ELECTRIC AND HYBRID ELECTRIC VEHICLES

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Abstract: Electric vehicles (EVs) are a viable solution for lowering greenhouse gas emissions. EVs not only reduce fossil fuel reliance, but they also minimize ozone depleting compounds and facilitate large-scale renewable deployment. Despite extensive study on the qualities and properties of electric cars, as well as the nature of their charging infrastructure, electric vehicle manufacturing and network modelling continue to change and be restricted. This article addresses the numerous modelling approaches and optimization strategies used in studies of Electric Vehicle, Hybrid Electric Vehicle, Plug-in-Hybrid Electric Vehicle, and Battery Electric Vehicle penetration rates in the market. The study is unique in that it addresses crucial hurdles and insufficient charging facilities for a growing country like India. When renewable energy sources are unavailable, the development of the innovative Vehicle-to-Grid concept has provided an additional power source.

KEYWORDS- Electric vehicles, hybrid electric vehicles, types, charging methods, optimization.

I. INTRODUCTION

India is one of the top ten automotive markets in the world today and having highly increasing middle-class population with buying potential and the steady economic growth. But petrol price has increased more than 50% in 13 different steps in the last two years. Here comes the potential need for alternative technologies in automobiles such as electric vehicles (EVs) in India.
An electric vehicle (EV) is one that uses an electric propulsion system rather than an internal combustion engine (ICE). The vehicle's entire power comes from an electric motor, which also serves as the vehicle's primary drive source. The key benefit is the great efficiency of power conversion via the electric motor propulsion system. There has been a lot of research and development activity reported recently, both in academia and in industry. With the commercialization of electric vehicles, several governments have offered customers with incentives such as lower taxes or tax refunds, free parking, and low-cost/free charging stations. A hybrid electric vehicle (HEV), on the other hand, is a viable option. In recent years, it has received a lot of attention.
Major car manufacturers across the globe have at least one model that uses hybrid technology or is completely converted to electric.

Electric Vehicles (EVs) are experiencing rapid growth because of five key global trends:

(i) Fossil fuel depletion.
(ii) Growing public awareness.
(iii) Advances in technology.
(iv) The development of electric motors and electronic control systems.
(v) Advances in EV supporting technologies.

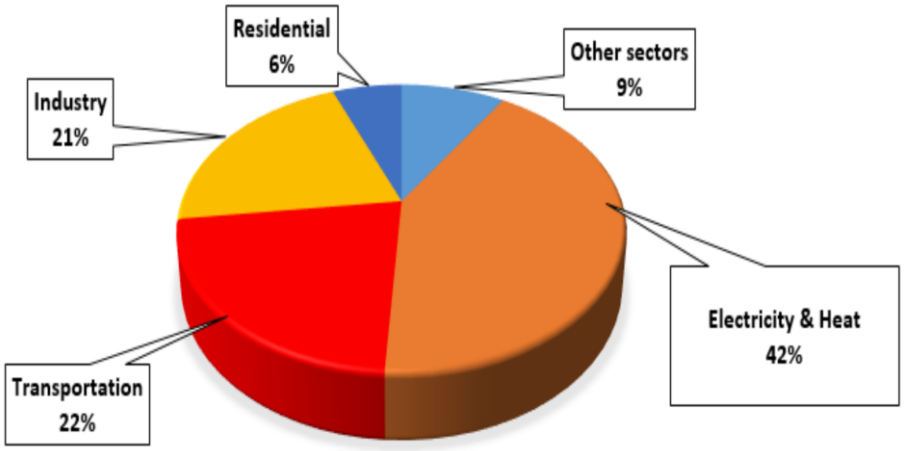


Fig 1: CO_2 emissions of various sectors

Transportation is a substantial source of CO2 emissions, accounting for 22% of global CO2 emissions in 2020. EVs, on the other hand, do not emit CO2 and are less vulnerable to rising oil prices. The world population will rise from 7 billion to 11 billion

people in the next 50 years, while the number of automobiles will rise from 700 million to 2.5 billion. Fossil fuels are anticipated to be depleted by 2050 due to an increase in the use of ICEs. Air pollution will rise as long as petrol and diesel engines are used, resulting in dark and dreary skies. Compel individuals to strive for 21st-century sustainable road transportation as a solution for a greener and cleaner future.

II. Types of electric vehicles

We already know that any vehicle powered by an electric motor is classified as an EV. Electric cars may encompass battery electric vehicles (BEV), hybrid electric vehicles (HEV), and fuel cell electric vehicles (FCEV) under this wide definition.

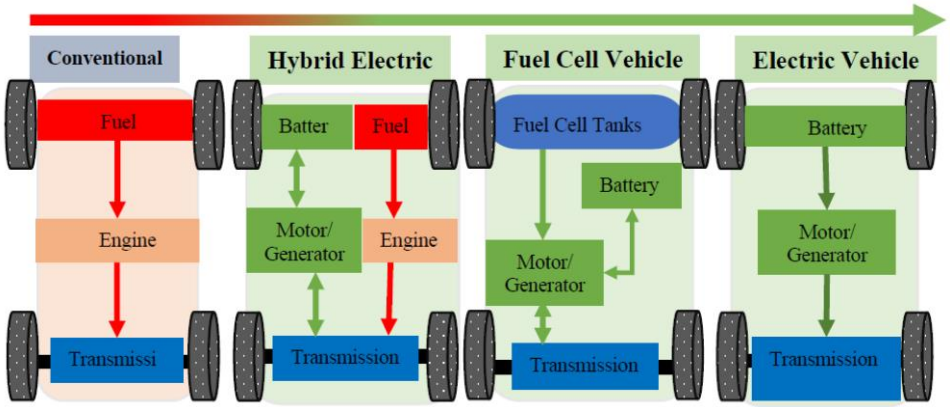


Fig 2: Difference between Conventional and various EVs

Battery electric vehicle

A fully electric vehicle is a battery electric vehicle, commonly known as a BEV. It eliminates a gasoline engine, instead relying on high-capacity, rechargeable battery packs that can be charged from an external source. The electric motor and the internal electronics of a battery electric car are powered by chemical energy stored in rechargeable batteries. The BEV has the potential to cut not only CO2 emissions from the light-duty vehicle fleet, but also the reliance on fossil-fuel automobiles.

Hybrid Electric Vehicle

Hybrid Electric Vehicles (HEVs) include an internal combustion engine (ICE) and batteries, which are utilized to move the vehicle; hence, the energy source can be either a battery or an ICE. As a result, the HEV is often known as a vehicle with two power sources. Because the battery may be recharged by recapturing the vehicle's kinetic energy through regenerative braking, HEVs are superior for city driving. The car often starts and stops while city driving. As a result, HEVs are better for city driving than country or highway travel.

Fuel Cell Electric Vehicle (FCEV)

Like electric vehicles, Fuel Cell Electric Vehicles (FCEVs) include an electric engine, but the fuel cell tank utilizes hydrogen as an energy source. FCEVs are classified into two categories based on their power train configuration:

1. Fuel Cell Electric Vehicle.
2. Fuel Cell Hybrid Electric Vehicle.

Types of EVs	Battery EVs	Hybrid EVs	Fuel Cell EVs
Propulsion	• Electric motor drives	• Electric motor drives • Internal combustion engines	• Electric motor drives
Energy system	• Battery • Ultra-capacitor	• Battery • Ultra-capacitor • ICE generating unit	• Fuel cells
Energy source & infrastructure	• Electric grid charging facilities	• Gasoline stations • Electric grid charging facilities(optional)	• Hydrogen • Methanol or gasoline • Ethanol
Characteristics	• Zero emission • Independence on crude oils • 100-200 km short range • High initial cost • Commercially available	• Very low emission • Long driving range • Dependence on crude oils • Complex • Commercially available	• Zero emission or ultra-low emission • High energy efficiency • Independence on crude oils • Satisfied driving range • High cost now • Under

			development
Major issues	• Battery and battery management	• Managing multiple energy sources	• Fuel cell cost • Fuel processor
	• High performance propulsion • Charging facilities	• Dependent on driving cycle • Battery sizing and management	• Fuelling system

Table.1 Types of Electric Vehicles

III. THE KEY COMPONENTS IN EV

The electric vehicle is rather simple in structure. The key components are the propulsion parts. Fig 3 shows the configuration.

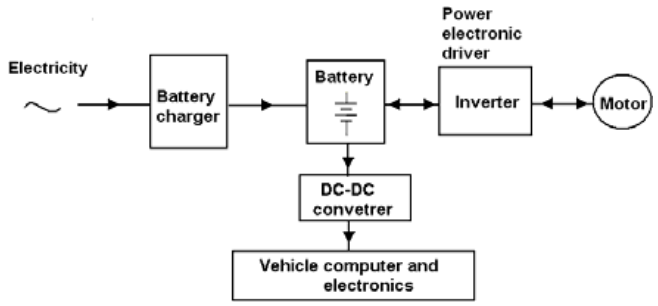


Fig 3: EV Configuration

The battery is the main energy storage. The battery charger is to convert the electricity from mains to charge the battery. The battery voltage is DC and is inverted into switched-mode signal through power electronic inverter to drive the motor. The other electronic components in a vehicle can be supplied to the battery through DC-DC converter that step down the voltage from the battery pack to lower voltage such as5V-20V.

EV Charging Methods

Battery exchange, wireless charging, and conductive charging are the three main charging techniques. The conductive charging is further divided into pantograph (Bottom-up and Top-down) and overnight charging, as shown in Figure 4.

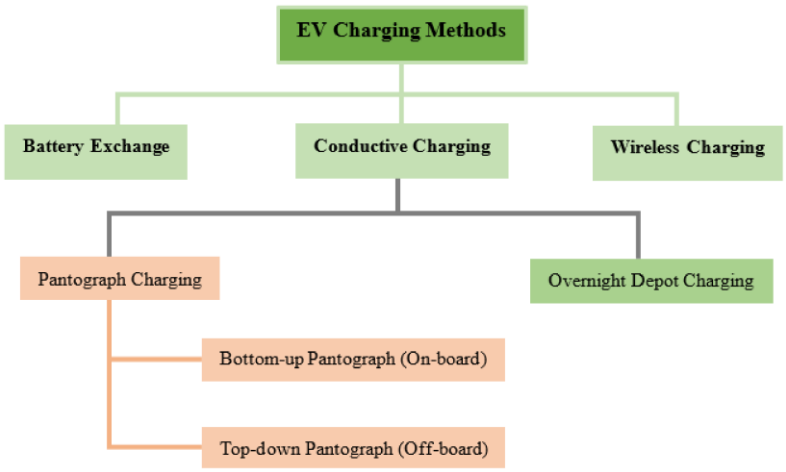


Fig 4. EV charging methods.

Battery Swap Station (BSS)

The battery swapping technique is also known as "Battery Exchange," and it is based on the BSS owner receiving monthly rent for the battery. The BSS's slow charging mechanism helps to extend battery life. Locally produced Renewable Energy Sources (RESs) such as solar and wind are easier to connect into the BSS system. One of the key benefits of this procedure is that the drivers do not have to exit the car and can swiftly replace the drained battery. Furthermore, the station's battery can participate in

the V2G (vehicle-to-grid) project. However, because the BSS owner owns the EV batteries, this sort of EV charging strategy might be more expensive than fueling the ICE engine due to significant monthly leasing rates levied by the BSS owner.

Wireless Power Transfer (WPT)

Two coils are used in this technique, which is based on electromagnetic induction. The primary coil is installed on the road, while the secondary coil is installed inside the car. WPT technology has recently gained popularity in EV applications due to its ability to allow EVs to recharge securely and easily. It also doesn't require a standard connector (but does require standard coupling technology) and may charge while driving.

Conductive Charging (CC)

Conductive charging necessitates an electrical connection between the car and the charging outlet and offers several charging options, such as level 1, level 2, and level 3 charging, as well as high charging efficiency owing to the direct connection. For a public charging station, two power charging levels (Levels 2 and 3) are used. The distribution system is less affected by the first two levels (Levels 1 and 2).
Conductive charging lowers grid loss, maintains voltage level, prevents grid power overloading, offers active power assistance, and can provide reactive power adjustment by using the vehicle's battery. Level 3 has a variety of effects on the distribution system, including voltage variation, system dependability, and transfer/power loss.

Overnight Depot Charging:

The overnight depot charging mechanism may be set up to charge slowly or quickly. It's commonly found at the end of the lines and is utilized for charging at night. Slow charging is thus the most advantageous choice because to its little impact on the distribution system. The Pantograph charging approach, on the other hand, is appropriate for applications that demand a large battery capacity and rapid charging.

Pantograph Charging:

This type of charging is one of the opportunities for charging options. This kind of charging infrastructure is used for higher battery capacity and power requirement applications, such as buses and trucks. Pantograph charging is further divided into the following two categories:

(i) **Top-down Pantograph**

(ii) **Bottom-up Pantograph**

BRAKING AND STEERING

1. **Braking and power regeneration**

In the past, a vehicle's braking system was based on a mechanical system such as a disc brake. Both mechanical and electrical brakes should be integrated into an EV's braking system. Electrical power regeneration braking should be used in the first area of the braking pedal. The kinetic energy of the vehicle can be returned to the battery while decelerating or driving down a slope. Mechanical braking is employed in the last part of the braking process. This achieves a balance between energy efficiency and safety.

2. **Anti-lock braking(ABS)**

Traditional anti-lock brakes (ABS) are installed in the majority of vehicles to prevent skidding and provide consistent braking performance. The braking behavior is influenced by both wheel slip and road conditions. The anti-lock braking system uses PID and finite state machine theory to combine continuous slip change with discrete valve action, which creates discrete hydraulic pressure.

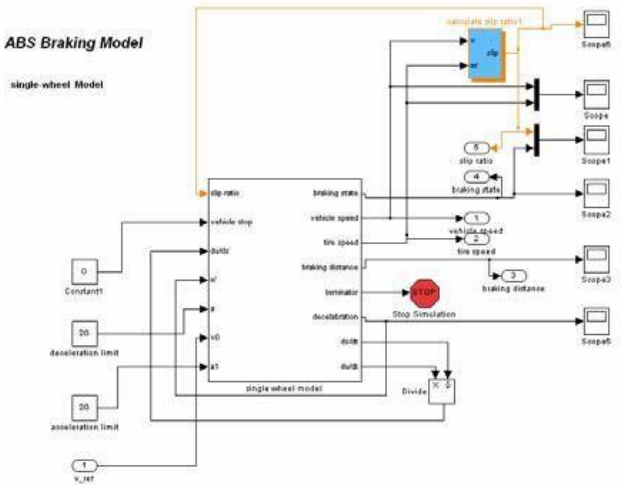


Fig 5: ABS Circuitry

3. Skid Steering

To create yaw, differentially altering the speeds of the lines of wheels on opposite sides of the vehicle is used to steer the vehicle. The longitudinal slip must be managed to meet the turn radius requirement, hence a method of slip limiting feedback is utilized in the simulation. The drive wheels may slip while the vehicle is turning on a slick surface due to a decline in the coefficient of road adhesion. The traction control system decreases engine torque, allowing sliding wheels to return to the desired skid range. Figure 6 depicts the location of skid steering for various turn radiuses.

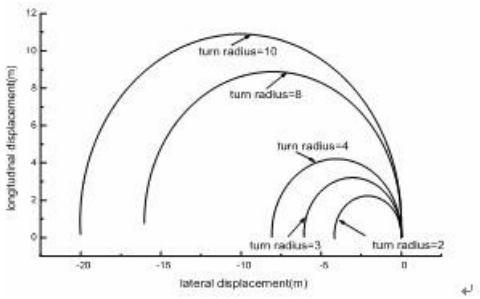


Fig 6: Locus of different turn radius achieved by skid steering

IV. CHALLENGES

- The range and cost are the two main criteria that make EVs affordable. To address the range, improved batteries such as nickel-metal hydride, zinc/air, and lithium-ion are being developed. However, because batteries have a far lower specific energy and energy density than gasoline, the development of fuel cells for EVs has increased in recent years.
- Meanwhile, commercial hybrid electric vehicles (HEVs) are being developed at a rapid pace. Because of the additional energy source, engine, and other accessories, HEVs effectively increase the range and performance of EVs at a higher complexity and cost.
- To reduce costs, improvements are being made to electric motors, power converters, electronic controllers, energy management units, battery chargers, batteries, and other EV auxiliaries, as well as EV system level integration and optimization.

DEVELOPMENT TRENDS

In order to see the development trends of various EV aspects, a survey has been made with respect to the number of papers published on various topics in leading EV related international conferences from 1984 to 2000. With regard to propulsion system, it was observed that the research papers on induction motor drives (IM) and permanent magnet motor drives (PM) are highly dominant, whereas those on DC motor drives (DC) are drooping while those on switched reluctance motor drives (SR) are still in a crawling stage. With regard to the development trend of various energy sources, including lead- acid batteries (LA),

nickel-based batteries (NB), lithium-based batteries (LB), fuel cells (FC) and capacitors/flywheels (CF); the number of papers published in LB, FC and CF are becoming more and more attractive, though LA and NB are still undergone continual improvement.

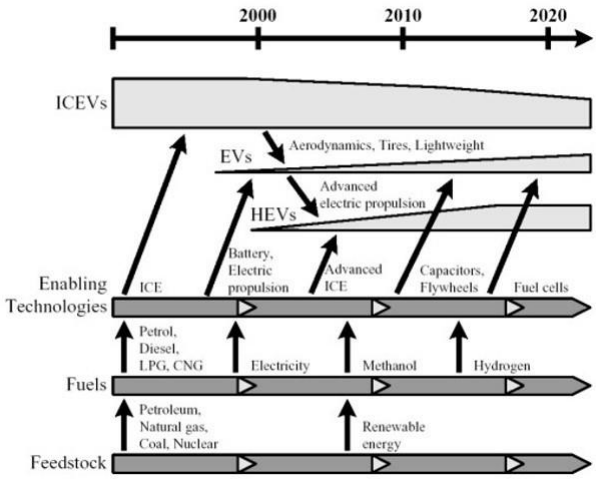


Fig 7: Development trends of EVs and HEVs

Barriers for EVs in the Indian market Barriers for EVs in the Indian market can be addressed from various prospective such as Technical barriers, policy barriers, and lack of infrastructure.

Market – Service and Maintenance
In order to take proper care of the electric car, a trained technician should be available to repair, and provide maintenance of the electric vehicle. They must be able to apply their skills to rectify the problem as quickly as possible.
1. High capital cost
2. Consumer perception
3. Raw materials for batteries

Technical Barriers

1. Battery lifespan/efficiency
2. Driving range of electric vehicle
3. Charging time
4. Safety requirements of electric vehicle
5. Environmental impact

Government Policies

To speed up the Indian electric vehicle revolution, the Government of India is planning to subsidize EVs charging infrastructure in the country. The ministry of power has also recently clarified that the EV charging station requires no license to operate in India, which can boost nationwide EV charging station infrastructure. The Govt. should not only slash applicable rate for Goods and Service Tax (GST) on Li-ion batteries, provide incentives and concessions to EV buyers, but also should provide incentives for shifting the public transport sector to Electric vehicle.

Optimization Method and Objectives

The advanced optimization methods uses for the energy resource allocation are as follows:
1. Mixed-integer linear programming.
2. Mixed-integer programming.
3. Second-order conic programming (Convex Optimization).
4. Markov chain Monte Carlo simulation.
5. Particle swarm optimization and Voronoi diagram.
6. Simulated annealing approach.
7. Quadratic programming.
8. Standard linear programming with the root-mean-square objective function.
The above optimization methods are used in the state-of-the-art research to:
(i) enhance the reliability of the electrical grid using the available energy in the parking lot;
(ii) Maximize EV penetration;
(iii) Minimize total system loss;

(iv)Maximize parking lot owner profit;
(v) Minimize distribution system operator costs;
(vi) Minimize the station energy cost and ESS storage cost; and
(vii) Minimize the distribution power loss

V. Conclusion-

Hybrid, Plug in Hybrid and Electric Vehicles are capable of increasing the fuel economy of vehicles but with an increase in the cost of buying compared to traditional vehicles. In general their decreased consumption of petroleum and increased productivity offers economic benefit to buyers, society, automakers and policymakers over the lifetime. This paper provides a detailed overview of the literature, overview, and guidelines for HEV, PHEV and BEV penetration rate studies into the Indian Market. The recent initiatives and various subsidies by the Indian Government will help push the e-mobility drive in India. The development of a new concept of Vehicle-to-Grid can either deliver power to the grid or can be used to charge the battery when non-conventional energy sources are not available. This technology is an important aspect of energy security, renewable energy, and giving a great scope to deal with global warming issues. This paper provides a summary of an electric vehicle's barriers and problems in the Indian context and is the main novelty of the paper.

VI. References

[1] Jones, W.D., "Hybrids to the rescue [hybrid electric vehicles]", IEEE Spectrum, Vol. 40(1), 2003, pp. 70 – 71.

[2] Jones, W.D., "Take this car and plug it [plug-in hybrid vehicles]", Spectrum, IEEE, Vol. 42, Issue 7, July 2005, pp. 10 – 13.

[3] Hyunjae Yoo; Seung-Ki Sul; Yongho Park; Jongchan Jeong, "System Integration and Power Flow Management for a Series Hybrid Electric Vehicle Using Supercapacitors and Batteries", IEEE Trans. on Industry Applications, Vol. 44, Issue 1, Jan.-Feb. 2008, pp. 108 – 114.

[4] Manishaben Jaiswal, "CRYPTOCURRENCY AN ERA OF DIGITAL CURRENCY", International Journal of Creative Research Thoughts (IJCRT), ISSN:2320-2882, Volume.8, Issue 1, pp.60-70, January 2020, Available at :http://www.ijcrt.org/papers/IJCRT2001010.pdf

[5] Burke, A. (2000), Ultracapacitors : Why, How and Where is the *Technology, Journal of Power Source*, 91, , pp. 37-50

[6] N. Daina , A. Sivakumar , J.W. Polak ," *Modelling electric vehicles use: a survey on the methods, Renew. Sustain. Energy*" Rev. 68 (2017) 447–460 .

[7] Giannakis, E.; Serghides, D.; Dimitriou, S.; Zittis, G.*" Land transport CO2 emissions and climate change*": Evidence from Cyprus. Int. J. Sustain. Energy, (2020), 39, 634–647.

[8] Li, Z.; Khajepour, A.; Song, J. "*A comprehensive review of the key technologies for pure electric vehicles. Energy",* (2019), 182, 824–839.
[9] Gold, R. Status Report on "*Electrification Policy: Where to Next? Curr. Sustain./Renew. Energy"* Rep. (2021), 8, 114–122.
[10] Molyneaux, L. Queensland "*Energy Storage Manufacturing Plan 2020; Centre for Policy Futures*", The University of Queensland: Brisbane, Australia, 2021.

[11] Bozhkov, S. "*Structure of the Model of Hybrid Electric Vehicle Energy Efficiency. Trans. Motauto World"* (2021), 6, 76–79.