



## An Overview of Electric Vehicles

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### ARTICLE INFO

### ABSTRACT

“Electric vehicles (EVs) are a promising technology for achieving a sustainable transportation. This article includes an overview of EVs technologies as well as associated energy storage systems and charging mechanisms. The history behind and the evolution of Electric vehicles are presented. An in-depth knowledge of the fundamental principles of electric Vehicles, basic types and functions of various components of an Electric vehicle are demonstrated”. Further, the advantages and potential applications of Electric vehicle industry are addressed. The article also highlights the significance of Electric Vehicles in context of sustainable mobility in the automobile sector for the future generation.

**Keywords:** Electric Vehicles (EVs), Components of EVs, Principles of EV, Applications, Challenges and Opportunities in EVs sector

### INTRODUCTION

“An Electric vehicle (EV) is a vehicle propelled by an electric motor. Electric vehicles run on electricity and these are also known as battery-electric vehicles. A vehicle that is fully or partially driven by electric motors using energy stored on rechargeable batteries can be termed as Electric Vehicle (EV) [1]. Thus, an EV runs on an electric motor rather than an Internal Combustion Engine (ICE) that creates power by burning a mixture of gases of gasoline. Such an electric vehicle is considered a potential replacement for current automobiles to solve issues such as pollution, global warming, and decreasing natural resources [2]. They use an electric motor rather than an IC engine. Running costs are extremely low because there are fewer moving parts to maintain. The vehicle produces no exhaust gases because it is powered by electricity” [3].

### Evolution of Electric Vehicles

“Electric Vehicle was first popularized as a term in the early 1800s, but the EV has been around much longer. William Morrison of Des Moines, IOWA, invented the first practical electric car in the United States. His automobile is hardly more than an electrified wagon, but it captivates people’s curiosity about electric vehicles” [4].

“In 1901, many inventors were focusing on the electric car’s technology due to its huge demand and working to enhance the technology. For example, Thomas Edison believed that electric cars were the superior means of transportation and tried to develop a better battery” [5-6].

- 1908–1912: Around the turn of the Century, electric cars gained popularity in the US.

- 1968–1973: The need for alternative fuel cars decreased over the next fifty years or more due to the widespread availability of inexpensive gasoline and continuous improvements in internal combustion engines.
- But as gas prices increased in the 1960s and 1970s, interest in electric vehicles technology increased as well.
- 1973: Numerous automakers, both big and small, started looking at the potential of alternative fuel vehicles. For instance, “at the First Symposium on Low Pollution Power Systems Development in 1973, General Motors exhibited a prototype of an urban electric car”.
- 1974 – 1983: In these period “Sebring-CitiCar vanguards is a successful electric vehicle at that moment. The company produces around 2,000 CitiCars, which are compact, wedge-shaped cars with a 50–60 mile range. By 1975, Sebring-Vanguard was the sixth-largest automobile manufacturer in the US due to its popularity” [7].
- By 1983, electric cars had already entered their third century of commercial viability. In spite of numerous other technological advancements which have come and gone, it has been incredibly successful [8].

An “EV uses electric motors powered by batteries or other energy storage, instead of relying on internal combustion engines that burn fossil fuels [9]. EVs are recognized for their ability to reduce emissions, enhance energy efficiency, and provide a more sustainable transportation option compared to traditional vehicles” [10].

### Working Principle of an Electric Vehicle

“Electric vehicles operate on the principle of converting electric energy into mechanical energy, which is then utilized to generate kinetic energy and enable vehicle mobility. Electric vehicles use electric motors powered by energy stored in batteries, which they recharge from the grid via charging stations” [11]. “Electric energy, therefore, replaces traditional fuel (petrol/diesel). Electrical energy is converted into mechanical energy by the electric motor”. This direct use of electricity makes EVs highly efficient and allows for quicker acceleration due to the instant torque provided by electric motors. Unlike internal combustion engines (ICE), where power is gradually built, electric motors deliver their full torque immediately, giving EVs that rapid, responsive feel when accelerating [12].

Additionally, “EVs have fewer moving parts than conventional fuel-powered vehicles, resulting in lower maintenance costs” [13]. Their quiet operation and the absence of tailpipe emissions are also major benefits, contributing to a smoother driving experience and a reduced environmental impact [14]. “Electric vehicles function by plugging into a charge point and taking electricity from the grid. They store the electricity in rechargeable batteries that power an electric motor, which turns the wheels” [15].

- “Electric vehicles accelerate faster than traditional fuel engines [16].
- When the pedal is pressed, the controller gathers energy from the battery.
- Controller delivers the appropriate amount of electrical energy to the motor.
- Motor converts electrical energy transforms to mechanical energy.
- Wheels turn and vehicle moves” [17].

### Steps of Working of an EV

Step I: The controller transfers and manages electrical energy from the battery to the inverter [18].

Step II: “The inverter transmits a specific amount of electrical energy to the motor [19].

Step III: The motor transforms electrical energy into rotational mechanical energy.

Step IV: The vehicle moves when the wheels turn as a result of the motor rotor's rotation spinning the transmission [20].

Step V: The motor turns into an alternator and produces power when the brakes are applied, which are then returned to the battery” [21].

“An automobile that operates on traditional gasoline (petrol/diesel) has fundamental components such as an engine, gearbox, fuel tank, and so on. The engine in an electric vehicle has been replaced by an electric motor, and a battery pack has replaced the gas tank. The transmission stays the same; however, all-electric vehicles have a simplified gear system” [22].

To understand how an electric vehicle works, below are some points:

- “The battery retains electrical energy when it is charged. The electric motor and additional accessories/components are powered by the stored energy.
- The controller controls the electrical energy flow to the motor.
- The information obtained from the accelerator pedal is used by the controller to regulate the electric flow” [23].
- The electric motor draws energy from the battery and transforms it into mechanical energy.
- The transmission is in charge of transferring the motor's mechanical energy to the wheels.

- The battery pack receives the energy generated when the vehicle is slowed down or braked.
- “The charging port can be used to charge the battery pack. Alternating current (AC) gets converted to direct current (DC) by the onboard charger [24].
- The battery may be charged by attaching an external power source to the charging port on the vehicle.
- An EV additionally includes an supplementary battery that powers the vehicle’s accessories and other equipment.
- For recharging the auxiliary battery, a DC-to-DC converter transforms the high-voltage current coming from the battery pack into low-voltage current” [25].

### Working of an Engine in an Electric Vehicle

- As mentioned earlier, “an electric motor functions as the vehicle's engine. AC motors, which operate on Alternating Current (AC), are frequently used by automakers in Electric cars/vehicles” [26].

The operation of an electric car is explained as follows:

- When you press down on the accelerator pedal, the Power Electronics Controller (PEC) controls how much electricity is sent to the motor.
- The pressure exerted on the accelerator pedal determines how much current is needed to run the motor [27].
- The rotors spin and produce mechanical energy when the motor is turned on.
- “The gears or transmission start to revolve as a result of the motor's mechanical energy.
- The gearbox transfers the mechanical energy to the wheels, causing the vehicle to drive ahead” [28].

### Types of Electric Vehicles

Electric Vehicles (EVs) can be classified into 4 types:.

#### 1. “Battery Electric Vehicle (BEV):

Also known as All-Electric Vehicles (AEV), they are entirely powered by electric batteries. These types of vehicles do not have an internal Combustion Engine. All the energy is stored in battery pack that is recharged from the electricity grid” [29]

Eg: Tesla Model 3

“Powered entirely by electricity. These are more efficient than hybrids and plug-in hybrids. The electricity needed to power the vehicle is stored in a massive battery pack, which can be recharged by connecting to the power grid. The charged battery pack then powers one or more electric motors, which drive the electric car”. Different types of EVs are depicted in Figure 1.

2. “Hybrid Electric Vehicles (HEV). The vehicle's power train consists of an internal combustion (typically petrol) engine and a battery-powered motor. When the battery is empty, the petrol engine is used for both driving and charging. These vehicles are less efficient than all-electric or plug-in hybrid automobiles. HEVs are also referred to as series or parallel hybrids. HEVs contain both an engine and an electric motor. Fuel provides energy to the engine, while batteries supply power to the motor. The transmission is rotated simultaneously by the engine and the electric motor, which drives the wheels.

HEVs have both an electric battery and internal combustion engine. The electric battery is recharged using regenerative braking. The battery cannot be recharged from electricity grid”.

Eg: Toyota Prius Hybrid

#### 3. “Plug-in Hybrid Electric Vehicle (PHEV):

PHEVs have both an internal combustion engine and a battery that is charged via an external socket (a plug). This means that the vehicle's battery can be charged using electricity rather than the engine. Eg: BMW 330e  
The electric battery is recharged from electricity grid as well as from regenerative braking.

PHEVs are more efficient than HEVs, but not as efficient as BEVs. They have an engine and a motor. One can pick between conventional fuels (gasoline) and alternative fuels (such as biodiesel). It may also be powered by a rechargeable battery pack and can be recharged externally”.

#### 4. “Fuel cell electric vehicle (FCEV): An FCEV generates electricity from chemical energy.

FCEVs are also known as fuel cell vehicles (FCVs). These employ ‘fuel cell technology’ to generate the electricity required to run the vehicle. In this type of vehicles, the chemical energy of the fuel is converted directly into electric energy [30]”.

FCEVs are often referred to as Zero Emission Vehicles. Eg: Toyota Mirai

### MAIN COMPONENTS OF AN ELECTRIC VEHICLE

This section provides a brief overview of the major characteristics and components of an EV. The followings are important and essential components in a electrical vehicles [31].

The components and specifications of an EV are presented in Table 1 and Fig 2.

- 1. Battery pack:** “It stores electrical energy that is used by the vehicle’s electric motor and other components. It supplies the vehicle with electricity.
- 2. Charging port:** This is a port that allows you to connect the EV to an external power source to charge the battery pack” [32].
- 3. “DC-to-DC converter:** This device changes battery-derived higher voltage DC power into lower voltage DC power that may be used to replenish the auxiliary battery. The converter is also utilized to power various car accessories/components.
- 4. Electric Motor:** The electric motor is the core of the electric powertrain, converting electrical energy from the battery pack to mechanical energy. The gearbox, which drives the wheels, is linked to the motor. The vehicle's wheels are powered by an electric motor” [33].
- 5. Onboard charger:** “This device charges the battery by converting AC power to DC power.
- 6. Power Electronics Controller (PEC):** This is a controller that controls the flow of electrical energy from the battery pack. In turn, it regulates the power and torque output of the electric motor” [34].
- 7. Thermal system (cooling):** “An EV’s cooling system is analogous to a radiator in a traditional automobile. The cooling system assists in keeping the battery pack, electric motor, power controller, and other power train components at optimal operating temperatures. It keeps the engine, motor, etc., within the appropriate operating temperature range” [35].
- 8. Transmission:** “Usually known as a gearbox, it distributes mechanical energy from the motor to drive the wheels. The gearbox in EVs is automated, and the gear configuration is simple in comparison to traditional automobiles” [36].
- 9. Auxiliary battery:** “An EV, like a petrol or diesel engine-powered automobile, has a 12-volt battery to power the lights, horn, accessories, and other.
- 10. Vehicle components.** The battery is powered by the energy stored in the main battery pack”.

## RESULTS AND DISCUSSION

**Mechanism of an Electric Vehicle** is presented below and the model of an EV is illustrated in Fig 3.

1. Take AC Input via wire charger from charging station infrastructure to battery bank.
2. The battery provides a 48V DC power output to the controller.
3. Accelerator gives signal to the controller.
4. Accordingly controller gives the output to the motor.
5. Motor converts Electrical energy to Mechanical energy and it gives torque to move the vehicle.

### Charging in Electric vehicles:

“An electric car features a built-in charger that transforms AC power into DC in addition to a charging outlet. Depending on the model and battery capacity, a number of connections may be included with an all-electric car charger. However, the fundamental idea of charging an eco-friendly electric vehicle remains the same. The process of charging an electric vehicle is similar to that of charging a smart phone. Connect directly to the battery-powered vehicle to an external power source using the cable supplied by the automobile manufacturer.

An EV may be charged by connecting it to an external power source. It might be a domestic power outlet or a separate charging station. EV charging is further classified into three tiers based on the capability of the electrical energy flow:

**Level 1 charging:** It is just charging an EV using a standard 120-volt power outlet accessible in most homes. One can connect the charger to a power outlet and charge the battery overnight.

**Level 2 charging:** it is the most popular form of the public charging station. One can even build a Level 2 charging station at home if the automobile manufacturer allows it. It requires a 240-volt power outlet. Charging time is lowered when compared to 120-volt charging.

**Level 3 charging:** Rapid chargers or DC fast chargers are used in this system. Fast-charging stations are typically installed in strategic areas by EV manufacturers, and may be charged to use such charging stations. With fast chargers, charging speed is quick (usually slightly over an hour for a full charge) due to DC power. However, to use Level 3 charging, an EV must be compatible with rapid charging”.

### Advantages and Disadvantages of Electric vehicles

#### Advantages

- a. Electric vehicles are energy efficient.
- b. They cut emissions.
- c. It provides excellent performance while requiring minimal maintenance.
- d. It can be fuelled for a minimal cost.
- e. It is more convenient and simple to recharge.

#### Disadvantages

- a. Electric cars can go shorter distances.

- b. Refueling takes longer, is more expensive,
- c. Battery packs may need to be changed.
- d. Electric fueling facilities are still in development.
- e. The initial investment is extremely high.

### Features of the Electric Vehicles

- **Zero-emission:** “Unlike conventional vehicles, all-electric vehicles emit no emissions due to the use of electrical energy. Because electric cars do not release hazardous gases, they contribute to the reduction of fast-growing air pollution caused by automotive emissions.
- **Low maintenance costs:** The initial expenditure required to acquire an EV is more than that required to own a conventional automobile. However, because electric vehicles have fewer mechanical parts, their maintenance costs are significantly lower in the long term. Furthermore, the operating costs of an electric automobile are minimal since electrical energy is less expensive than traditional petrol.
- **Easy-to- drive:** Battery-powered vehicles are simple to operate since they lack a clutch and need manual gear changing. All you have to do is press the gas pedal and go. With minimal noise, it is easier to concentrate on the road, which is not the case with gasoline/diesel vehicles”.

### CONCLUSION

“The future of Electric vehicles in India looks promising, driven by a booming transportation sector and a large population seeking sustainable options. In comparison to conventional vehicles, which are directly reliant on depleting fossil fuel reserves, EVs represent a feasible option. In this research article, the key components of EVs include batteries, electric motors, and charging infrastructure, which are essential for widespread adoption are discussed with practical applications. This shift towards EVs not only addresses transportation needs but also supports India's commitment to environmental sustainability.

Electric vehicles (EVs) have a huge potential to become the mode of transportation of the future, while also saving the earth from the impending tragedies caused by global warming.

Further, EVs has also opened various job opportunities in the electric vehicle industry. For professionals looking for jobs in this field, an EV Design and Manufacturing Skill course can provide valuable knowledge and career growth.

Thus, EVs are becoming a green transportation tool for the twenty-first century and will drive the Future”.

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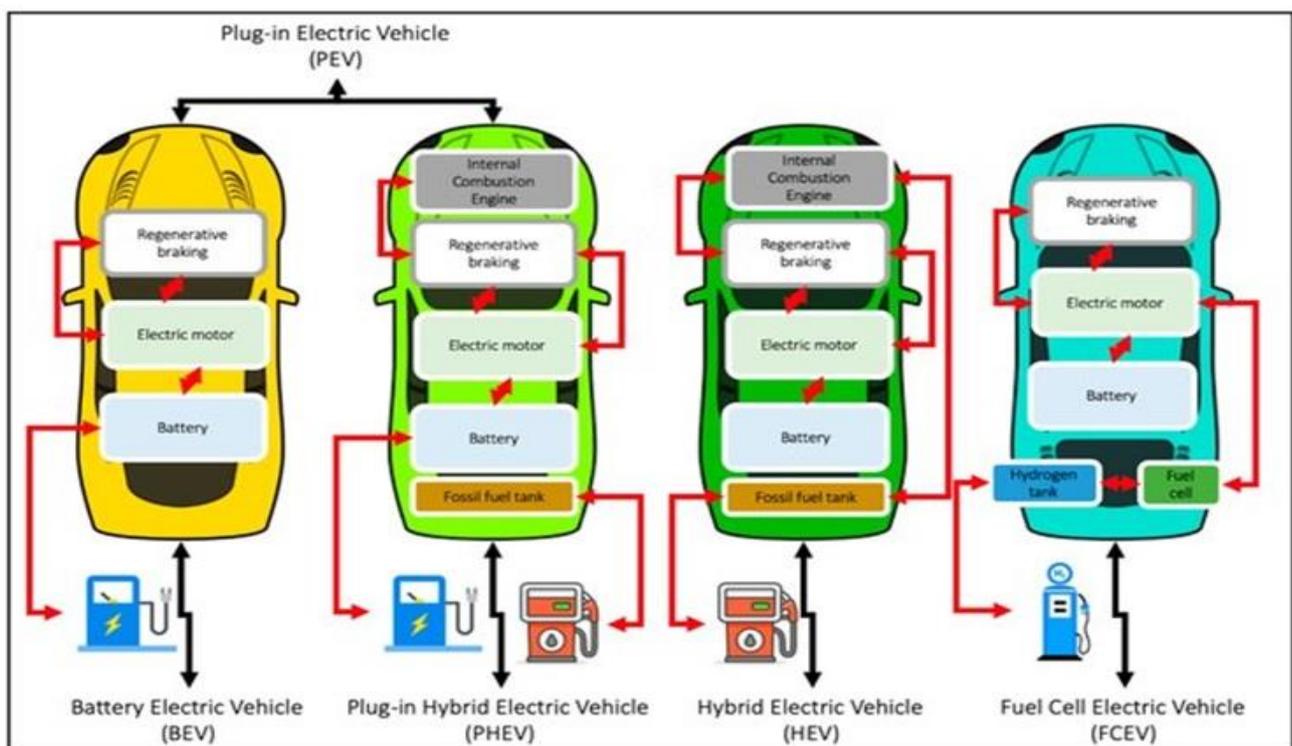
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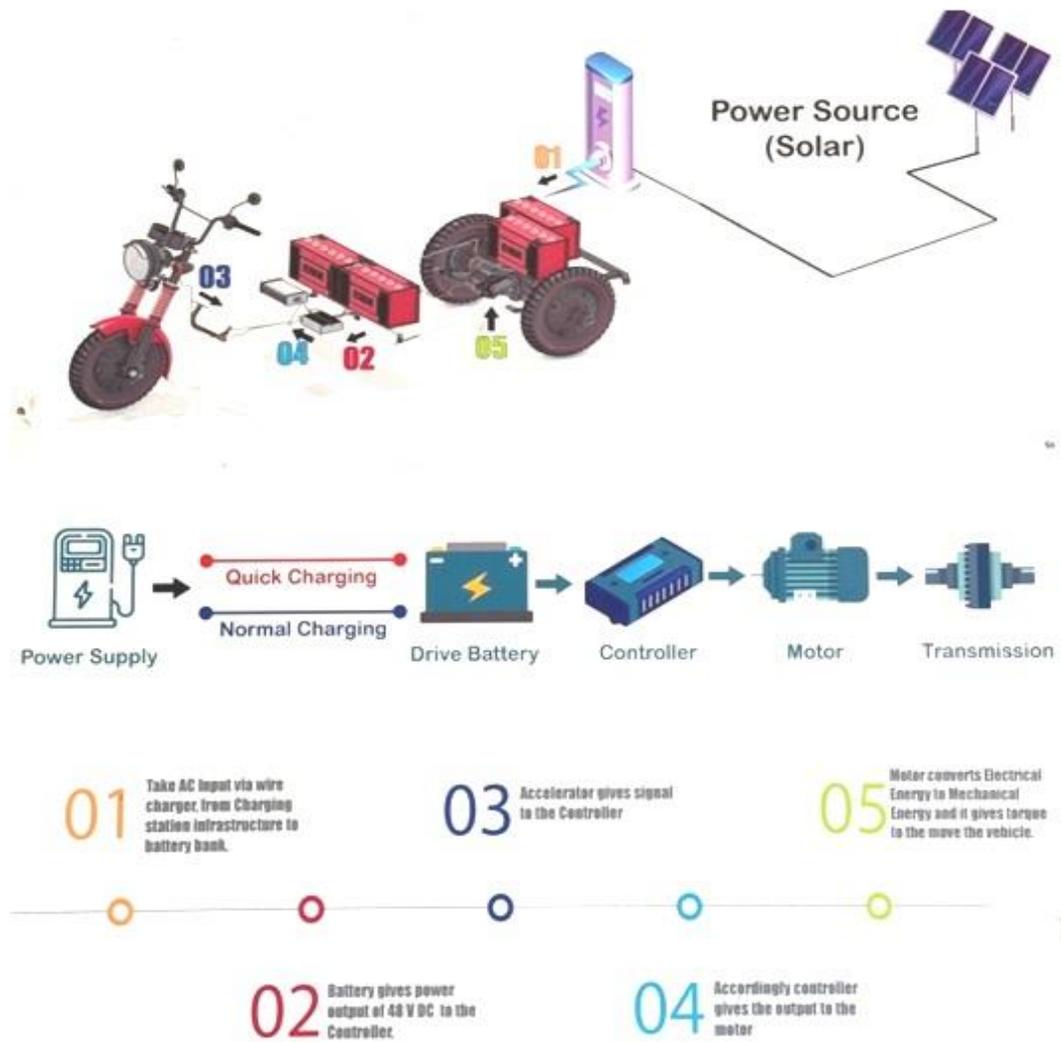
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**Table1.** Components and Specifications of an Electric-Vehicle

S. No.	Component	Specifications ( Electric Vehicle)
1	Battery	Lithium-ion battery Voltage- 48V; Capacity-80-100Ah; Deep Charge cycle-180ocycles
2	Motor	2000 watt PMSM motor Rated Voltage-48V Rated Current-100A Rated Power 4 & 3KW Rated Speed-3000rpm
3	Controller	4000watt controller 24 tube Moffett Power- 4KW; Voltage- 48V DC;
4	Converter	Converter (DC-DC); Input Voltage- 48V; 25Amp DC to DC convertor Range 25-50 amps Output Voltage- 12V; Output Current-10A;
5	Power and Signal Distribution	Assembly of Multiple cables used for power and signal distribution



**Figure 1:** Types of Electric Vehicles



**Figure 2:** Mechanism of an Electric Vehicle



**Figure 3:** Model of an Electric Vehicle at Centurion University