

Exploring Challenges and Opportunities in the Electric Vehicle Landscape

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Abstract:

The global automotive industry is experiencing a transformative shift towards Electric Vehicles (EVs) driven by sustainability imperatives. This paper explores the opportunities and challenges accompanying this shift. It analyses key factors influencing the EV market trajectory, including technological advancements, government support schemes, and infrastructure development. Additionally, the paper examines obstacles such as range anxiety, charging infrastructure limitations, and upfront costs, while highlighting opportunities such as reduced emissions, job creation, and energy independence. Drawing on a comprehensive literature review, government support schemes, and insights from central, state, and local governments, the paper offers strategies for overcoming challenges and capitalizing on opportunities in the EV market. Ultimately, understanding these dynamics is crucial for fostering a sustainable and resilient transportation system.

Keywords:

electric vehicles, e-Vehicles, Sustainability, Market opportunities, Infrastructure development

Introduction

In the recent years, the global automotive industry has witnessed a profound shift towards sustainability and environmental consciousness, largely driven by the urgent need to mitigate climate change. As a result, Electric Vehicles (EVs) have emerged as a promising alternative to traditional internal combustion engine vehicles, offering reduced emissions and a pathway towards a greener future. However, the widespread adoption of EVs presents both opportunities and challenges that must be carefully examined.

On one hand, the transition to EVs present significant opportunities for various stakeholders across the automotive value chain. Manufacturers have the chance to innovate and develop cutting-edge technologies that enhance the performance, range, and affordability of EVs, thereby attracting a broader consumer base. Additionally, the rise of EVs opens up new avenues for collaboration between automotive companies and renewable energy providers, fostering the development of integrated solutions that promote sustainable transportation.

Despite these opportunities, the EV industry also faces several challenges that must be addressed to realize its full potential. One such challenge is the need for extensive infrastructure development, including the establishment of charging stations and grid upgrades to support the growing demand for electric vehicles. Moreover, concerns about the availability and sustainability of raw materials used in EV batteries, such as lithium and cobalt, highlight the importance of establishing responsible supply chains and exploring alternative battery technologies.

In this paper, we will explore the opportunities and challenges associated with the rapid growth of the EV industry, examining key factors that influence its trajectory and potential strategies for overcoming obstacles. By gaining a comprehensive understanding of the dynamics shaping the EV market, we can pave the way for a more sustainable and resilient transportation system.

The Electric Vehicle (EV) revolution is upon us, promising a paradigm shift in transportation towards cleaner, more sustainable mobility. With advancements in battery technology, supportive government policies, and increasing consumer awareness, the EV market is poised for exponential growth. However, amidst this wave of optimism, it's crucial to acknowledge and address the challenges that accompany this transformative journey.

The opportunities presented by the EV industry are vast and multifaceted. From reducing greenhouse gas emissions to decreasing dependence on fossil fuels, EVs offer a compelling solution to some of the most pressing environmental and energy security issues of our time. Furthermore, the rapid growth of the EV market has sparked innovation and investment across various sectors, creating new business opportunities and driving economic growth.

Nevertheless, the path to widespread EV adoption is not without obstacles. Infrastructure gaps, such as the availability of charging stations and grid capacity constraints, pose significant challenges to the scalability of EVs. Additionally, concerns regarding the affordability and accessibility of EVs for all socioeconomic groups must be addressed to ensure equitable access to sustainable transportation solutions. Moreover, the environmental footprint of EV production, particularly the sourcing and disposal of battery materials, raises important questions about the lifecycle sustainability of these vehicles.

In this paper, we will delve into the opportunities and challenges facing the EV industry, examining the complex interplay of technological, economic, and policy factors that shape its trajectory. By critically evaluating these dynamics and proposing actionable strategies, we aim to contribute to the advancement of a more sustainable and inclusive mobility ecosystem.

Literature review:

Beaudet, A., Larouche, F. et.al. (2020) discusses key economic and environmental drivers for recycling electric vehicle (EV) batteries, technical and financial challenges to large-scale deployment of recycling initiatives, and the main recycling process options currently under consideration.

Husain, I., Ozpineci, B., Islam et.al. (2021) discuss the electric drive technology trends for passenger electric and hybrid EVs with commercially available solutions in terms of materials, electric machine and inverter designs, maximum speed, component cooling, power density, and performance.

Pareek, S., Sujil, A., Ratra et.al. (2020) state that Indian Government is concentrating towards environmental friendly ecosystem and as per its mission to reduce carbon emission from the transport sector, deployment of EV's and installation of EVCS is the biggest concern. Government has reduced the tax on EV's and is providing subsidy for installing charging station.

Monteiro, V., Afonso, J., Ferreira et.al. (2018). Present the new challenges and opportunities that smart grids are facing, including the new technologies in the vehicle electrification, towards a sustainable future.

Juan, A., Mendez, C.et.al. (2016) reviewed challenges related to the introduction of EVs in L&T activities like environmental-related issues, strategic, planning and operational issues associated with “standard” EVs and with hydrogen-based EVs. They also analyzed how the introduction of EVs in L&T systems generates new variants of the well-known Vehicle Routing Problem, one of the most studied optimization problems in the L&T field, and proposes the use of metaheuristics and simheuristics as the most efficient way to deal with these complex optimization problems.

Sreeram, k, Preetha, P. K. et.al. (2019). focused on providing an overall picture of the modern Electric Vehicle scenario and areas for further growth. Making India an all EV market by 2040 also ushers in incentives for the development of EVs like the Faster Adoption & Manufacturing of Electric Vehicles

(FAME) Scheme in 2015 to incentivize manufacturing of Eco-friendly vehicles including Hybrid Electric Vehicles (HEV).

Hasan, M. K., Mahmud, M. et.al. (2021) studied the electric vehicle energy storage and management systems. They also reviewed various aspects of lithium-ion batteries.

Ji, Z., & Huang, X. (2018) studied Plug-in electric vehicles (PEVs) as one of the solutions for China to reduce both greenhouse gas emissions and dependency on oil importation in the transport sector. They showed that, while the major challenge lies in the profit expectation of the infrastructure investor sector, the design of subsidies for PEVs and chargers should be strengthened and well-balanced at the initial stage.

Hossain Lipu, M. S., Hannan et.al. (2021) studied different intelligent approaches and control schemes of the battery management system in electric vehicle applications. In line with that, the review evaluates the intelligent algorithms in battery state estimation concerning their features, structure, configuration, accuracy, advantages, and disadvantages.

İnci, M., Büyük, M., Demir, M. H., & İlbey, G. (2021) studied the technological advancements showing the use of FCs in electric vehicles (EVs) will increase rapidly and cause a revolution, and will be an alternative to traditional vehicles in the future.

Government support schemes:

The global transition towards sustainable transportation has prompted governments around the world to implement various support schemes aimed at accelerating the adoption of Electric Vehicles (EVs). These schemes encompass a wide range of initiatives, including financial incentives, regulatory policies, and infrastructure development programs, all designed to overcome barriers and promote the widespread adoption of EVs. In this paper, we will explore some of the key government support schemes for EVs, highlighting their impact on market dynamics and the transition to a low-carbon transport future.

Financial incentives

One of the most common forms of government support for EVs comes in the form of financial incentives. These incentives can take many forms, including tax credits, rebates, and grants, all aimed at reducing the upfront cost of purchasing an EV and making them more economically attractive to consumers. For

example, countries like the United States offer federal tax credits for the purchase of qualifying EVs, while countries such as Norway provide significant tax exemptions and incentives, resulting in EVs comprising a substantial portion of new vehicle sales.

Regulatory policies

In addition to financial incentives, governments have implemented various regulatory policies to support the adoption of EVs. These policies often include emissions standards, vehicle quotas, and mandates for automakers to produce a certain percentage of zero-emission vehicles. By setting ambitious targets and creating a regulatory environment conducive to EV adoption, governments can incentivize automakers to invest in EV technology and accelerate the development of cleaner, more efficient vehicles.

Infrastructure development

A critical aspect of supporting EV adoption is the development of charging infrastructure. Governments play a key role in this regard by investing in the deployment of charging stations and supporting the expansion of EV charging networks. This infrastructure development is essential for alleviating range anxiety among EV drivers and ensuring convenient access to charging facilities, thereby encouraging more people to make the switch to electric transportation.

Research and Development Funds

Government support for EVs also extends to research and development funding aimed at advancing battery technology, improving charging infrastructure, and enhancing the overall efficiency and performance of electric vehicles. By investing in R&D, governments can spur innovation and drive down the cost of EVs, making them more accessible to a broader segment of the population.

To summarize, Government support schemes play a crucial role in driving the adoption of Electric Vehicles and facilitating the transition towards sustainable transportation systems. By implementing financial incentives, regulatory policies, infrastructure development programs, and research funding initiatives, governments can create an enabling environment for the widespread adoption of EVs, ultimately contributing to the reduction of greenhouse gas emissions and the achievement of climate goals.

Central government support:

As nations worldwide endeavour to mitigate climate change and transition towards sustainable energy solutions, Electric Vehicles (EVs) have emerged as a pivotal component of this transformative journey. Recognizing the urgency of reducing carbon emissions and fostering clean mobility, central governments play a crucial role in driving the adoption of EVs through a range of policy initiatives and support measures. In this paper, we will delve into the key initiatives undertaken by central governments to promote the widespread adoption of EVs and facilitate the transition to a greener transportation ecosystem.

- **Subsidies and Incentives:**

Central governments often provide financial incentives and subsidies to encourage consumers to purchase EVs. These incentives may include tax credits, rebates, or direct subsidies, effectively

reducing the upfront cost of EVs and making them more affordable for consumers. Such measures not only stimulate demand but also incentivize automakers to invest in EV technology and ramp up production.

- **Regulatory framework:**

Central governments enact regulatory frameworks to support the adoption of EVs and drive market transformation. This may include setting emissions standards, vehicle quotas, or establishing mandates for automakers to produce a certain percentage of zero-emission vehicles. Additionally, regulatory measures such as exemptions from congestion charges or access restrictions in urban areas further incentivize the adoption of EVs.

- **Infrastructure Development:**

To address range anxiety and ensure the widespread adoption of EVs, central governments invest in the development of charging infrastructure. This includes the installation of public charging stations along highways, in urban areas, and at workplaces. Moreover, governments may incentivize private investment in charging infrastructure through grants, subsidies, or regulatory support, fostering a robust charging network accessible to all EV users.

- **Research and Development Funds:**

Central governments allocate funds for research and development initiatives aimed at advancing EV technology and infrastructure. This includes investments in battery research, charging technology, and vehicle electrification. By supporting innovation and collaboration between industry and academia, governments accelerate the development of cutting-edge EV solutions, driving down costs and improving performance.

- **Public procurement and fleet Electrification:**

Central governments lead by example through the electrification of public sector fleets and procurement policies favoring EVs. By incorporating EVs into government fleets and procurement contracts, central governments create demand signals that stimulate market growth and demonstrate the feasibility of EV adoption at scale. This not only reduces emissions from government operations but also catalyzes the development of a competitive EV market.

In summary, Central governments play a pivotal role in shaping the trajectory of the Electric Vehicle market through a comprehensive suite of policy initiatives and support measures. By providing subsidies and incentives, enacting supportive regulatory frameworks, investing in infrastructure development and R&D, and leading by example through public procurement and fleet electrification, central governments can accelerate the transition to a sustainable, low-carbon transportation future powered by Electric Vehicles.

State government support:

While central governments set overarching policies and frameworks, state governments play a crucial role in implementing localized initiatives to promote the adoption of Electric Vehicles (EVs). Recognizing the importance of clean mobility and the unique needs of their regions, state governments across the globe have developed tailored strategies and support mechanisms to accelerate the transition towards EVs. In this paper, we will explore the diverse initiatives undertaken by state governments to foster the uptake of EVs and build sustainable transportation ecosystems.

- **Incentives and subsidies:**

State governments often offer their own set of incentives and subsidies to complement central government programs, tailored to the specific needs and priorities of their jurisdictions. These incentives may include additional rebates, tax credits, or exemptions from state-level taxes and fees, further reducing the cost of EV ownership and incentivizing adoption among consumers.

- **Charging Infrastructure Development:**

State governments play a pivotal role in facilitating the deployment of charging infrastructure within their jurisdictions. Through strategic partnerships with private companies and utilities, state governments invest in the installation of public charging stations in key locations such as urban centres, highways, and commercial areas. Moreover, states may offer grants or incentives to businesses and property owners to encourage the installation of charging infrastructure at their premises.

- **Education and Awareness Campaign:**

To address consumer concerns and promote EV adoption, state governments conduct education and awareness campaigns to inform the public about the benefits of electric transportation. These campaigns may include outreach programs, workshops, and promotional events aimed at dispelling myths, highlighting the cost savings and environmental benefits of EVs, and showcasing available incentives and support programs.

- **Support for Local manufacturing and Innovation:**

State governments often support the growth of the EV industry within their jurisdictions by providing incentives for local manufacturing, research, and innovation. This may include grants, tax incentives, or infrastructure support for EV-related businesses, startups, and research institutions. By fostering a conducive ecosystem for EV innovation and manufacturing, states stimulate economic growth and job creation while advancing sustainable transportation goals.

- **Regulatory support and policy Alignment:**

State governments align their policies and regulations with broader sustainability objectives, creating an enabling environment for EV adoption. This may involve streamlining permitting processes for charging

infrastructure installation, implementing zero-emission vehicle mandates for government fleets, or integrating EV considerations into urban planning and transportation policies.

In conclusion, State governments play a pivotal role in driving the adoption of Electric Vehicles and building sustainable transportation ecosystems tailored to the unique needs and priorities of their regions. Through a combination of incentives and subsidies, infrastructure deployment, education and awareness campaigns, support for local manufacturing and innovation, and regulatory alignment, state governments can accelerate the transition to clean, electrified transportation systems, contributing to reduced emissions, improved air quality, and enhanced energy security.

Local bodies support:

At the grassroots level, local governments play a critical role in implementing initiatives to promote Electric Vehicles (EVs) and build supportive ecosystems for sustainable transportation. Recognizing the importance of addressing local mobility challenges and reducing emissions, municipalities, cities, and regions around the world have been at the forefront of innovative efforts to encourage the uptake of EVs. In this paper, we will explore the various initiatives undertaken by local governments to foster the adoption of EVs and drive the transition towards cleaner, more efficient transportation systems.

- **Municipal fleet Electrification:**

Many local governments lead by example through the electrification of their own vehicle fleets. By transitioning municipal fleets to electric vehicles, local governments not only reduce emissions from their operations but also demonstrate the feasibility and benefits of EV adoption to the community. This serves as a powerful catalyst for broader EV uptake and helps create a market for EVs in the region.

- **Charging infrastructure Development:**

Local governments play a pivotal role in facilitating the deployment of charging infrastructure within their communities. Through partnerships with businesses, utilities, and other stakeholders, local governments identify suitable locations for charging stations and provide support for their installation. This includes incentives for property owners, streamlined permitting processes, and funding assistance to accelerate the expansion of charging networks.

- **Zoning and Planning Policies:**

Local governments integrate EV considerations into zoning and planning policies to support the growth of electric transportation. This may involve requirements for new developments to include EV charging infrastructure, incentives for the installation of charging stations in commercial and residential buildings, and the designation of EV-friendly zones with preferential parking and access privileges for electric vehicles.

- **Public Awareness Campaign:**

To encourage EV adoption among residents, local governments conduct public awareness campaigns to educate the community about the benefits of electric transportation. . These campaigns may include outreach events, workshops, and informational resources that highlight the environmental, economic, and social advantages of EVs. By raising awareness and addressing misconceptions, local governments empower residents to make informed decisions about their transportation choices.

- **Support for community – Based initiatives:**

Local governments provide support for community-based initiatives aimed at promoting EV adoption and sustainability. This may include grants, incentives, or technical assistance for community organizations, schools, and businesses that are implementing EV-related projects such as car-sharing programs, electric vehicle ride-and-drive events, or renewable energy-powered charging stations.

In conclusion, Local governments play a crucial role in driving the adoption of Electric Vehicles and building sustainable transportation ecosystems at the community level. Through initiatives such as municipal fleet electrification, charging infrastructure deployment, zoning and planning policies, public awareness campaigns, and support for community-based initiatives, local governments can accelerate the transition to clean, electrified transportation systems that improve air quality, reduce greenhouse gas emissions, and enhance quality of life for residents.

Obstacles and challenges in selling e- vehicles:

Selling electric vehicles (EVs) presents several obstacles and challenges, despite their growing popularity and environmental benefits. Some of these challenges include:

- **Limited Range Anxiety:** Range anxiety refers to the fear of running out of battery charge before reaching a destination. Although EV technology has improved significantly, many potential buyers still worry about the limited range of electric vehicles compared to traditional gasoline-powered cars.
- **Charging Infrastructure:** The availability of charging stations remains a significant barrier to widespread EV adoption. In many areas, charging infrastructure is sparse or non-existent, making it inconvenient for EV owners to recharge their vehicles, especially during long trips.
- **Charging Time:** Even with fast-charging technology, recharging an EV still takes significantly longer than refuelling a traditional car. This can be a deterrent for consumers who are accustomed to the quick turnaround time of gas stations.
- **Initial Cost:** Although the long-term operating costs of EVs are generally lower than those of internal combustion engine vehicles, the upfront cost of purchasing an EV is often higher. This can be a barrier for consumers who may not be able to afford the initial investment, despite potential savings in fuel and maintenance over time.

- **Lack of Model Variety:** While the number of EV models available on the market is increasing, there is still a lack of variety compared to traditional vehicles. Limited options in terms of body styles, features, and price ranges can restrict consumer choice and hinder adoption.
- **Perceived Performance Issues:** Some consumers still have reservations about the performance of electric vehicles, particularly concerns regarding acceleration, towing capacity, and overall driving experience compared to traditional vehicles.
- **Battery Degradation Concerns:** There are concerns about the longevity and degradation of EV batteries over time. While manufacturers offer warranties on battery performance, some consumers may be hesitant to invest in EVs due to uncertainty about battery lifespan and replacement costs.
- **Educational Barriers:** Many consumers still lack knowledge about EV technology, including how it works, charging options, and the environmental benefits of electric vehicles. Educating consumers about these aspects is essential for increasing acceptance and adoption rates.
- **Government Policies and Incentives:** Government policies and incentives play a significant role in promoting EV adoption. However, inconsistent policies or the lack of supportive measures can hinder market growth and investment in EV infrastructure.

Overcoming these obstacles requires collaboration among automakers, governments, infrastructure providers, and other stakeholders to address concerns, improve technology, and create a supportive environment for electric vehicle adoption.

Opportunities of e- vehicles:

Electric vehicles (EVs) offer numerous opportunities across various sectors including automotive, energy, technology, and environmental sustainability. Here are some key opportunities associated with electric vehicles.

- **Reduce Greenhouse Gas Emissions:** EVs produce lower or zero emissions compared to traditional internal combustion engine vehicles, which helps in reducing air pollution and combating climate change. This reduction in greenhouse gas emissions presents a significant opportunity for environmental sustainability.
- **Energy Independence:** By transitioning to electric vehicles, countries can reduce their dependence on fossil fuels for transportation. This shift can lead to greater energy security by diversifying energy sources and relying more on domestically produced electricity or renewable energy sources like wind and solar.
- **Innovation and Technological Advancements:** The development and adoption of electric vehicles are driving innovation in battery technology, electric drivetrains, charging infrastructure, and smart

grid technologies. These advancements not only improve the performance and range of EVs but also create opportunities for new businesses and industries.

- **Job Creation and Economic Growth:** The electric vehicle industry has the potential to create jobs across various sectors including manufacturing, engineering, research and development, and infrastructure development. As demand for EVs increases, it stimulates economic growth and creates opportunities for skilled workers.
- **Cost Savings for Consumers:** Although the upfront cost of electric vehicles is often higher than that of traditional vehicles, EVs offer long-term cost savings due to lower fuel and maintenance costs. Additionally, government incentives and subsidies can further reduce the cost barrier, making EVs more accessible to consumers.
- **Grid Integration and Demand Management:** Electric vehicles can serve as distributed energy resources and help balance electricity demand by participating in demand response programs and vehicle-to-grid (V2G) technologies. This integration of EVs with the grid presents opportunities for optimizing energy use, reducing peak demand, and enhancing grid stability.
- **Urban Planning and Infrastructure Development:** The adoption of electric vehicles necessitates the development of charging infrastructure, including public charging stations, workplace charging, and residential charging solutions. This infrastructure development presents opportunities for urban planners, utilities, and private companies to invest in sustainable transportation solutions.
- **Improved Public Health:** By reducing tailpipe emissions, electric vehicles contribute to improved air quality, which can have significant public health benefits. Lower levels of air pollution led to reduced respiratory illnesses and cardiovascular diseases, resulting in healthcare cost savings and improved quality of life.
- **Global Market Opportunities:** The shift towards electric vehicles is not limited to a single market but is a global trend driven by environmental concerns, policy incentives, and technological advancements. This presents opportunities for international collaboration, trade, and investment in the electric vehicle supply chain.
- **Rural Electrification and Energy Access:** In regions with limited access to electricity, electric vehicles powered by renewable energy sources can serve as a means of transportation while also contributing to rural electrification efforts. This dual benefit presents opportunities for extending energy access to underserved communities.

Overall, the widespread adoption of electric vehicles presents multifaceted opportunities for addressing climate change, fostering innovation, creating economic growth, and improving quality of life globally. However, realizing these opportunities requires concerted efforts from governments, industries, and stakeholders to overcome challenges such as infrastructure development, policy support, and technological advancements.

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