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**Research Article**

# "The Road Ahead: Exploring The Paradigm Shift From Petrol Cars To Electric Vehicles"

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**ABSTRACT**

The study aims to investigate the transition from traditional Petrol cars to electric vehicles (EVs) and the resulting paradigm shift in the automotive industry. The abstract provides a concise overview of the study's objectives, research methodology, key findings, and implications for future developments in sustainable transportation. The automotive industry is on the cusp of a major paradigm shift. For over a century, the world has depended on fossil fuel-powered cars as the primary mode of transportation. However, there has been a significant push towards electric vehicles (EVs) as a sustainable alternative. This shift from traditional fossil fuel cars to electric vehicles represents a damaging change with respect to transportation. It not only promises cleaner air and reduced carbon footprints but also presents opportunities for innovation and technological advancements in the automotive sector. In this paper, we will delve into the road ahead for electric vehicles and explore the factors driving this paradigm shift. We will examine the environmental benefits of EVs and the challenges dealt to ensure their widespread adoption. Furthermore, we will consider the economic implications of this transition, including job creation and the impact on global energy markets. Additionally, we will assess the readiness of the infrastructure required to support electric vehicles, including charging stations and battery technology advancements. The role of government policies and incentives is also dealt which helps in promoting the adoption of EVs and fostering a sustainable transportation system. Throughout this paper, we will analyse industry trends, consumer attitudes, and technological developments that are shaping the future of electric vehicles. By gaining a comprehensive understanding of this paradigm shift, we hope to contribute to the ongoing discourse surrounding sustainable transportation and create the way for a greener future

**(Keywords:** Automotive, Implications, sustainability, transition, Fossil fuel car, Electric vehicle car)

## Introduction:

Climate change or global warming has been always in concern and issue of global warming has been discussed and concern raised by the government of many countries. Since by early 21st century many relevant reports have revealed the negative numbers which were of climate change which were dominantly driven by the human activities. Due to globally increasing population, industrialization and large number of fossil fuel burning in industries has led to air pollution.

As India is also facing the air pollution problem which is increasing year by year, the main causes which led to increase in air pollution were poor fuel quality, old vehicles which are still running on roads, congested traffic in cities and poor road traffic management system. The major pollutants, emitted by the automobiles are hydrocarbon, nitrogen dioxide, lead, carbon monoxide, Sulphur dioxide and particulate matter. The reason behind the air pollution in India is its gigantic automobile industry and hence it is very difficult to control air pollution. India has world's 4th largest industry in the world.

The automobile industry should focus on Research and Development all over the global and shift from their crude oil powered vehicles. But from past two decades electric vehicle has been an attraction as compared with the traditional vehicle powered by crude oil, for example tesla model 3, tesla model x, has attracted lot of customers and has captured a quite decent amount of market share. As environmental concerns have increased

among people due to increased exploitation caused by the crude powered vehicle and there has been limited conventional sources which can lead to shift to electric vehicles from crude powered vehicles. Many companies like General Motors, Honda, Tesla, Toyota, Jaguar, Ford, Volkswagen, Mercedes, and Indian companies like Tata and Mahindra have started the mass production of electric and hybrid vehicle to eliminate the issue caused by the fully gasoline or crude oil engine powered vehicles.

As with recent reports Norway, Iceland, and Sweden has the highest rate of purchasing electric vehicle and compared with gasoline powered vehicle, with the purchasing rate of 86% Norway, 72% Sweden and 43% Iceland all this has been achieved just because by implementation of tax exemption VAT and Import which were introduced in 1990's. This sector is driven by the internal combustion engines which is moving towards electrical vehicle. These vehicles are energy efficient as well as they generate less greenhouse gases (GHG) which follow the emission and reduction in the cabin noise also. The different types of EV's are: -

- HEV (Hybrid Electric Vehicle): -Hybrid electric vehicles (HEVs) uses an internal combustion engine (typically fueled by gasoline or diesel) with an electric propulsion system. This combination allows for improved fuel efficiency, reduced emissions, and sometimes enhanced performance. Here are some key features of Hybrid Electric Vehicles:

- Dual Power Sources: HEVs have both combustion engine (usually gasoline) and an electric motor. These two power sources work together to optimize fuel efficiency and reduce emissions.
- Regenerative Braking: HEVs use regenerative systems to capture and convert kinetic energy into electricity during braking or coasting. This energy is then stored in the vehicle's battery and can be used to assist the electric motor.
- Automatic Start-Stop System: HEVs often feature an automatic start-stop system, which shuts off the internal combustion engine when the vehicle is stationary (e.g., at traffic lights) and restarts it when the driver accelerates. This helps save fuel and reduce emissions during idling.
- Power Split or Series/Parallel Architecture: HEVs can have different architectures, such as series, parallel, or power-split configurations. Each design optimizes the use of the internal combustion engine and electric motor in various driving conditions to enhance efficiency.
- Battery Pack: Hybrid vehicles come equipped with a battery pack to store and supply electric energy to the motor. These batteries are generally smaller than those in plug-in hybrid or electric vehicles but play a crucial role in supporting the electric motor.
- Fuel Efficiency and Emissions Reduction: The integration of electric propulsion helps improve fuel efficiency by allowing the internal combustion engine to operate more efficiently and reducing fuel consumption. This, in turn, leads to lower greenhouse gas emissions.
- Seamless Transition between Power Sources: HEVs are designed to seamlessly transition between the internal combustion engine and the electric motor, providing a smooth and efficient driving experience. The transition is often automatic and imperceptible to the driver.
- Maintenance Benefits: The regenerative braking system in HEVs can contribute to reduced wear on traditional braking components, potentially leading to lower maintenance costs compared to conventional vehicles.
- Reduction in Noise and Vibration: The electric motor in HEVs can operate at lower speeds, contributing to reduced noise and vibration during low-speed driving. This can enhance the overall comfort and driving experience.
- Widespread Availability: HEVs are commercially available from various automakers and come in different vehicle types, including sedans, SUVs, and hatchbacks. This availability provides consumers with a range of options to choose from based on their preferences and needs.

- PHEV (Plug – in hybrid electric vehicle): - Plug-in Hybrid Electric Vehicles (PHEVs) combine an internal combustion engine with an electric motor and a larger battery pack than traditional hybrid vehicles. Here are key features of Plug-in Hybrid Electric Vehicles:

Dual Power Sources: PHEVs have both an internal combustion engine (often gasoline) and an electric motor, similar to traditional hybrid vehicles. However, PHEVs have larger battery packs and can be plugged into an external power source for charging.

- All-Electric Range (AER): PHEVs can operate in all-electric mode for a certain distance, known as the All-Electric Range (AER). The AER varies among models but generally allows for short commutes or local trips to be completed solely on electric power before the internal combustion engine is needed.
- Plug-in Charging: PHEVs can be charged by plugging them into an electric power source, such as a standard household outlet or a dedicated electric vehicle (EV) charging station. This charging capability allows the vehicle to operate in electric-only mode, reducing reliance on the internal combustion engine.
- Regenerative Braking: Similar to traditional hybrid vehicles, PHEVs use regenerative braking systems to capture and convert kinetic energy into electricity, which is then stored in the battery. This helps improve overall energy efficiency and extends the electric driving range.
- Gasoline-Powered Range Extender: When the battery charge is depleted or additional power is needed, the internal combustion engine serves as a range extender in PHEVs. This allows for longer trips, and the vehicle

operates in a hybrid mode, combining the power from both the engine and the electric motor.

- Battery Capacity: PHEVs have larger battery packs compared to traditional hybrids, allowing for a more extended electric-only driving range. Battery capacities vary among models, influencing the AER and overall vehicle efficiency.
- Charging Time: The charging time for PHEVs depends on the charging infrastructure and the battery capacity. Charging times can range from a few hours with Level 2 chargers to longer durations with standard household outlets.
- Hybrid Modes: PHEVs offer different driving modes, including all-electric mode, hybrid mode (utilizing both the electric motor and the internal combustion engine), and sometimes a "hold" mode, which allows the driver to conserve electric power for later use.
- Reduced Fuel Consumption: The ability to operate in all-electric mode for shorter trips contributes to reduced fuel consumption and lower greenhouse gas emissions compared to traditional vehicles, especially when the electric grid is powered by renewable energy sources.
- Government Incentives: Government offer incentives, such as tax credits or rebates, to encourage the acceptance of PHEVs. These incentives aim to promote the use of electric vehicles and reduce the environmental impact of transportation.
- Smart Charging and Connectivity: Some PHEVs come equipped with smart charging features and connectivity, allowing users to schedule charging times, monitor energy usage, and control certain vehicle functions remotely via smartphone apps.
- Environmental Benefits: PHEVs contribute to reduced air pollution and greenhouse gas emissions, especially when operating in electric-only mode. The environmental impact depends on the electricity mix used for charging.

PHEVs offer a flexible solution for drivers who want to experience electric driving with the added convenience of a gasoline-powered range extender for longer journeys. The combination of electric and internal combustion power provides versatility in various driving scenarios.

BEV (Batteries electric vehicle): - Battery Electric Vehicles (BEVs) are a type of electric vehicle that runs entirely on electric power stored in rechargeable batteries. Here are some key features of Battery Electric Vehicles:

- Zero Emissions: BEVs produce no tailpipe emissions, contributing to a cleaner environment and reduced air pollution.
- Electric Motor: BEVs are powered by an electric motor that is driven by electricity stored in a battery pack. This motor drives the wheels, providing propulsion.
- Battery Pack: BEVs use large battery packs to store and provide electric energy to the motor. These batteries are usually lithium-ion, and advancements in battery technology are improving energy density, range, and charging times.
- Charging Infrastructure: BEVs require charging infrastructure for recharging their batteries. This can include home chargers, workplace charging stations, and public charging stations.
- Range: The driving range of a BEV refers to the distance the vehicle can travel on a single charge. Range can vary widely, with newer models offering longer ranges as battery technology improves.
- Silent Operation: BEVs operate more quietly than traditional vehicles since electric motors produce less noise than internal combustion engines. Some models include simulated sounds at low speeds to alert pedestrians to the vehicle's presence.
- Incentives: Many governments offer incentives to encourage the adoption of BEVs, such as tax credits, rebates, and access to carpool lanes.
- Smart Features: BEVs often come with advanced technologies and smart features, including smartphone apps for remote monitoring and control, over-the-air software updates, and integration with smart home systems.
- Environmental Impact: While BEVs produce no tailpipe emissions, the overall environmental impact is reduced with respect to production and disposal.
- Performance: BEVs are known for their instant torque delivery, providing quick acceleration and responsive performance.
- As technology advances, the features of Battery Electric Vehicles continue to evolve, addressing challenges such as range anxiety, charging infrastructure, and overall cost to make them more viable for a wider range of consumers.

Current Finance Minister Nirmala Sitharaman made several announcements in 2023 budget. In several announcements, one announcement was related to electric vehicles. Which was the tax exemption related to capital good which were imported related to electric vehicle batteries.

Cost effectiveness of Electric Vehicle over Petrol Vehicle is the battery used that many individuals face when it comes to owning an electric vehicle and maintenance of the vehicle is the other reason.

## Literature Review: -

Many studies have been done to understand adoption of EV's. Factor studied are the cost of the EV, driving distance per charge, how much time is taken by the battery to get fully recharge, availability of charging points and cost of the battery. Government and other private companies should focus on the charging infrastructure. The literature review and paper covers the following topics: (1) How much cost effective are electric vehicle as compared with gasoline powered vehicles. (2) How many types of electric vehicle system are there. (3) How much EV vehicle are effective to environment (4) What are the drawbacks of EV vehicle and its probable solutions. Possibility will be there in the paradigm shift towards EV's replacing Gasoline powered vehicle, if solved then it well be most widespread acceptance of alternate powered vehicles.
Here is a list of key literature on electric vehicles up to that point:

- "Introduction to Electric Vehicle Technology" by M. C. Vesapogu: An introductory book that covers the basics of electric vehicle technology, including power electronics and energy storage.
- "Electric Vehicle Integration into Modern Power Networks" by Sumedha Rajakaruna, Farhad Shahnia, and Arindam Ghosh: This publication explores the integration of electric vehicles into power systems, addressing challenges and opportunities.
- "Electric Vehicle Battery Systems" by Sandeep Dhameja: Focuses on the battery systems used in electric vehicles, covering design, implementation, and management.
- "The Electric Vehicle Conversion Handbook" by Mark Warner: A practical guide for individuals interested in converting traditional vehicles into electric vehicles, covering the conversion process and components.
- "Plug-in Electric Vehicles: What Role for Washington?" by Paul Bledsoe: An analysis of policy considerations and the role of government in the promotion and adoption of plug-in electric vehicles.
- "Electric Vehicle Business Models: Global Perspectives" by David Beeton: Examines various business models related to electric vehicles, providing insights into the industry's evolving landscape.
- "Handbook of Electric Vehicles" edited by Joeri Van Mierlo, C. C. Chan, and M. L. Kuang: A comprehensive handbook that covers various aspects of electric vehicles, including technology, policy, and market trends.
- "Charging the Future: The Power and Promise of Electric Vehicles" by Alex Keros and Edward Kummer: Explores the future of electric vehicles, discussing advancements, challenges, and the societal impact of widespread adoption.

These books cover a broad spectrum of topics related to electric vehicles, including technology, policy, sustainability, and market trends. It's advisable to check for more recent publications for the latest developments in this rapidly evolving field.

## Objective: -

- To know how much cost effective is EV car than Fossil Fuel car in running and maintenance.
- To know the type of EV System available.
- To know how much EV vehicle will affect to environment.
- To know the various challenges of EV vehicle and its solutions.

## Research Methodology:

The secondary data has been collected from various publications such as journals, articles, research paper, which has been published by private and government institutions. The primary data has been done through via questionnaire which was done in google form and total 81 responses has been collected from the respondents.

- **Research Design-** This research consists of descriptive research study which has been focused on, future of EV vehicle in next 5 years, different technologies of EV, cost effective in running and maintenance of EV as compared with Fossil Fuel car, effective to environment, drawbacks and problem with EV cars and favourite EV car.

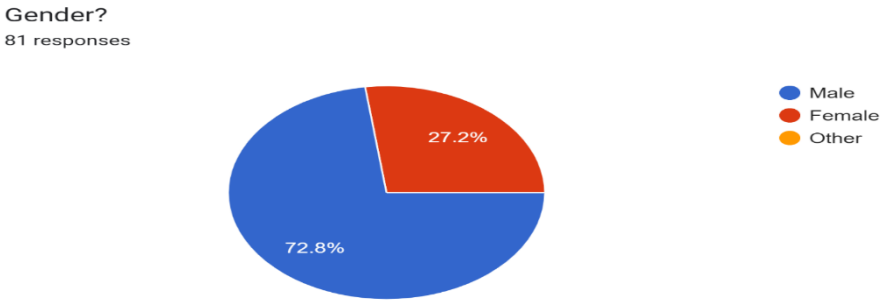
- **Sample Size-** 81 responses have been collected.
- **Sampling Design-** Convenience Sampling has been used. Responses are collected with the help of Google Forms.
- **Data Collection Tool-** Questionnaire

### Limitation of the Research: -

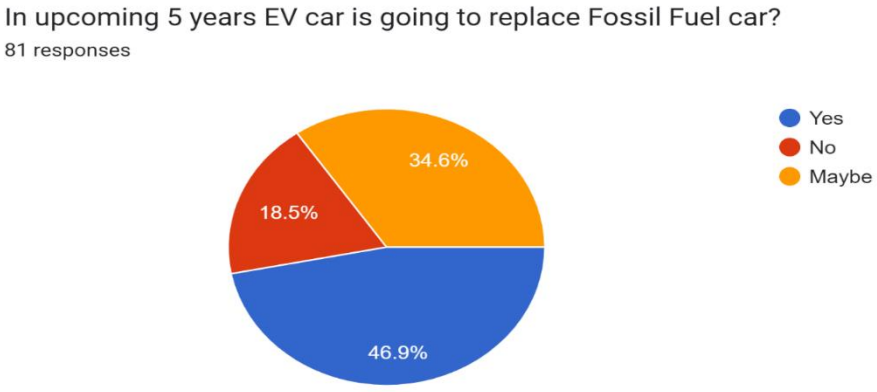
- Responses are collected from Mumbai and from outside of Mumbai also because some are residing in Mumbai and some are not.
- Responses which has received from respondents are some from Tier 1, Tier 2 cities and Tier 3 cities.

- Limited people has purchased the EV Car. So less responses has from the respondents who are using the EV Car.

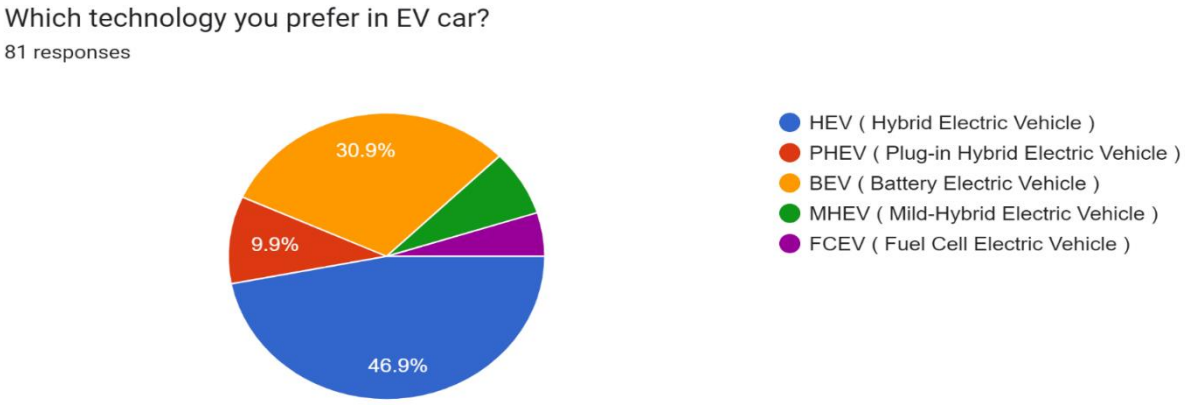
## Data analysis and Fin dings:-



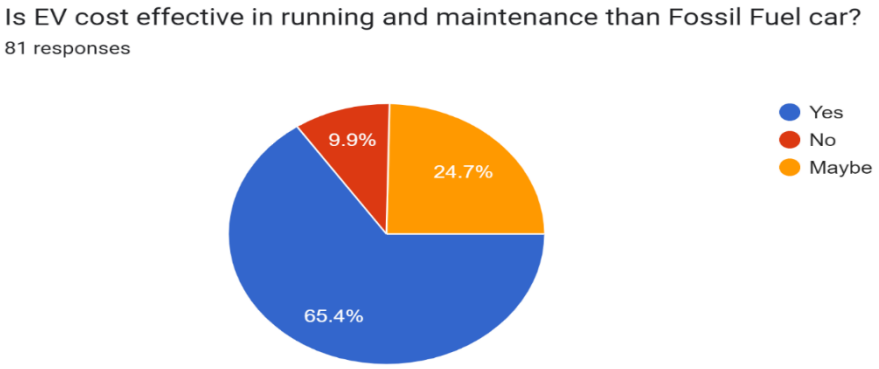

**Interpretation-** As the above pie chart shows that how many respondents has filled the responses, which are 72.8% males and 27.2% females which total comprises 81 respondents.
**Inference-** As majority of respondents are males which are 59 with 72.8%.



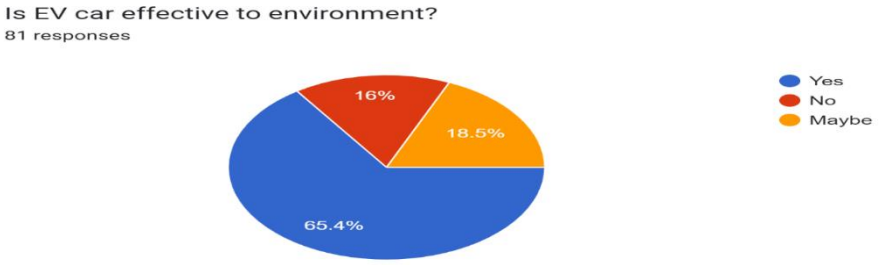

**Interpretation-** Out of 81 responses, 38 respondents has said Yes which is 46.9%, 15 respondents has said No which is 18.5% and 28 respondents has said Maybe which is 34.6% because Maybe respondents are still confuse that in upcoming 5 years EV cars can replace the Fossil Fuel car and also cannot replace the Fossil Fuel car.
**Inference-** As majority of respondents has said Yes which 46.9% that in upcoming 5 years EV cars can replace the Fossil Fuel car.



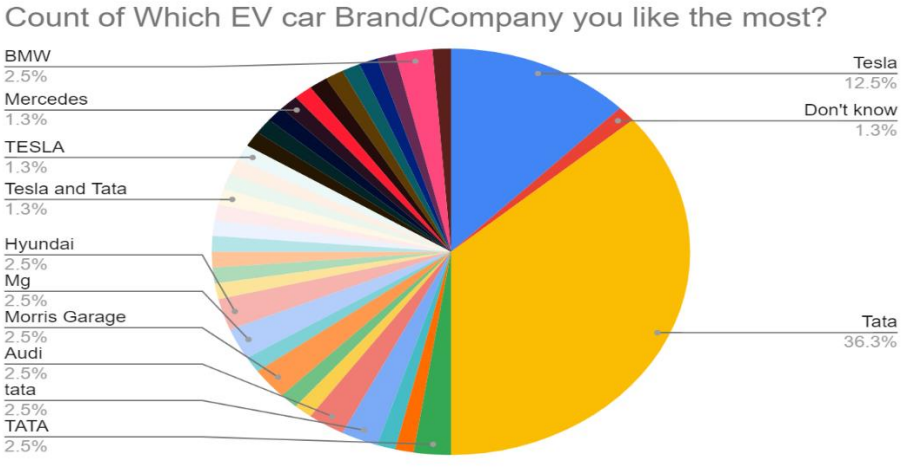
**Interpretation-** As the above Pie Chart shows that respondents are divided into five groups which are HEV, PHEV, BEV, MHEV, FCEV. In HEV 46.9% respondents are which are 38, PHEV 9.9% respondents which are 8, BEV 30.9% respondents which are 25, MHEV 7.4% respondents which are 6, FCEV 4.9% respondents which are 4.
**Inference-** Majority of respondents are going with the HEV since 46.9% which are 38, they have opted for HEV.




**Interpretation-** As the above the Pie Chart shows the purpose that EV car are cost effective in running and maintenance which shows 65.4% respondents are saying Yes which are 53 respondents, 9.9% are saying No which are 8 respondents, 24.7% respondents are going with 24.7% which are 20 respondents because they are confuse that EV cars are cost effective in running and maintenance or not.
**Inference-** 65.4% which is 53 respondents with the majority agrees to that EV car are cost effective in running and maintenance.

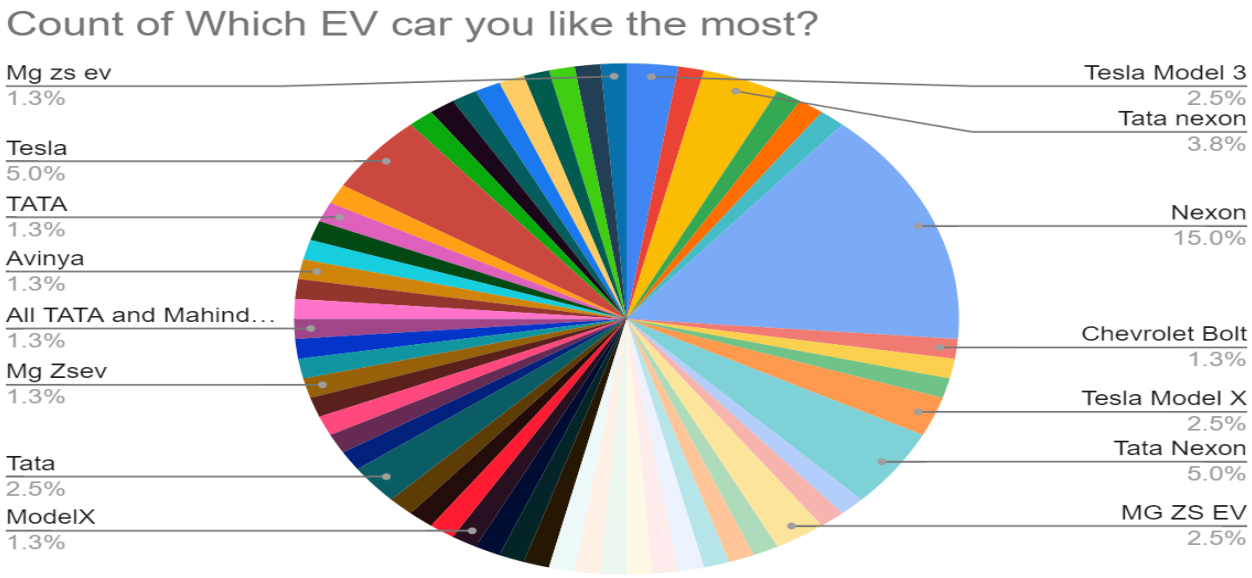



**Interpretation-** Out of 81 responses, 65.4% responses are saying Yes which are 53 respondents, 16% responses are saying No which are 13 respondents, 18.5% are saying Maybe which are 15 respondents because they are confused between that EV car is effective to the environment or not.
**Inference-** As we see the that majority of respondents which is 65.4% which are 53 respondents, that are agreeing EV car is effective to environment.



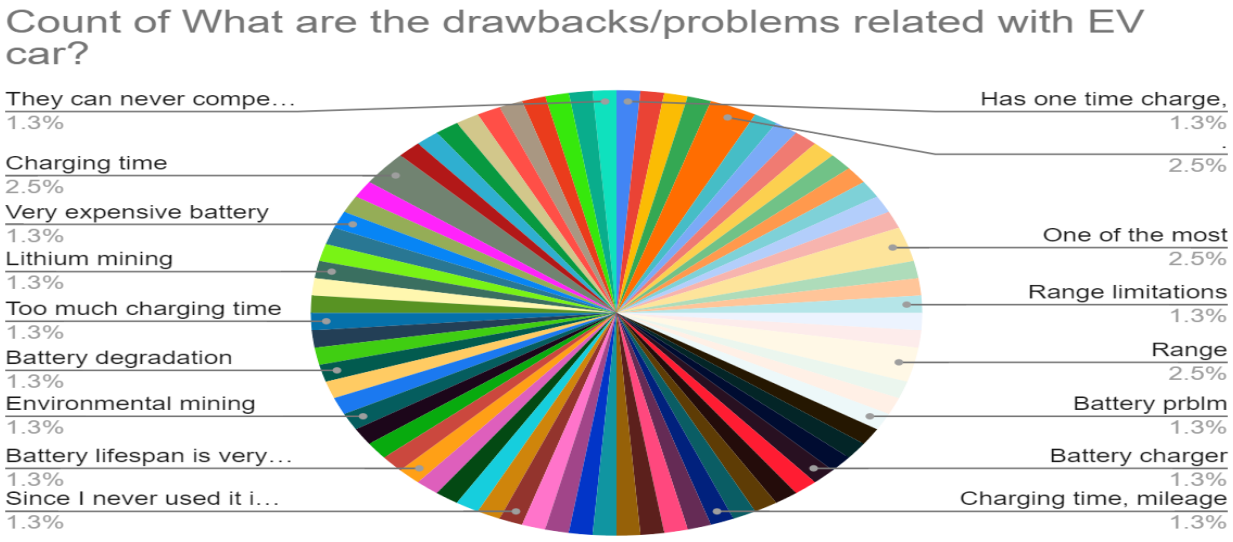
**Interpretation-** As the above the Pie Chart shows that respondents are liking the different brands like BMW, Mercedes, TESLA, TATA, Hyundai, MG, Audi. In percent we can see that BMW with 2.5% which is around 2 respondents, Mercedes with 1.3% which is around 1 respondents, TESLA combing all except Tesla and Tata are 13.8% which is around 11 respondents, Tesla and Tata with 1.3% which are around 1 respondents, Audi with 2.5% which are around 2 respondents, MG combing all together 5% which is around 4 respondents, Hyundai with 2.5% which is around 2 respondents, Tata combing all together which is with majority around 41.3% which is around 33 respondents and don't are 1.3% which is around 1 respondents.

**Inference-** Majority of respondents are liking the TATA brand with 41.3% which are around 33 respondents.

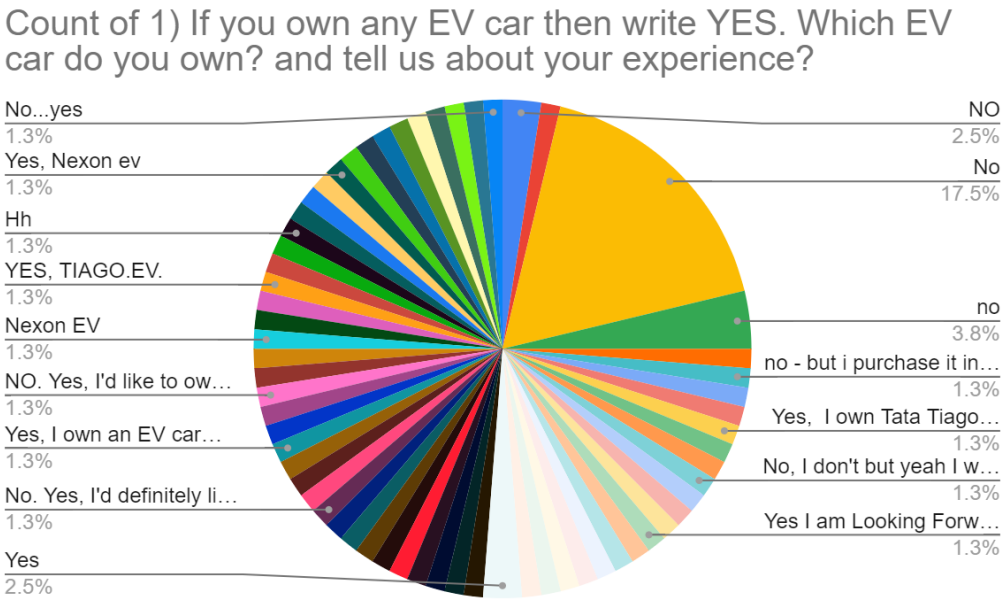



**Interpretation-** As the above Pie Chart shows that respondents are liking the EV car most as per their choice which are MG ZS EV, TATA Nexon, TATA and Mahindra, Chevrolet Bolt, Avania. In percent we can see that combing all TESLA which is 11.3% with 9 respondents, MG ZS EV combing all which is 5.1% with 4 respondents, Avinya which is 1.3% with 1 respondent, Chevrolet Bolt which is 1.3% with 1 respondent, all TATA and Mahindra which is 1.3% with 1 respondent, TATA combing all together which is 27.6% with 22 respondents.

**Inference-** Majority of respondents are going with TATA which 27.6% with 22 respondents that they like TATA cars more.



**Interpretation-** As the above Pie Chart shows that the respondents have highlighted the drawbacks or problem related with EV car which are shorter range, charging infrastructure, battery life, car burning issues, safety is concern issues, high cost of battery which led to high cost of car.
**Inference-** As respondents are getting major problem with Range of the car, charging availability points are less, safety issues are the major problems. Government and private sector should focus on the problems.




**Interpretation-** As the above Pie Chart shows that how many respondents have EV car and how many don't have and will they buy in future. 29% respondents are saying No that they don't have an EV car but they will buy in future which are 23 respondents, 10.3% respondents are saying Yes which means they are using the EV car which are 8 respondents, some of them has TATA Tiago EV, TATA Nexon EV, MG ZS EV, TATA Tigor EV and their experience has been great some them driven there are till 22000 km.
**Inference-** As majority of respondents are saying No that they do not any EV car but they will buy in future which are 23 respondents.

## Conclusion: -

We can see that there are lot of options are available in EV car which are related technology, there are many benefits and some negatives are there in owning an EV car. Government is also taking initiatives so that customer should be attracted more towards EV car and later they purchase by giving them tax benefits. It will take some more year for paradigm shift from fossil fuel cars to EV car, as small-small steps have been taken to reduce the carbon-dioxide burden from the mother earth.

## Suggestions: -

- Enhanced innovations required to reduce the cost of batteries, increase the range of the vehicle and reduce the overall cost of the vehicle.
- Government and private companies should increase charging facilities in every part of country.
- Governments should offer financial incentives such as tax credits, rebates, and subsidies to promote EV adoption. These incentives can help offset the higher upfront costs of electric vehicles, making them more accessible to a wider range of consumers.
- Government and private companies should also focus on the different alternatives like on bio-fuel in which ethanol is mixed with petrol. And green hydrogen fuel which will be highly effective and beneficial to the environment, so that by focusing on different alternatives it will reduce the dependency over source of fuel and it will give wide variety of choice will be available to the customers.
- Increased public awareness about the benefits of electric vehicles, including environmental advantages, cost savings on fuel and maintenance, and government incentives, can contribute to higher adoption rates. Educational campaigns can address common misconceptions and concerns.
- Collaboration among automakers, charging infrastructure providers, and government agencies is crucial. Standardizing charging connectors, communication protocols, and interoperability can enhance the user experience and facilitate the growth of the electric vehicle ecosystem.

**Annexures-**

Gender? *

- Male
- Female
- Other

Is EV cost effective in running and maintenance than Fossil Fuel car? *

- Yes
- No
- Maybe

1) If you own any EV car then write YES. Which EV car do you own? and tell us about your experience?
2) If you don't own an EV car then write NO. Would you like to own it in future? *

Long-answer text

What are the drawbacks/problems related with EV car? *

Long-answer text

In upcoming 5 years EV car is going to replace Fossil Fuel car? *

- ◯ Yes
- ◯ No
- ◯ Maybe

Which technology you prefer in EV car? *

- ◯ HEV ( Hybrid Electric Vehicle )
- ◯ PHEV ( Plug-in Hybrid Electric Vehicle )
- ◯ BEV ( Battery Electric Vehicle )
- ◯ MHEV ( Mild-Hybrid Electric Vehicle )
- ◯ FCEV ( Fuel Cell Electric Vehicle )

Which EV car Brand/Company you like the most? *

Long-answer text

Which EV car you like the most? *

Long-answer text

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