UNIT-II
EV AND ENERGY SOURCES

Subject Name: ELECTRIC VECHICLES

Electromobility and the Environment: -

Electromobility is he use of electric cars, as well as e-bikes, electric motorbikes, e-buses and e-trucks. The common feature of all of them is that they are fully or partly driven electrically, have a means of strong. Energy on board, and obtain their energy mainly from the power grid. Electric cars are quiet, efficient and bow-emission. Electric vehicles are normally associated with benefits to the environment and saving energy. The following are the benefits

i) Energy saving and overall reduction of carbon emissions.

ii)Reducing local pollution (improving air quality).

iii) Reducing dependence on oil. Or fossil fuels.

i) Energy saving and overall reduction of carbon emissions:

By replacing internal combustion (IC) vehicles with electric. Vehicles it saves energy, provided that the electricity is produced by an Efficient grid system using modern power stations. It will also further reduce carbon emissions plan a proportion of the electricity is generated by nuclear or alternative energy sources which Do not release carbon. It from wind or hydro.

ii) reducing local pollution:

There are increasing concerns about pollution from vehicles, particularly in towns and cities, and electric vehicles can and do make towns and cities more pleasant to live in. These vehicles reduce emissions of carbon dioxide and also the local emission of exhaust fumes.

Environmental issues may well be the deciding factor in the adoption of electric vehicles for town and city use.

iii) Reducing dependance on oil:

Oil is a finite resource which is becoming ever more expensive to produce. Many of the major wells from which we take oil are near exhaustion and we will need to take all from wells which are more difficult and hence more expensive to exploit or alternatively we will need to make oil from other fossil fuels such as cool.

These factors will dramatically affect the cost of petrol and diesel at the pumps and this may well be a significant factor in making More widespread use of electric vehicles.

History of Electric Powertrains

The history of EVs in those early years up to its peak period.
In the early 1900's is summarized below: -

Pre-830- steam-powered transportation.
1831 - faraday's law, and shortly thereafter, invention of dc motos.
1834- non rechargeable battery-powered electric car used on a short
1851 - non rechargeable 19mph electric car.
1859- development of lead storage battery.
1874 - battery-powered carriage.
Early 1870's- electricity produced by dynamo-generators
1885- gasoline-powered tricycle car.
1900 - 4200 automobiles sold: 40%. Steam powered
38%. Electric powered
22% gasoline powered.
1920's - EVs disappear, and ICE vs become predominant.
The factors that led to the disappearance of EVs after its Short period of success was as follows:

i)Invention of starter motos in 1911 made gas vehicles easier to start

ii) EVs were more expensive than gas-powered vehicles.

iii) Rural areas had limited access to electricity to charge batteries, whereas gasoline could be sold in those areas.

1960's-Electric vehicles started to resurge in the 1960's, primarily due to environmental hazards being caused by the emissions of ICEV's. The major ICEV manufacturers, General Motors (gm) and ford, became involved in EV research and development.

The components and specifications of GMEV of the 1960's are given below:
Motor - three phase induction motor, 115 hp, 13,000 rev/m.
Battery - silver-zinc (Ag-Zn), 512V, 680 lb.
Motor drive - dc-to-ac inverter using silicon-controlled rectifier (SCR).
Acceleration - 0-60 mi/h in 15.6 sec
The positive features were the acceleration performance that was comparable to the ICEV. The major disadvantage of the vehicle was he silver zinc (Ag-Zn) battery pack that was too expensive and heavy, with a short cycle life and a long recharge time.
1970's-
The scenario hired in favor of EVs in the early 1970's, as gasoline prices increased dramatically due to energy crisis.
The system and characteristics of a GMEV of the 1970's is as follows:
Motor - separately excited dc, 34 hp, 2400 rev/min.
Battery pack Ni-Zn, 120V, 735 lb.
Auxiliary battery - Ni-Zn, 14V
Motor drive - armature dc chopper using SCRs; field dc chopper using bipolar junction transistors (BJTs)
Acceleration - 0-55 mi/h in 27 sec.
This EV was used mainly as a test bed for Ni-Zn batteries.

1980's and 1990's:

In the 1980's and the 1990's, there were tremendous developments of high-power, high-frequency semiconductor switches along with the microprocessor revolution, which led to improved power converter design to drive the electric motors efficiently.

In the last 2 decades, legislative mandates pushed the cause for zero-emission vehicles (ZEV). the case studies of two GM EVs of the 1990's are given below

1) GM IMPACT 3:

Motor - one, three -phase induction motors, 137 hp, 12,000 rev/m.

Battery pack - lead-acid (26), 12v batteries connected in series (312), 8691b motor

Drive - Dc to Ac inverter using insulated gate bi-polar transistors

Acceleration - 0 to 60 miles in 8.5 sec.

2) SATURN EV1: -

- Motor one, three-phase induction motor
- battery pack - lead-acid batteries
- Motor drive- DC to AC inverted using IGBTS
- Acceleration to 60 miles in 8.5 sec.

These two vehicles were used as a test bed for mass production of EVs.

Recent EVs and HEV's-

- Most of the recent EV's use AC induction motors or PM synchronous motors. These vehicles use battery technology other than the lead-acid battery pack.
- A number of auto industries started developing hybrid electric vehicles (HEVs) to overcome the battery and range problem of pure electric vehicles.

- The hybrid vehicles use an electric motor and an internal combustion engine and these do not solve the pollution problem but it does mitigate it.
- Fuel cell electric vehicles (FCEV) can be a viable alternative to battery electric vehicles, serving as zero-emission vehicles without the range problem.

Carbon Emissions from Fuels and Pollutants

- The development of internal combustion engine vehicles, especially automobiles, is one of the greatest achievements of modem technology.
- However, the large number of automobiles in use around the world has caused and continues to cause serious problems for the environment and human life.
- Air pollution, global warming, and the rapid depletion of the earth's petroleum resources are the problems. Electric vehicles hybrid electric vehicles and fuel cell vehicles have been proposed to replace conventional vehicles.
- At present, all vehicles rely on the combustion of hydrocarbon fuels to derive the energy necessary for their propulsion.
- Combustion is a reaction between the fuel and the air that releases heat and combustion products.
- The heat is converted to mechanical power by an engine and the combustion. products are released into the atmosphere.
- Actually, the combustion of hydrocarbon fuel in combustion engines is never ideal.
- Besides carbon dioxide and water, the combustion products contain a certain amount of nitrogen oxides (NOx), carbon monoxides (Co), and unburned hydrocarbons (HC), all of which are toxic to human health.

i) Nitrogen oxides (NO_X)

- Nitrogen oxides now result from the reaction between nitrogen in the air and oxygen.
- Nitrogen dioxide (No_2) reacts with atmospheric water to form nitric acid (HNO_3) which dilutes in rain.
- This phenomenon is referred to as "acid rain" which is responsible for the destruction of forests in industrialized countries. Acid rain also contributes to the degradation of historical monuments made of marble.

ii) Carbon Monoxide (CO)

- Carbon Monoxide results from the incomplete combustion of hydrocarbons due to a lack of oxygen.
- It is a poison to human and animal beings that breathe it. Dizziness is the first symptom of carbon monoxide poisoning, which can rapidly lead to death. carbon monoxide binds more strongly to hemoglobin than oxygen.

iii) Unburned Hydrocarbons (HC)

Unburned hydrocarbons are. a result of the incomplete combustion. of hydrocarbons. Depending on their nature, unburned hydrocarbons may be them to age harmful to living beings. The Sun's ultraviolet radiations interact with unburned hydrocarbons and NO in the atmosphere to form ozone and other products. Ozone attacks the membranes of living cells, this prematurely or to die. Causing

iv) Other Pollutants

Impurities in fuels result in the emission of pollutants. Major impurity is sulfur, which is mostly found in diesel and jet fuel and also in gasoline and naturel gas.

Petroleum Companies add chemical compounds to Heir fuels in order to day improve the performance lifetime of engines. "Lead" was used to improve engine performance.

However, the combustion of their chemical releases lead metal, which is responsible for a neurological disease called "saturnism.". Its use is now forbidden in most developed countries and it has been replaced by other chemicals.

Different fuels emit different amounts of carbon dioxide (CO_2) in relation to the energy they produce when burned. Pounds of $C0_2$ emitted per million British Thermal units (Btu) of energy for various fuels:

Fuel	**Pounds of Co_2 emitted**
Coal (anthracite)	228-6
Coal (bituminous)	205.7
Coal (Lignite)	215-4
Cool (Subbituminous)	914-3
Diesel fuel & heating all	161.3
Gasoline (without ethanol)	157.2
Propane	139.0
Natural gas	117.0

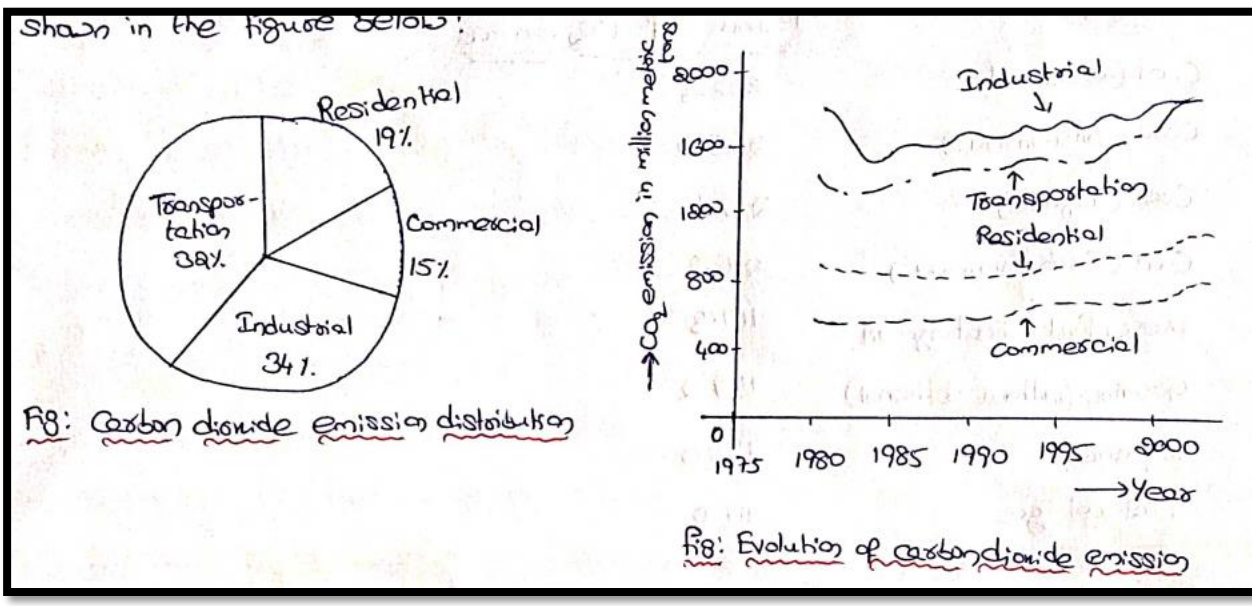
Greenhouse Effect:

- The greenhouse effect is the way in which heat is trapped close to Earth's surface by "greenhouse gases. Global warming is a result of the "greenhouse effect induced by the presence of carbon dioxide and other gases. such as methane, in the atmosphere. These An increased Earth temperature results in major ecological damage to its ecosystems and in many natural disasters that affect human populations.

- Among the ecological damages induced by global warming, the disappearance of some endangered species is a Concern, because it disability the natural resources that feed some populations.

- Natural disasters cause more damage than ecological disasters. Global warming has induced meteorological phenomena such as "El Nino" which disturbs the south-Pacific region and regularly causes tornadoes, inundations and dryness.
- The melting of the polar icecaps, another major result of global warming, raises the sea level and can cause He permanent inundation of Coastal regions, and sometimes of entire countries

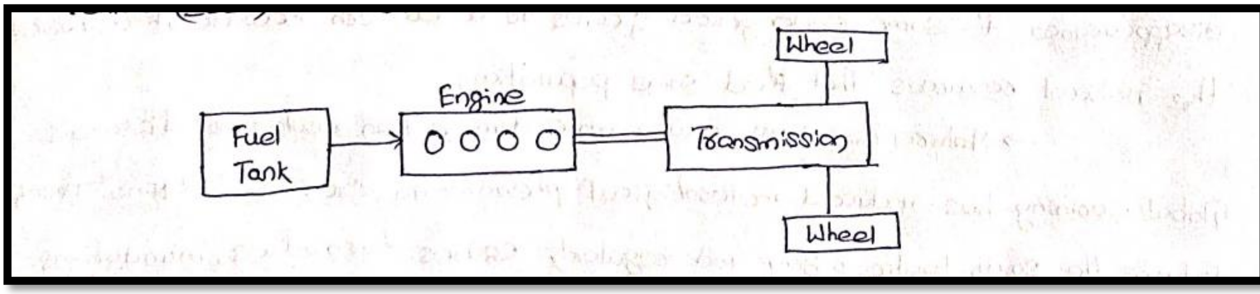
- Carbon dioxide is the result of the combustion of hydrocarbons and coal. Transportation accounts for a large share (32% from 1980 to 1999) of carbon dioxide emissions. The distribution of carbon dioxide emissions is shown in the figure below:



The above graph shows the trend in carbon dioxide emissions. The transportation sector is clearly now the major contributor of carbon dioxide emissions. The large amounts of carbon dioxide released in the atmosphere by human activities are believed to be largely responsible for the increase in global Earth temperature

Internal Combustion Engine Vehicle: - (Conventional Vehicle)

The general layout of Internal Combustion Engine Vehicle (ICEV) is shown below: -



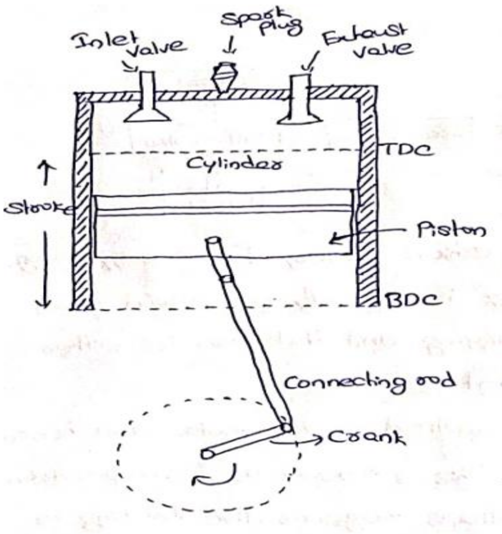
The main parts of an ICEV are fuel tank, Engine, Transmission and wheels.

Internal Combustion (IC) engines are type of devices which convert the chemical fuel energy into mechanical Work. IC engines are classified into two types

i)Spark- Ignition (SI) engines

ii) Compression - Ignition (CI) engines

In the operation both SI engines and CI engines operate on cycles. Specifically, four-stroke cycle and two-stroke cycle are used. Since the two-stroke cycle has lower fuel efficiency than that of the four- stroke one, it is seldom adopted in passenger cars. The schematic of IC engine is shown below.



In the four-stroke cycle engine, each power stroke will take two crank shaft revolutions. That means each cycle will take about half-crank shaft revolution. The four strokes are explained as below: -

1.Intake stroke: The intake stroke is from Top Dead Centre (TDC) to Bottom Deed Centre (BDC). In this stroke, fresh charge is drawn into the cylinder though

2. Compression stroke:

The compression Stroke is sight after the intake stroke. In this stroke, both intake and exhaust valves. are closed and charge in the cylinder is compressed. The cylinder pressure increases during the compression. When it is close to the end of the compression stroke (near TDC), Combustion is initiated through SI engines or CI engines.

3) Power stroke: -

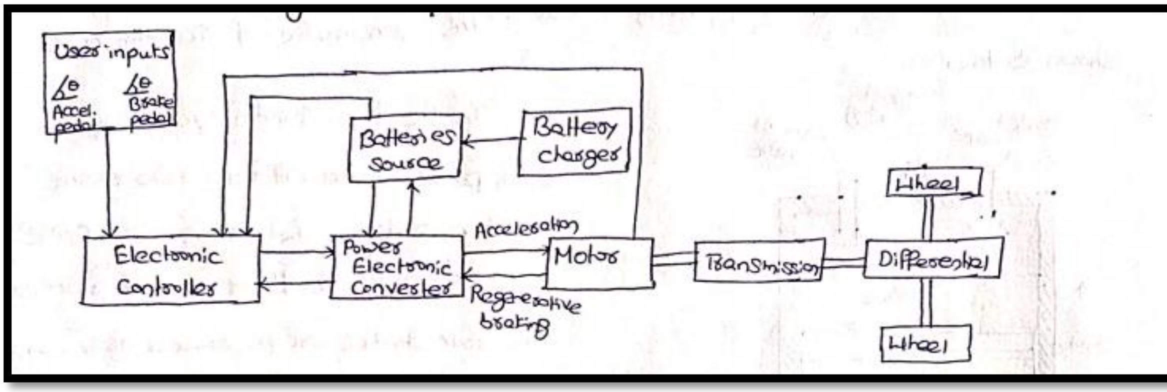
After compression stroke, the cylinder pressure increases rapidly due to the combustion. The mixture gas with high pressure and tempering pushes the piston downward and enhances the crank rotation. In this stroke the power is generated through combustion, and transferred into the mechanical work in the form of crank rotation.

4) Exhaust stroke: -

At the end of the power stroke, the piston is ground BDC. Then the exhaust valve sorts to open and He exhaust gas is pushed out When the piston moves from BDC to TDC.

Battery Vehicle (Electric Vehicle)

The general layout of a battery vehicle is shown below.



The battery vehicle consists of an electric vehicle battery for energy storage, an electric motor, Power electronics converters, transmission and a controller.

i) The battery is normally recharged from mains electricity via a plug and a battery charging unit that can be either carried on board or fitted at the charging point.

ii) The Controller will normally control the power supplied to the motor, and hence the vehicle speed, in %forward and reverse. This is known as "Two-quadrant Controller". When in addition the controller allows regenerative braking in 4 forward and reverse directions it is known as a "Four-quadrant controller."

iii) EV motors usually require frequent start/stop, high rate of acceleration/ deceleration, high-torque low speed hill climbing, low torque high-speed Cruising and Very wide-speed range of operation.

iv) Power Electronic Converters are used to achieve high power density, high efficiency, high controllability and high reliability. Power Converters may be AC-DC, AC-AC at the same frequency, AC-AC at different frequencies DC-DC or DC-AC. DC-DC converters are known as de choppers while dc-ac converters are known as Inverters, which are respectively used for DC and AC motors for electric propulsion.

v) The transmission is the mechanical linkage that transmits power between the electric motor shaft and the wheels. The gearbox, drive shaft and differential are the major components of the transmission. The output of the electric motor is the input to the transmission.

Hybrid Electric Vehicle (HEV):

A HEV is a vehicle which uses both the Internal Combustion. Engine (ICE) and the battery-powered motor powertrain. The general layout of Hybrid Electric Vehicle (HEV) is shown below.

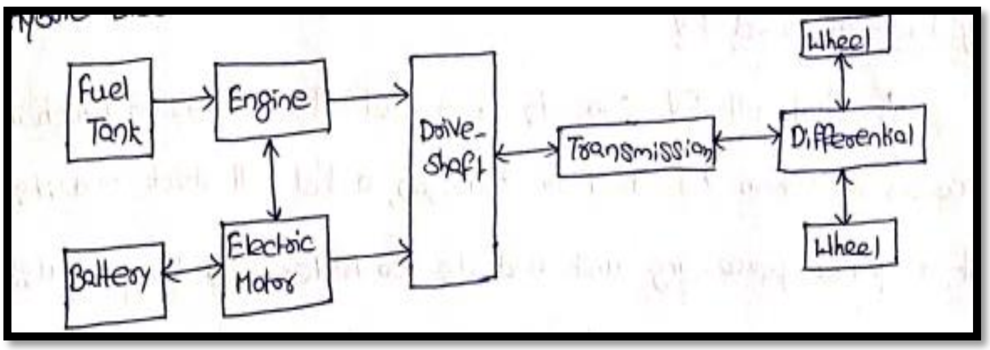


Fig: layout of Hybrid Electric Vehicle

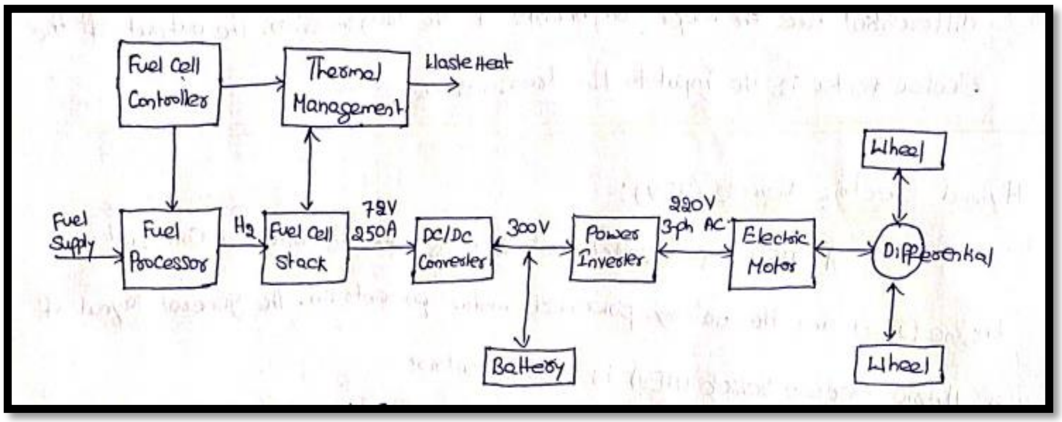
A HEV is formed by merging components from a pure electrical Vehicle and a pure gasoline vehicle, HEV's are classified into two configurations! Series and parallel.

A series hybrid is one in which only one energy converter can provide propulsion power. The heat engine or ICE acts as a prime mover in this configuration to drive an electric generator that delivers power to the battery or energy storage link and the propulsion motor.

A parallel hybrid is are in which more than one energy source con provide propulsion power. The heat engine and the electric motor are configured in parallel, with a mechanical coupling that blends He torque from the two sources.

The fuel cell EV:

The general layout of fuel cell-based EV as shown in below fig.



A fuel cell EV consists of a fuel storage system which include a fuel processor to reform row fuel to hydrogen, a fuel cell stack and its Control Unit, a power-processing unit and its controller, and the propulsion unit Consisting of the electric machine and drivetrain.

The power electronic interface circuit between the fuel cell and electric motor includes the DC/DC Converter for Voltage boost, DC/AC inverter to supply an Ac motor, microprocessor / digital signal processor for controls, and battery/capacitors for energy storage. The battery storage System is necessary to supply the power during transient and overload Conditions and also to absorb the reverse flow of energy due to regenerative braking.

The by-product of the fuel cell reaction is water in the form of steam that exits the cell along with any excess hydrogen. The water vapor can be used for heating the inside of the vehicle, but the hydrogen that is vented out is a waste for the System.

A fuel cell is an electrochemical device that produces electricity by means of a chemical reaction, much like a battery. The major difference between batteries and

fuel cells is that fuel cell con produce electricity as long as fuel is Supplied, while batteries produce electricity from stored chemical energy and hance require frequent recharging.

The basic structure of a fuel cell consists of an anode and a cathode. The fuel supplied to the cell is hydrogen and oxygen. The concept of fuel call is the opposite of electrolysis of water, where hydrogen and oxygen are combined to form electrical energy and water.

The basic chemical reaction is: $2\ H_2 \longrightarrow 2H_{2}0$ + Electrical energy.

Comparison of conventional, Battery, Hybrid and fuel cell electric systems

Features/ Requirements	**Conventional Vehicles**	**Battery (Electric) Vehicle**	**Hybrid Electric Vehicle**	**Fuel cell Electric Vehicle**
1.Powertrain	IC Engine	Electric Motor (EM)	IC Engine +EM	Fuel cell + EM
2.Energy source	IC Engine Gasoline	Electricity	Gasoline + Electricity	Electricity
3.Energy Container	Fuel tank	Battery	Fuel tank + battery	Fuel cell
4.Transmission systems	Mechanically & hydraulically actuated transmission System	Electrically mechanically actuated transmission system	Electrically & mechanically hydraulically actuated system	Electrically & mechanically, actuated transmission system.
5.Propulsive system	One Propulsive system	One Propulsive system	More than one Propulsive system	One Propulsive system
6.Emissions	Higher emissions during operation	No emissions during operation	Fewer emissions during operation	Fewer emissions during operation

7.Operational energy efficiency	Low energy efficiency, during stop and go(city)driving Conditions	High energy efficiency, during stop and go(city)driving Conditions	Higher energy efficiency	Higher energy efficiency
8. Technology	Matured technology	Growing technology	Growing technology	Growing technology
9.Cost	Inexpensive	Expensive	Expensive	Expensive
10.Energy recovery system.	No energy-recovering capability during braking	Energy recovering capability during braking.	Energy recovering capability during braking.	Energy recovering capability during braking.

Electric vehicles impact the environment:

It’s commonly considered electric vehicles are better for the environment, as they do not require traditional gasoline or contribute to emissions. Let’s take a look, however, at some of the positive and negative impacts EVs have on the environment.

Positive Impacts

- EVs have no emissions that contribute to air pollution.
- EVs are relatively quiet, so they do not contribute to noise pollution.
- EVs do not use engine oil, which is generally bad for the environment.
- EV brake pads are different so they “don’t corrode, crumble, and fail prematurely” thus requiring expensive maintenance.
- EV manufacturers traditionally try to use eco-friendly materials whenever possible.
- EV chargers, when powered by renewable energy sources, have less impact on the environment and its natural resources than traditional gas stations. No transportation is required to get the “fuel” to the chargers, unlike a gas station’s need to transport fuel.

Negative Impacts

- EV chargers generally rely on electricity from power plants, which still use fossil fuels.
- EV battery production can adversely impact the environment, such as a loss of biodiversity, air pollution and decreased freshwater supply.

- EV batteries consist of materials like nickel, lithium, cobalt and others, which are energy-intensive to mine. These minerals are also often mined in regions with a poor environmental record.
- EV battery recycling methods are still in their early stages, but they are not specifically designed to be recycled.
- EV tires wear out faster due to the heavier weight and increased torque of the vehicle. Expected lifespan on EV tires is only between 30,000 to 40,000 miles. This means you'll be buying tires more often and thus contributing to increased emissions.

EV charging has the following negative impacts on power grids

Voltage Instability and Phase Unbalance

EVs consume more power in a short time to fully charge the battery. Single-phase EVs chargers increase phase unbalance at the distribution network which increases unwanted negative effects on distribution network operation and connected loads. According to the study, it is found that rural power distribution faces higher voltage drops and needs voltage regulation devices.

Overloading of Distribution Network Components

Electricity needs three stages to reach its customers Generation, Transmission, and Distribution (*it is the consumer side of power lines*). The high EV energy demand requires a large amount of electric energy to be transmitted from the generation stations to the distribution networks. The distribution networks' equipment such as transformers and cables may get overloaded due to the new EVs load. These components are also affected by the type of charging- fast or slow. In a study, it is found that cable can handle up to 25% of EV penetration for slow charging and 15% for fast charging.

Harmonics Distortion

Electricity comes in AC form at 50Hz frequency but EV integration causes harmonics distortion (*generation of a frequency other than 50Hz of the fundamental frequency*) which causes power loss. So, the transformer and cable get heated and this causes a decrease in components life.

Economical impact:

Another economic impact of EV production is the creation of new jobs. EV production creates 538,658 new jobs in the economy, representing a 0.5% increase. Approximately, 85% of the additional employment comes from the ten industries with the greatest increase in employment

Most countries import oil, which forces their economies to depend on oil prices and affects budget deficits and GDP. If electric vehicles take over, oil-importing countries will reduce their fiscal deficits and this will also increase GDP, as fewer imports will help.

For starters, India is the world's third-largest oil importer, but the transition to EVs will significantly reduce its oil dependency, disrupting global oil markets. If

India can meet its ambitious adoption targets, the country will create a model that other emerging economies can replicate.