Electric Vehicles

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- A hybrid electric vehicle (or HEV for short) is a vehicle without the capacity to plug in but has an electric drive system and battery. It's driving energy comes only from liquid fuel.
- A plug-in hybrid electric vehicle (also called a PHEV) is a vehicle with plug-in capability, and it can use energy for driving from either its battery or liquid fuel.
- An all-electric vehicle (often called a battery-electric vehicle (BEV), an electric vehicle, or an EV or AEV for short) is a vehicle that gets its energy for driving entirely from its battery and it must be plugged in to be recharged.

- A plug-in electric vehicle (or PEV) is any vehicle that can be plugged in (either a plug-in hybrid or an all-electric vehicle).

Parameters	Petrol car	Diesel car	CNG Car
Fuel price	High	Lower than petrol	Low
Car price	More affordable than diesel and CNG cars.	More expensive than petrol and CNG cars.	More expensive than petrol cars, but affordable compared to diesel cars.
Performance	It offers good performance with better pickup than diesel and CNG cars.	Slower initial acceleration but offers good top-end performance.	Lower power output than petrol and diesel cars. Also, you may experience a slight lag in power delivery.
Comfort	Petrol engines are refined, and the NVH (Noise, Vibration, Harshness) levels are low inside the car. Hence, they offer a comfortable driving experience.	Diesel engines are less refined than petrol engines. Hence, the NVH levels are higher inside the cabin.	Since CNG cars run on petrol-compatible engines, the refinement is on par with petrol cars.
Boot space	Spacious	Spacious	It is non-existent since the CNG fuel tank eats up the boot space, which may not be practical for long drives.
Mileage	Lower than CNG and diesel cars.	Higher than petrol cars, but lower than CNG cars.	Higher than petrol and diesel cars.
Running cost	High	Lower than petrol cars, but higher than CNG cars.	Low

Maintenance cost	Higher than CNG cars but lower than diesel cars.	High	Higher than petrol and diesel cars due to the fitment of a CNG kit.
Environmental friendliness	It is not environment-friendly as the exhaust gas comprises carbon monoxide.	It produces carbon emissions.	They are environment-friendly as the fuel is completely combustible and produces clean emissions.
Fuel availability	Easily available	Easily available	CNG fuel stations are not as easily available as petrol or diesel fuel stations.
Engine life	Lower than diesel engines.	Diesel engines last longer than petrol engines.	The engine life is similar to that of petrol engines.

Comment on environment friendliness

- traditionally diesel engines have been known to emit more harmful pollutants like nitrogen oxides (NOx) and particulate matter (PM) than petrol engines.
- However, advancements in technology have reduced the gap, particularly in newer diesel models with particulate filters.

E-mobility

- E-mobility, or electric mobility, refers to the use of electric power to operate vehicles, including cars, buses, trucks, and other forms of transportation. It encompasses the entire ecosystem of electric vehicles (EVs), charging infrastructure, and related technologies.

- EVCI (Electric Vehicle Charging Infrastructure)
- EVCS (Electric Vehicile Charging Station)

News Articles

https://www.qualcomm.com/news/onq/2017/05/wireless-dynamic-ev-charging-evolution-qualcomm-halo

https://www.autoevolution.com/news/forget-the-apple-car-this-could-be-microsoft-s-car-229644.html

News Articles

- https://www.wired.com/story/electric-cars-qualcomm-apple/
- https://www.qualcomm.com/news/releases/2025/01/qualcomm-s-snapdragon-digital-chassis-solutions-power-mahindra-s
- https://www.pwc.com/us/en/industries/industrial-products/library/electric-vehicles-supply-chain.html

- https://kpmg.com/in/en/blogs/2024/04/india-strides-towards-faster-ev-adoption.html

Linkedin Post of Mahindra University

Celebrating the 2023–2025 M.Tech Batch in Autonomous Electric Vehicles!

I am happy to congratulate all my students from the M.Tech (Autonomous Electric Vehicle) program, Batch 2023–2025, on successfully graduating with 100% placements and higher studies in top institutions.

🌟 Special applause to our batch topper, Mr. Firoz, with an exceptional 9.02 CGPA!

Placement & Higher Studies Highlights:

1. Firoz – HBL Power Systems, Hyderabad
2. Usha – HBL Power Systems, Hyderabad
3. Rama Krishna – HBL Power Systems, Hyderabad
4. Mahesh – Silov Solutions Private Limited, New Delhi
5. Gowthami – HBL Power Systems, Hyderabad
6. Chandrakala – Enrolled for PhD
7. Jagadeesh – OhM, Hyderabad
8. Vaibhav – Tata Motors, Pune
9. Abeeb – University of Southern California (Higher Studies)
10. Imran Ansari – Entrepreneur (Own Business)

History

- Electric vehicles have a surprisingly long history, predating the widespread adoption of gasoline-powered cars.
- While modern EVs are often associated with recent advancements, their roots trace back to the early 19th century, with prototypes and practical electric vehicles emerging throughout the 1800s.

- Here's a brief overview:
- Early Innovations (1828-1880s):

1828:

- Hungarian priest Ányos Jedlik created a small electric motor, a precursor to electric vehicles.

1830s:

- Scottish inventor Robert Anderson built a crude electric carriage powered by non-rechargeable primary cells.

- In 1834, the first non-rechargeable battery operated EV (tricycle) was built by Thomas Davenport.
- After invention of lead-acid battery, a rechargeable battery based EV was built by David Salomons in 1874.
- Twelve years later, first electric trolley systems was built by Frank Sprague in 1886.

- In 1900, among 4200 automobiles sold in USA, 38% were EV, 22% were ICEV and 40% Steam powered vehicles.

- Several companies in US, England and France made EVs by 1900.
- Electric Carriage and Wagon Company, US [1894] 'Electrobat'
- Pope manufacturing Company, US [500 EVs by 1898] 'Columbia'
- Riker Electric Motor Company, US 'Victoria' [1897]
- London Electric Cab Company, England [started 1897].
- Bouquet, Garcin and Schivre (BGS), France [1899-1906].
  - BGS EVs in 1900 had world record of 290 Km/charge.
- An EV named 'Jamais Contente' captured a record of 110 Km/Hr in May, 1899.

EVs disappeared by 1930s.

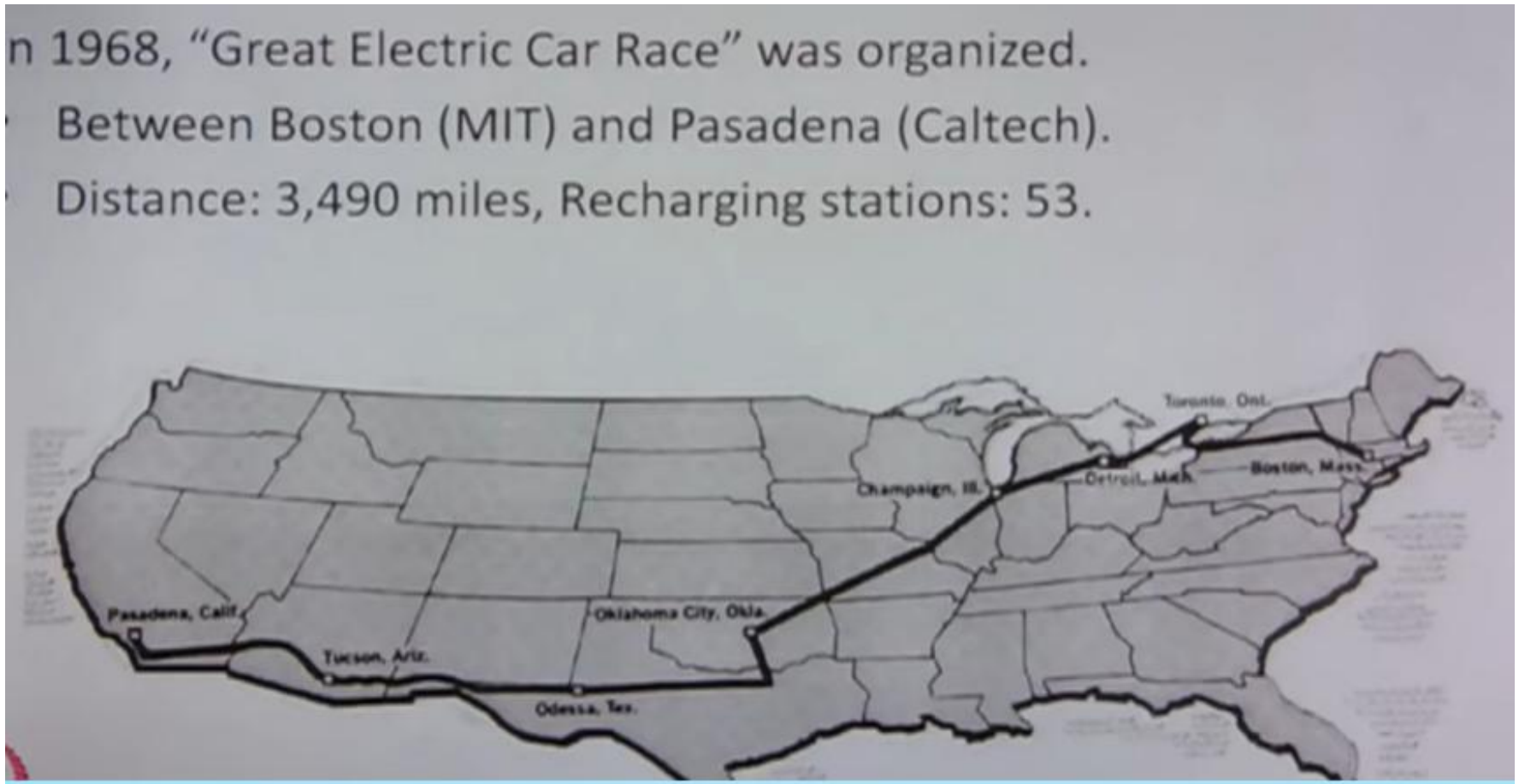
- First Development was that, Henry Ford mass produced 'Ford Model T' in 1925, and reduced its price by over $1/3^{rd}$ to its price in 1909.
  - This made EVs costlier compared to ICEV.
- The second development was invention of automobile starter motor, by Charles Keetering, that helped remove manual cranking required in ICEV, and enabled electric ignition and start.
  - This made ICEV user friendlily compared to EVs.

Reasons that led resurgence of EVs in 1970s.

- The Arab oil embargo of 1973 increased demands for alternate energy sources
- Increased air pollution led to worst smog in London in 1950s and in California in 1960s/70s retriggered strict emission regulations .
  - In 1976, Congress enacted Public Law 94–413, the Electric and Hybrid Vehicle Research, Development and Demonstration Act. This act authorized a federal program to promote electric and hybrid vehicle technologies and to demonstrate the commercial feasibility of EVs.
  - In 1990, California Air Resource Board (CARB) established rules that 2 % of all vehicles sold in California in 1998 should be ZEV (zero emission vehicles) and it should be 10 % by 2003.

n 1968, “Great Electric Car Race” was organized.

- Between Boston (MIT) and Pasadena (Caltech).
- Distance: 3,490 miles, Recharging stations: 53.



- Many automakers especially in US, Japan and Europe started development of EVs.
  - In US, General Motors, Ford, Chrysler, US Electricar and Solectria etc.
  - In Japan, Toyota, Nissan, Honda, Mazda, Daihatsu, Mitsubishi, Suzuki, Isuzu, Subara etc.
  - In Europe, PSA Peugeot, Renault, BMW, Mercedez-Benz, Audi, Volvo, Opel, Volkswagen, Fiat, Bedford etc.

- GM built number of experimental EVs, such as Electrovair in 1966, Electrovan in 1968, Electrovette in 1979 etc.
  - SCR based SE DC Motor, with Ni-Zn Batteries, 60 miles/Hr, 80 Km range.

- Ford EV projects resulted in Fiesta EV, Escort EV, Aerostar, Ecostar etc in 1970s.
- Nissan development work includes EV-4, EV-Resort, President EV and Cedric-EV in 1970s/80s.
- Toyota produced series in EVs named EV-10 to EV-40 in 1980s.
- Fiat experimental EVs were X1/23, Y10 in 1980s and Elettra in 90s.
- BMW produced early convertibles such as E30E, E36E in early 90s and E1 in mid 90s.

- Popular EVs in 1990s/Early 2000
  - GM EV1 [100 KW, IM, VRLA, 0-100 km/hr in 9 sec, 144 Km]
  - Nissan Altera EV [62 KW, PMSM, Co-Li, 120 km/hr, 192 Km]
  - NIES- Luciole [72 KW, In-Wheel PMSM, VRLA, 130 Km/Hr, Solar]
  - HKU-U2001 [45 KW, PMSM, Ni Cd, 110 Km/Hr, 176 Km]
  - Reva Etc. [13 KW, SE DC, VRLA, 65 Km/Hr, 80 Km]
- Popular HEVs in 1990s
  - Toyota Prius [52 KW ICE, 33 KW PMSM, Ni mH, 160 Km/hr]
  - Honda Insight Etc. [50 KW ICE, 10 KW PMSM, Ni mH, 26-30 Km/L]
- Popular FCEV in 1990s/Early 2000
  - Ford P2000
  - Daimler-Benz NECAR-3 Etc.

- Current Popular EVs
  - Tesla Roadstar (2007), Model-S(2012), Model-X(2015), Model-3(2017)
  - Nissan Leaf
  - Chevy Bolt
  - BMW i3 Etc.
- Current Popular HEVs are mostly PHEVs variants.
  - Honda Accord hybrid
  - Toyota Camry, Prius hybrid
  - Ford Fusion hybrid
  - Lexus RX 450h
  - Volvo XC60 T8
  - BMW 740e xDrive Etc.

- https://www.energy.gov/articles/history-electric-car
- https://en.wikipedia.org/wiki/History_of_the_electric_vehicle

- https://www.fool.com/research/largest-ev-companies/
- https://www.wri.org/insights/countries-adopting-electric-vehicles-fastest

Indian Manufacturers

- Tata Motors
- Bajaj Auto
- Ather Energy
- Mahindra and Mahindra
- Ola Electric
- Hero Electric Vehicles
- Greaves Electric Mobility

Autonomous Cars

- An autonomous car is a vehicle capable of sensing its environment and operating without human involvement.
- A human passenger is not required to take control of the vehicle at any time, nor is a human passenger required to be present in the vehicle at all.
- An autonomous car can go anywhere a traditional car goes and do everything that an experienced human driver does.

ADAS

- **Advanced driver-assistance systems** (**ADAS**) are technologies that assist drivers with the safe operation of a vehicle.
- Through a human-machine interface, ADAS increases car and road safety.
- ADAS uses automated technology, such as sensors and cameras, to detect nearby obstacles or driver errors and respond accordingly.
- ADAS can enable various levels of autonomous driving.

Monitoring and Assistance

- Adaptive Cruise Control
- Anti-lock braking system
- Collision avoidance systems
- Lane Centering
- Electric Vehicle monitoring
- Wrong-way driving warning

And many more

- According to a 2021 research report from Canalys, approximately 33 percent of new vehicles sold in the United States, Europe, Japan, and China had ADAS
- ADAS are categorized into different levels based on the amount of automation and the scale provided by The Society of Automotive Engineers (SAE)

LEVELS OF DRIVING AUTOMATION

0	1	2	3	4	5
NO AUTOMATION	DRIVER ASSISTANCE	PARTIAL AUTOMATION	CONDITIONAL AUTOMATION	HIGH AUTOMATION	FULL AUTOMATION
Manual control. The human performs all driving tasks (steering, acceleration, braking, etc.).	The vehicle features a single automated system (e.g. it monitors speed through cruise control).	ADAS. The vehicle can perform steering and acceleration. The human still monitors all tasks and can take control at any time.	Environmental detection capabilities. The vehicle can perform most driving tasks, but human override is still required.	The vehicle performs all driving tasks under specific circumstances. Geofencing is required. Human override is still an option.	The vehicle performs all driving tasks under all conditions. Zero human attention or interaction is required.

THE HUMAN MONITORS THE DRIVING ENVIRONMENT

THE AUTOMATED SYSTEM MONITORS THE DRIVING ENVIRONMENT

- V2G
- G2V
- V2V
- V2X
- V2I
- V2P
- V2N

IOT enabled Vehicle

- IOT- Internet of things
- Using internet to communicate
- AI/machine learning

Smart Charging

- **Real-time Monitoring:**
- IoT enables remote monitoring of charging station status, energy consumption, and equipment health.
- **Optimized Charging Schedules:**
- IoT platforms can integrate with power distribution networks to optimize charging schedules, balancing grid loads and reducing energy costs.
- **Vehicle-to-Grid (V2G) Capabilities:**
- IoT enables EVs to communicate with the power grid, allowing them to potentially feed energy back into the grid during peak demand.
- **Demand Response:**
- IoT helps manage EV charging during peak hours, potentially incentivizing users to charge during off-peak times.
- **Renewable Energy Integration:**
- IoT can integrate EV charging stations with renewable energy sources like solar panels, optimizing the use of green energy.

Enhanced User Experience

- **Real-time Information Access:**
- Drivers can access real-time data about their vehicle's charging status, battery range, and performance through smartphone apps or vehicle dashboards.
- **Improved Navigation and Journey Planning:**
- IoT facilitates finding nearby charging stations, planning routes with charging stops, and optimizing travel based on available charging infrastructure.
- **Remote Management and Control:**
- IoT allows for remote management of charging stations, enabling personalized services and addressing issues promptly.
- **Data-driven Insights:**
- IoT systems collect vast amounts of data, which can be used to generate efficiency reports, improve decision-making, and personalize services.

Predictive Maintenance and Diagnostics

- **Predictive Maintenance:**
- IoT can analyze vehicle data to predict potential maintenance needs, reducing downtime and improving reliability.
- **Remote Diagnostics:**
- IoT enables remote diagnostics, allowing technicians to troubleshoot issues and resolve problems quickly

Cyber Security

- Cyber-Physical Systems
- **Secure Communication:**
- IoT systems in EVs require robust cybersecurity measures to protect data and prevent unauthorized access.
- **V2G Security:**
- V2G systems need to be designed with strong security protocols to prevent potential cyberattacks.