A Review On Barriers And Potential Solutions Of Electric Vehicle

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Abstract - Researchers have given electric vehicles (EVs) a lot of attention as a green transportation option, which has resulted in a number of in-depth studies. As high-storage batteries and electric vehicles (EVs) become more common, the sheer volume of EVs on the road will pose significant problems to the safe and stable functioning of power grids due to their erratic charging and discharging patterns. This paper provides a quick introduction to many aspects of electric vehicles (EVs), encompassing government legislation, charging procedures, important approaches, impacts of charging, and solutions to associated problems. Talk about the EV trend based on the issues and present state of development. This study explores the development of EVs over time and emphasizes their advantages, which include a decrease in air pollution and carbon emissions. It also discusses the obstacles and problems encountered in their adoption, including the expensive cost of infrastructure, the dearth of charging stations, the short range or range anxiety, and battery performance. Enhancing the infrastructure for charging, expanding the number of charging stations, employing battery swapping strategies, and advancing battery technology to mitigate range anxiety and shorten charging times are some potential answers to these problems. Governments might invest in developing a strong charging infrastructure and offer tax breaks or other subsidies to encourage people to buy electric vehicles.

***Key Words*: Electric Vehicles, Vehicle to grid, Optimisation technique, CO_2reduction, challenges, charging infrastructure**

1.Introduction:

The automotive sector has grown to be a significant force in both research and development (R&D) and the global economy. The safety of both passengers and pedestrians is increasingly given priority in cars thanks to ongoing technological advancements. In addition to using solar plates, electric buses can operate on grid electricity. A battery is present that can be used after being charged. To lessen their carbon footprint, all automakers are required to create at least one hybrid electric vehicle type. By 2030, France and Japan will be the only nations remaining in the petroleum industry. This is an additional step towards improving electrical vehicles and reducing pollutants for a cleaner environment. Electric vehicles (EVs) are emerging as a possible avenue for enhancing air quality, energy security, and economic opportunity due to the swift growth of the Indian automobile sector. The Indian government understands how urgent it is to investigate sustainable mobility options in order to lessen reliance on foreign energy sources, cut greenhouse gas emissions, and lessen the negative effects of transport, such as global warming. By adopting preventative steps to lessen the catastrophic climate change that threatens the planet's biodiversity, carbon dioxide emissions can be decreased. Significant efforts have been made to reduce the amount of fossil fuels used for energy production, transportation propulsion, energy consumption, and carbon sequestration protection. An alternative to reduce carbon dioxide petrol emissions could be electric vehicles (EVs). Even if EV adoption has started, people still rely on cars that run on fossil fuels. In contrast to traditional fossil fuel-powered vehicles, electric vehicles (EVs) have difficulties with life cycle assessment (LCA), charging, and driving range. The production of electric vehicles emits 59% more CO2 than that of internal combustion engines. From a tank to wheel perspective, the ICEV emits 120 g/km of CO2, but from an LCA perspective, this rises to 170–180 g/km. Although CO2 emissions from EVs are zero from tank to wheel, we estimate that average CO2 emissions are measured over the car's life cycle rather than just one vehicle. Due to the transportation sector's harmful emissions and various OEM investments, there is a growing worry about the need for more affordable and efficient electric vehicles in the years to come. The adoption of EVs in India may be influenced by a number of variables, including improvements in technology, falling car prices, government policy support, incentives for buying new cars, parking benefits, and well-developed public charging infrastructure. Since there is very little production of EVs, their entire market share in India is very small. Electric vehicles (EVs) can be classified into three categories: (i) three-wheelers, such as e-rickshaws; (ii) four-wheelers, which comprise electric cars.

The aim of this research is:

- To determine the necessary procedures, obstacles, and difficulties associated with using a battery-operated vehicle in a developing nation such as India.
- To determine the causes of the lack of interest in electric vehicles in India.
- To raise awareness in India of the benefits that battery-operated automobiles have over traditional fossil fuel-powered vehicles.

- To research various government programmes designed to promote hybrid and electric vehicles.

2. Backround:

2.1: Smart Cities:

A smart city is a developed area that uses a variety of sensors and technology gadgets to gather data. Using information and communication technology (ICT), smart cities prioritise comfort, upkeep, and sustainability while managing public resources to improve service quality. Electric vehicles (EVs), which include neighborhood electric vehicles, electric buses, and electric cars, will soon rule the transportation sector. The whole transportation network will be electrified as part of the city's overall effort to reduce petrol emissions. However, because of novel problems with power distribution and traffic control, the efficacy of these new transit systems cannot be guaranteed in a normal metropolis. Thus, a smart city can help achieve this national objective. Smart cities and electric cars are closely related since electric vehicles are an essential component of many smart city initiatives. The widespread adoption of electric vehicles is one of the primary goals of many smart city initiatives, which aims to significantly reduce emissions and improve the quality of the air in metropolitan areas. Smart cities can also become more efficient by using electric vehicles, which have lower running costs and require less maintenance than conventional automobiles. Furthermore, the adoption and integration of electric vehicles can be aided by infrastructure created for smart cities, such as charging stations and intelligent traffic control systems. [2]

However, there are several challenges involved in incorporating electric vehicles into smart cities. One of the main issues is the cost of electric automobiles and the infrastructure required to charge them, which can be costly and need a significant investment. Additionally, because electric vehicles have a limited range, some locals could be concerned about running out of energy. Make sure the infrastructure for charging is in line with people' needs; careful planning and oversight are required for this. Another challenge is ensuring that electric vehicles are successfully and efficiently incorporated into the infrastructure of smart cities, which calls for coordination and collaboration across a number of stakeholders, including the public sector, businesses, and individuals. The emergence of smart cities may lead to more efficient, sustainable, and livable urban regions. Cities must, however, resolve the implementation-related problems to guarantee effectiveness and fairness. By investing in technology and data management, establishing stringent cybersecurity and privacy rules and procedures, collaborating productively with stakeholders, and developing inclusive and accessible projects, cities can successfully execute smart city efforts and enjoy their benefits.

2.2. Overview of Intelligent Transportation Systems:

Smart cities require an Intelligent Transportation System (ITS) that can meet their transportation requirements. transit in a smart city should be hassle-free, eco-friendly, and consist of networked and shared cars for better public transit services. The best choice is an electric vehicle (EV), which also provides a solution to global energy issues. Intelligent electric vehicles, also known as autonomous electric vehicles, provide the networked and communal layer required for a smart city.

In light of the growing popularity of smart cities, new regulations have been proposed to restrict carbon emissions (CEs) in the transport sector. The problems with carbon emissions and traffic congestion caused by the significant increase in the number of cars are solved by intelligent transport systems, or ITS. (ITS).

2.3. Electric Cars:

Electric vehicles (EVs) are becoming a more and more popular mode of transportation because of their ability to reduce greenhouse gas emissions and dependency on fossil fuels. They have also received a lot of attention lately. An electric motor that runs on rechargeable batteries powers an electric car instead of requiring petrol or diesel fuel. By 2030, there will be three times as many electric vehicle (EV) users as there were in 2011. This is the outcome of technological developments in battery performance and how they impact the autonomy of vehicles. One of the primary advantages of electric cars is their impact on the environment. The energy-related carbon dioxide emissions for the US, China, and Europe are displayed in Figure 1 for the years 1983 through 2023. Although the US and China have seen a rise in the sales of electric vehicles, it is important to remember that these nations still have a large number of conventional fossil fuel-powered cars on the road. Furthermore, as a result of these nations' growing energy needs, more coal is being used, which is the main source of carbon dioxide emissions. [3]

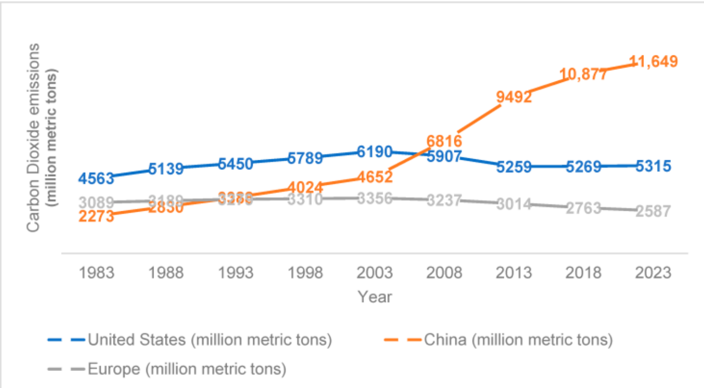

Figure 1. Energy-related carbon dioxide emissions in the US, China, and Europe from 1983 to 2023 [3]

Long-term carbon dioxide emissions reductions from electric vehicles are still anticipated in these nations despite this. EVs are exhaust-free vehicles, in contrast to conventional automobiles. They emit less pollution than gasoline-powered cars, even when the electricity they use comes from fossil fuels. As a result, EVs are a preferred substitute for people who want to reduce their carbon footprint. There are several types of electric vehicles, including plug-in hybrid electric vehicles (PHEVs) and battery electric vehicles (BEVs). Batteries power BEVs, whereas conventional petrol or diesel engines and batteries power PHEVs. Before the petrol engine kicks in, PHEVs can only travel a set distance on electricity alone.

Because they make electric vehicles more accessible and cheap for the general public, government incentives are crucial in driving up sales of these vehicles. A good example of this is China, where the government has introduced a number of laws and financial incentives to promote the use of electric cars. These consist of monetary rewards like tax exemptions, subsidies, and free licence plates in addition to non-monetary rewards like free parking and priority access to carpool lanes. Due in part to these incentives, the initial cost of electric vehicles has decreased, increasing their competitiveness with respect to conventional gasoline-powered vehicles. Government expenditures on R&D and the infrastructure needed for charging have also assisted in resolving issues with technological dependability and range anxiety.

China is now the world's largest market for electric vehicles because to these incentives, which have caused a spike in sales of electric vehicles there. Figure 2 shows the worldwide inventory of electric cars, including plug-in hybrid electric vehicles (PHEVs) and battery electric vehicles (BEVs), broken down by country. As Figure 3 illustrates, China is also home to the greatest number of public EV charging stations. [4]

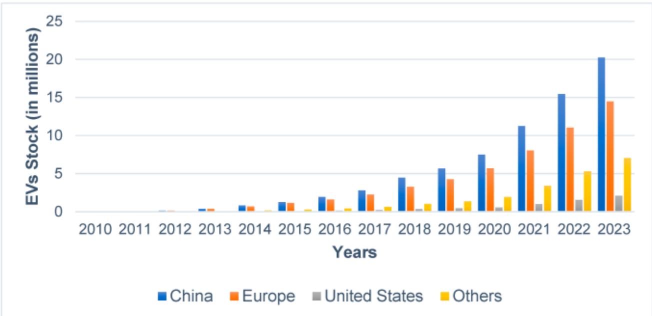

Figure 2. Global electric car stock country-wise, including both battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs) [4]

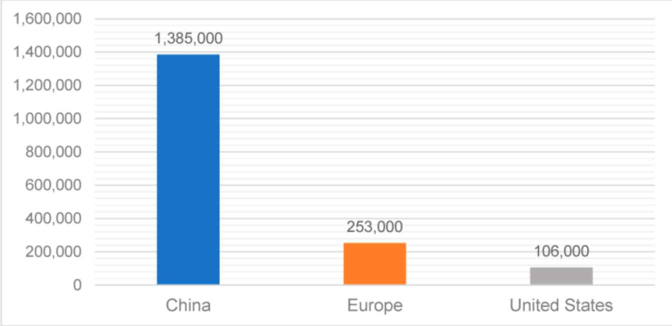

Figure 3. Public EV charging stations. [5]

It's important to remember that these numbers change frequently due to investments made by public and private organisations to increase the availability of EV charging stations. With plans to have 4.8 million charging stations by 2025, China has been especially active in expanding its network of charging stations. With aims to have one million public charging stations by 2025, Europe is also a major investor in the expansion of its charging infrastructure. Although there aren't as many charging stations in the US as there should be, the Biden administration has suggested large amounts of money to support the development of the nation's EV charging infrastructure.[3]

3. Difficulties in Putting Electric Vehicles into Practice:

Utilities, state and local governments, and private sector participants such as EV service providers, fleet employees, and individual automobile owners are examples of public sector operators in the EV market. Diverse operational decisions are made by variable adopters, which include private vehicle owners, managers of private company fleets, and public fleet operators. At-home charging, public charging, and battery-swapping stations should be optimised for the charging models based on the types and distribution of adopters. Infrastructure rollout and incentive programmes are also related to the type of client. Figure 4 provides a summary of the major issues faced by the members of the EV service business.

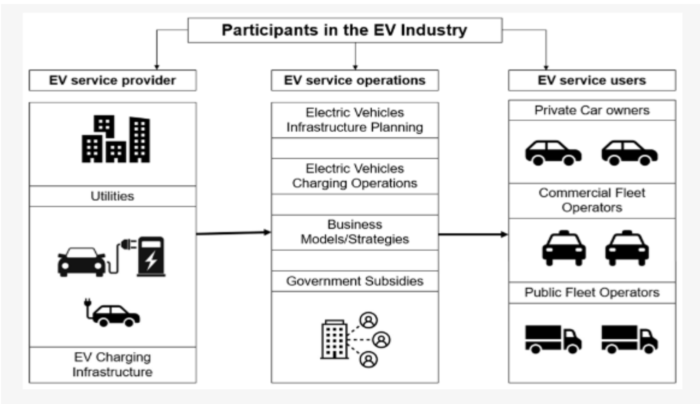

Figure 4. EV service operations/participants.

This definition classifies as a "EV" any car in which an electric battery provides the majority of the driving force. (For instance, plug-in hybrid electric cars (PHEVs), battery electric vehicles (BEVs), and plug-in electric vehicles (PEVs). The only source of power for a BEV is its battery pack, which may be charged using the grid. PHEVs, on the other hand, are powered by an internal combustion engine, an electric motor, and a battery that can be charged from the grid. "PEVs" are another term for BEVs and PHEVs, which are EV models that can be charged with grid electricity. The most widely used battery substitute for electric cars (EVs) is lithium-ion, which is followed by lead-acid, nickel-metal hydride, and sodium-nickel chloride batteries.[6]

4. Techniques for Overcoming Obstacles:

It is well recognised that electric vehicles (EVs) have the potential to offer a number of important social and individual benefits as compared to cars with internal combustion engines (ICEs). Recent studies have examined the various challenges faced by EVs and have generally found that the most prevalent ones are those related to cost, range, charging infrastructure, and customer perceptions.

The range of BEVs is now limited as compared to refuelling ICEVs, and charging still takes significantly longer. This leads to overly optimistic route design, with certain routes being too long for BEVs (battery electric vehicles). As a result, appropriate implementation solutions for electric vehicles (EVs) in smart cities are suggested in this research article. [6]

4.1. Infrastructure Charging:

Owners of electric vehicles might worry that they won't have enough fuel to get to their destination because these vehicles often have a shorter driving range than conventional ones. Despite the fact that EVs' range is increasing, some drivers still find it difficult, especially those who must travel large distances. If they can schedule charging times ahead of time, though, the customer will be informed of the available slots. Thus, customers have the option to look at slots other than those that are already in queue. Good charging infrastructure will also aid in lowering consumers' "range anxiety" by responding to their questions and assuaging their concerns about the charging network.

First, when travelling by highway between cities, quick DC charging is a useful technique for shortening the recharging time and increasing the range. Planners of EV infrastructure should take into account the fact that different driving habits need different amounts of energy and time to recharge. Range anxiety can be reduced by designing EV recharging infrastructure properly and dynamically.

Secondly, precise estimation of energy consumption and drivable range can be achieved by using a mathematical vehicle model that can forecast "real road" driving energy consumption and drivable range.

Third, creating charging stations across the nation can also help reduce range anxiety, but this requires cooperation between the public and commercial sectors as well as government incentives.

Finally, a network path selection model can be used to reduce range anxiety. This model uses an algorithm to determine the best and fastest route for electric vehicle drivers. In the meanwhile, these models could be enhanced by determining the length of a halt at a charging station and the time of departure. Using highly efficient electric motors in series, parallel, and series-parallel charging configurations can extend the driving range. Some EV manufacturers even offer free rental cars for short excursions outside the EV range to help reduce range anxiety. [6]

4.2. Auxiliary Load Balancing:

Electric automobiles' range is limited by the significant influence of auxiliary loads on their energy consumption. First, when driving in cities, high auxiliary loads deplete batteries, limiting the range of the electric vehicle. When using the AC in the summer, the driving range drops by 17.2–37.1% (under simulated parameters). Just as EVs use PTC (Positive Temperature Coefficient) heaters, the range (based on simulations) is 17% to 54% because of the requirement for heating in the winter. Secondly, the impacts of auxiliary loads like heating and air conditioning when driving electric automobiles at highway speeds have not been thoroughly studied yet.

Using a heat pump to warm EVs in the winter is one solution to solve the issue of auxiliary loads' short range and high energy consumption. This can result in a 7.6–21.1% increase in driving range due to a higher heating coefficient of performance (CoP). A heat pump's vapour compression cycle regulates both heating and cooling. There's also a four-way valve that reverses the flow of refrigerant. Furthermore, it has a coefficient of performance that is 1% higher than PTC heaters. Furthermore, an accurate evaluation of EVs' cooling and heating needs could save the energy consumption of the air conditioner by a large margin. Lowering the overall energy usage during cooling is also possible with the right energy management strategy. [6]

4.3. Advancements in Battery Technology:

One of the primary barriers to the broad adoption of electric vehicles (EVs) is the limitations of battery technology. The current EV battery design has a low energy density, which reduces the driving range of the car [58]. Over time, numerous battery technologies and combinations have been developed to increase EV efficiency. Because stronger, more reasonably priced, and larger-capacity batteries will boost vehicle autonomy, consumers view electric vehicles as a viable alternative to internal combustion engine automobiles.

Given the importance of batteries to electric vehicles, more producers—including LG, Panasonic, Samsung, Sony, and Bosch—are devoting resources to producing better, more reasonably priced batteries.

The most expensive component of any EV is the battery package. For example, the lithium-ion batteries of the Nissan LEAF originally cost one-third of the vehicle's entire price. But this cost should gradually go down; by the end of 2014, the battery pack cost about $500 per kWh, which was half of what it cost in 2009; currently, it costs $200 per kWh, and by the end of 2025, it should only cost about $100. Another piece of evidence that supports the trend towards reduced battery costs is the fact that Tesla Motors is building a "Mega factory" in order to improve battery output and reduce manufacturing costs.

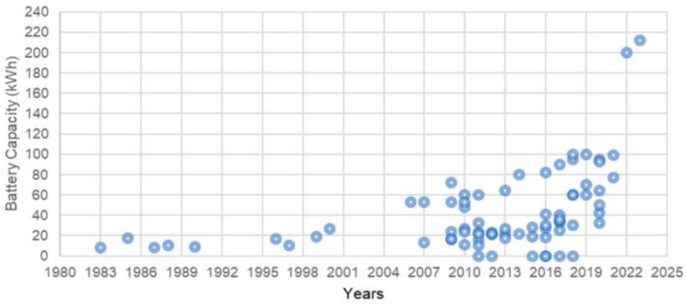

Figure 5. Battery capacity development from 1980–2025

4.4. Improving Battery Switching Stations for EV Charging Processes:

Battery swapping stations could be used instead of battery charging stations to reduce range anxiety. At battery switching stations, standard, fully charged batteries are kept available so that electric vehicle drivers can rapidly swap them out and resume their journey. EVs at a highway charging point can be switched out right away in this manner. Figure 6 shows the working mechanism of the battery swapping stations. Tesla and battery suppliers in the US and Europe are already using this instantaneous EV charging technology.

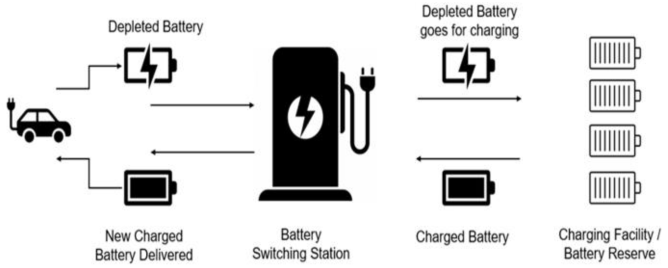

Figure 6. The battery changing stations' operational mechanism.

Comparing normal petrol stations and battery switching stations demonstrates that the majority of conventional vehicles can run on any of the three fuels: petrol, diesel and petrol. Battery switching stations may occasionally run out of a particular type of battery, thus they will need to handle a wide variety of batteries. This could make drivers of electric vehicles nervous. Batteries are available in a variety of forms, energies, and power densities.

Thanks to smartphone applications created by battery swapping facilities, electric vehicle drivers will be able to keep an eye on the various battery kinds that are available. Better yet, they could pre-store extra batteries to swap out their depleted ones. Reducing waiting times and eliminating range anxiety can be achieved by providing a communication platform for both the driver of the electric vehicle and the battery switching locations.

But this can cause extra problems for the battery switching stations, since they may need to stock a lot more batteries to service customers—especially if some of them exchange batteries multiple times a day. This problem can be solved in a number of ways. Some of the options are to set a daily cap on the number of swaps that may be conducted, charge extra for each additional swap that can be completed in a single day, penalise users who go over their daily cap, etc. As mentioned, levying fines can discourage individuals from adopting EVs, therefore we need to think about the most practical options. Moreover, another problem with battery swapping stations is the inconsistent availability of specific battery kinds.

It's important to note that battery switching technology has become rather popular in China in this regard. China-based EV maker NIO is a major player in this market, having installed battery swapping stations all around the country. The robotic arm at these completely automated stations removes the EV's drained battery and replaces it with a fully charged one. According to NIO, the entire procedure takes less than five minutes, giving EV users a quick and easy option to continue their trip. As of March 2023, there were more than 1323 battery swapping stations operational throughout China.

A different business by the name of CATL has created a universal battery switching solution for use with various EV models. This method gives EV makers freedom and lets them use battery swapping technology without requiring them to create exclusive solutions of their own. Moreover, a McKinsey & Company study projects that by 2030, battery swapping technology may supply up to 30% of China's EV charging needs. Additionally, the report points out that battery swapping can have advantages like lowering EV ownership costs, increasing EV battery utilisation, and lowering the requirement for extensive charging infrastructure. [7]

5. Suggestions for Future Investigations:

Even though the evolution and development of electric vehicles have advanced significantly, particularly in recent years, this section addresses issues that are currently being researched and addressed or that may be worth investigating in order to come up with better and more creative solutions. [9]

5.1. New Advancements and Innovations in EV Batteries:

As we've said before, batteries are among of the most important parts of electric cars (EVs), as they bear the brunt of the vehicle's expense and have a direct impact on its efficiency.

A variety of resources have been required in order to develop new technologies that can outperform the current lithium-ion batteries, which are mostly utilized in automobiles, due to advancements in durability, charging density, and charge and discharge procedures.

Considering all the factors, it is evident that more work has to be done in this field, primarily because batteries are crucial and could greatly accelerate the development and adoption of EVs. Investigating new parts and technology is now a thing. Regarding this, current research is being conducted using graphene, a material with great thermal conductivity and light weight that is composed entirely of carbon. One of the key benefits of graphene-based batteries is that they almost never warm up, making it possible to charge them quickly or extremely quickly without experiencing significant power losses due to heat. [7]

5.2. EV's Artificial Intelligence:

In order for electric cars to completely replace other forms of transportation on our roads and in our communities, as was already mentioned, a number of conditions must be met.

As the world transitions to AI, there is a large research vacuum in this domain. There have been several suggestions for artificial intelligence (AI)-based EV themes, including battery temperature control, more intelligent charging, and energy-efficient routing. The energy consumption of the various road segments that comprise the planned or real vehicle routes can be predicted using their method.

In order to enhance the battery temperature management system and reduce total energy usage suggests using Artificial Neural Networks (ANNs). Under the plan, the battery temperature may be kept within reasonable bounds. The relationship between battery temperature behaviour and design parameters is examined. According to their computer research, with varying discharge rates, a distributed forced convection cooling technique may produce consistent voltage and temperature distributions across the battery pack. [10]

5.3. Governmental Directives:

Government subsidies have a major role in encouraging the use of electric vehicles, as was previously indicated. While the impact of subsidies on EV production has been examined in earlier research, few models have been created to investigate how governments might use subsidies to encourage EV adoption among consumers with limited budgets.

In order to optimise EV market demand or consumer surplus while taking into account the goals of EV manufacturers, retailers, and consumers, further research is primarily required to better understand the aims of subsidies and the design of government subsidy programmers and policies. Game models offer an answer to this issue. The goals and strategies of the subsidy programmes will be greatly impacted by a few factors, such as the negotiating power of the customers when selecting between specifically built cars and electric vehicles.

Government subsidies will affect how the car industry evolves and grows. How governments should reconcile competing goods (such BEVs and ICVs) with the objectives of different supply chain structures (like the producer, retailer, or customer) is still up for debate. For example, government subsidies will affect consumer demand, retailer orders and pricing, and manufacturer output and price if a manufacturer sells individually designed and battery-electric automobiles through different retailers. Game models can be used to characterize various situations. By comparing the results of multiple scenarios, the ideal industrial structure can be found. [9]

6. Conclusion:

This article examines electric vehicles (EVs), their advantages and potential, as well as the challenges—such as range anxiety, infrastructure, and battery cost—that prevent EV adoption and integration into smart cities. According to the report, EV integration can result in a more efficient and sustainable urban environment with lower operating costs, fewer greenhouse gas emissions, and better air quality in smart cities. Smart cities may use data analytics, smart grid technologies, and a strong charging infrastructure to overcome the obstacles that come with EV adoption. We can create more livable, sustainable communities that put residents' health and well-being first while lowering our carbon footprint by encouraging the use of EVs in smart cities.

There are several obstacles to the widespread use of electric cars (EVs), including high initial costs, a short driving range, inadequate infrastructure for charging, and negative public opinion. To overcome these obstacles, however, policies from the public and private sectors can be used to promote the adoption of EVs, create new business models that facilitate their use, finance the construction of charging infrastructure, advance battery technology and charging speeds, and raise public awareness of the advantages of EVs. By overcoming these obstacles, the transition to a sustainable transport system can be accelerated and the effects of climate change can be lessened.

The initiatives to encourage the use of electric cars (EVs) as a sustainable form of transportation are covered in the article. These tactics consist of public outreach and education programmes, charging infrastructure investments, and supportive laws and regulations. Governments can assist by enacting minimum EV sales requirements, offering financial incentives, and financing the infrastructure needed for charging EVs. To encourage EV adoption, private businesses might make investments in the infrastructure needed for charging, create fresh business plans, and collaborate with automakers. Programmers for public education can assist in overcoming challenges including lack of awareness of the advantages of electric vehicles and range anxiety. By putting these tactics into practice, we can fight climate change and move away from fossil fuels in favour of a more sustainable transportation system.

Positive developments in battery technology, infrastructure for charging, and policies that encourage them portend a bright future for electric vehicles. It is anticipated that battery costs would decline sharply, lowering the cost and increasing customer convenience of EVs. By moving to electric vehicles (EVs), one can lessen dependency on fossil fuels, fight climate change, and increase efficiency by integrating EVs into smart city initiatives. New models with longer driving ranges and quicker charging periods are anticipated as the industry expands, and self-driving EVs may be among them. [8]

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