to-DC convertor which converts high-voltage current from the battery pack to low voltage current.





## II. How does charging work?

An electric vehicle is equipped with a charging port and an onboard charger that converts AC power to DC.

You can charge an EV by connecting it to an external power source. It could be the power outlet found in households or a dedicated charging station. EV charging is further divided into three levels depending on the capacity of the flow of electrical energy.

The battery will not charge while you drive an electric-powered car. However, some electric motors produce regenerative braking energy during braking/deceleration, which is sent back to the battery pack. But the energy produced during regenerative braking is not sufficient to charge the battery pack.

### Charging Levels

- **Level 1 charging:** It is nothing but charging an EV via the regular 120-volt power outlet found in households. You can plug in the charger to the power outlet and can allow the battery to charge overnight.
- **Level 2 charging:** It is the most common type of public charging station. You can even install a Level 2 charging station at your home, provided the car manufacturer gives you an option to do so. It uses a 240-volt power outlet. The charging time is reduced compared to 120-volt charging.
- **Level 3 charging:** This system uses rapid chargers or DC fast chargers. Typically, EV manufacturers set up fast-charging stations at strategic locations, and you may also have to pay for using such charging stations. Thanks to DC electricity, the charging speed is rapid (typically, just over an hour for a full charge) with fast chargers. However, your EV needs to be compatible with quick charging to make use of Level 3 charging.

### Charging Time

- The charging time depends on various factors such as the charging station, battery capacity, rate of current flow, etc. So, the time required for a full charge depends on the vehicle and the charging conditions.

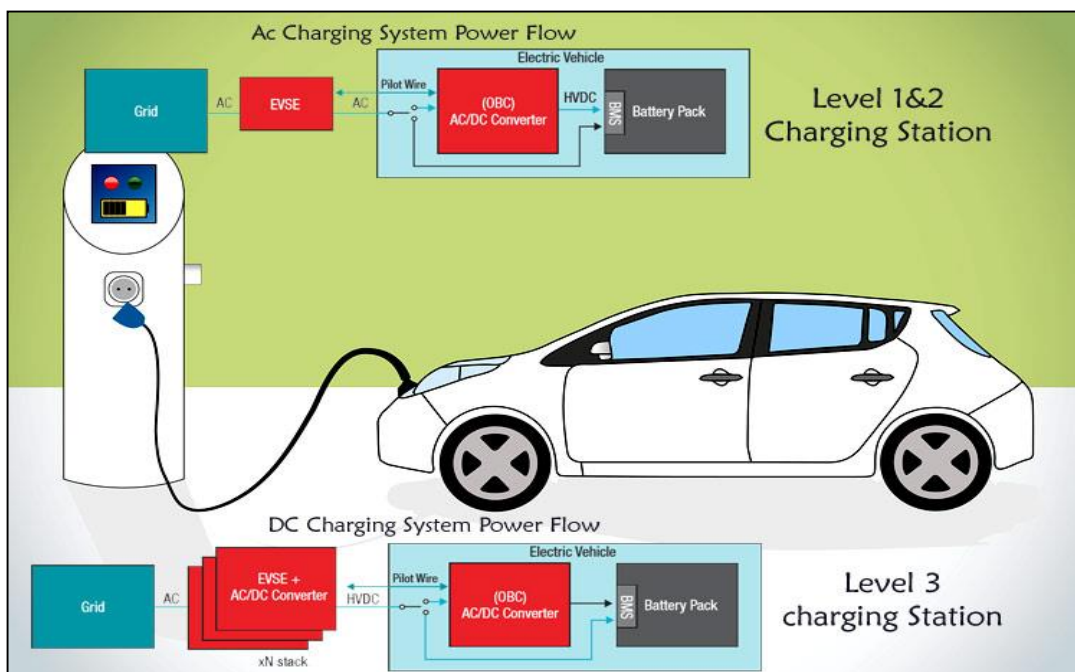


Figure 14: AC Charging System Power Flow

### III. Electric Vehicle Vs Fuel Vehicle

- Here is a comparison table that showcases the difference between electric vehicles and fuel vehicles:

Parameters	Electric Vehicle	Fuel Vehicle
Fuel Requirement	<ul style="list-style-type: none"> <li>Its operation relies on an electric motor and battery that stores and retains power.</li> </ul>	<ul style="list-style-type: none"> <li>It has a combustion engine that runs on fossil fuels like petrol and diesel.</li> </ul>
Recharge	<ul style="list-style-type: none"> <li>You can set up a charging station at home to recharge the vehicle.</li> </ul>	<ul style="list-style-type: none"> <li>You have to take the vehicle to the petrol pump for refuelling.</li> </ul>
Carbon Emissions	<ul style="list-style-type: none"> <li>It does not emit any polluting substances and is smoke-free, making it an eco-friendly option for daily commuting.</li> </ul>	<ul style="list-style-type: none"> <li>It emits large volumes of carbon dioxide and other pollutants that are harmful to the environment.</li> </ul>
Cost	<ul style="list-style-type: none"> <li>It is expensive but is cost-effective in the long run due to lower charging costs than refuelling.</li> </ul>	<ul style="list-style-type: none"> <li>Though it is relatively cheaper to buy, it is not cost-effective. Fuel costs fluctuate and maintenance charges are expensive.</li> </ul>
Insurance	<ul style="list-style-type: none"> <li>Insurance premiums are expensive for electric vehicles.</li> </ul>	<ul style="list-style-type: none"> <li>Insurance premiums are cheaper for fuel-based vehicles.</li> </ul>
Tax Benefits	<ul style="list-style-type: none"> <li>Road taxes are comparatively lower for e-vehicles. Additionally, the government offers several incentives depending upon the state you live in.</li> </ul>	<ul style="list-style-type: none"> <li>Fuel vehicle buyers have to pay the standard road and other taxes. There are no special incentives for fuel vehicles.</li> </ul>

<ul style="list-style-type: none"> <li>• <b>Convenience</b></li> </ul>	<ul style="list-style-type: none"> <li>• It is more convenient to drive as there are no complicated controls.</li> </ul>	<ul style="list-style-type: none"> <li>• You need to learn the complex system of fuel cars to be able to drive them.</li> </ul>
<ul style="list-style-type: none"> <li>• <b>Noise Pollution</b></li> </ul>	<ul style="list-style-type: none"> <li>• Electric motors function silently, ensuring that your vehicles do not make any noise. This contributes towards reducing noise pollution.</li> </ul>	<ul style="list-style-type: none"> <li>• It comparatively contributes towards noise pollution more.</li> </ul>

#### IV. Conclusion

Electric vehicles present a promising alternative to conventional fuel vehicles, with numerous benefits that can contribute to a more sustainable transportation future. Nonetheless, it's essential to recognize and tackle potential issues and limitations as technology and infrastructure advance. By understanding the full range of the advantages and disadvantages of electric vehicles, buyers can decide if an electric vehicle suits their requirements and tastes.

#### V. References

Relevant research papers, articles, and resources.

