Journal of Energy Research and Environmental Technology (JERET)
p-ISSN: 2394-1561; e-ISSN: 2394-157X; Volume 10, Issue 2; April-June, 2023, pp. 1-5

http://www.krishisanskriti.org/Publication.html

The Future of Electric Bikes in India

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INTRODUCTION

India, and in fact the entire world, currently stands at a crossroads, facing both the challenge of reducing carbon emissions and the opportunity to lead the global electric vehicle revolution - but achieving this requires navigating the complex interplay between economic factors and engineering advancements. In India, the transport sector is the second-largest emitter of greenhouse gasses, accounting for approximately 142 million metric tons of carbon dioxide equivalent emissions in 2019 (Ministry of Environment, Forest and Climate Change, 2021). The Indian government has set a target of achieving 30% electric vehicle penetration by 2030 (NITI Aayog, 2018), which presents both opportunities and challenges for the Indian auto industry. The adoption and development of electric vehicles in India are influenced by a range of factors, including economic factors such as supply chain localisation, taxation policies, and market dynamics, as well as engineering advancements such as battery technology, charging infrastructure, and vehicle design. These factors are interrelated and can both support and constrain the growth of the Indian electric vehicle market. On one hand, economic factors such as supply chain localisation and taxation policies can influence the cost and availability of electric vehicles in India. Localizing supply chains can help to reduce costs and improve the availability of parts, while government incentives and tax breaks can help to make electric vehicles more affordable for Indian consumers (Mehrjerdi, 2021). For example, the Indian government has introduced a range of incentives and subsidies for electric vehicle manufacturers and buyers, including reduced GST rates, income tax exemptions, and subsidies for electric two-wheelers (Ministry of Heavy Industries and Public Enterprises, 2018).

On the other hand, engineering advancements such as improvements in battery technology and charging infrastructure can make electric vehicles more practical and convenient for Indian consumers. Advances in battery technology can increase driving range and reduce charging times, which can help to address range anxiety, a major concern for many potential electric vehicle buyers (Gupta, 2020). Meanwhile, the development of charging infrastructure, including both public and private charging stations, can help to address another major concern for potential electric vehicle buyers: the availability of charging stations (Mehrjerdi, 2021). Within a networked structure of economic factors, the adoption and development of electric vehicles in India is the outcome of their complex interplays such as that of supply chain localisation and taxation policies, and engineering advancements, such as battery technology, charging infrastructure, and vehicle design. However, the interrelationship between these factors also demands critical attention in shaping the course of EV development in India. For example, localised supply chains can help to reduce the cost of electric vehicles, but advances in battery technology can also contribute to cost reductions by improving battery efficiency and reducing the need for expensive materials (Kedar, 2019). Similarly, the development of charging infrastructure can make electric vehicles more practical, but government incentives and subsidies can help to support the growth of the charging infrastructure industry (Mehrjerdi, 2021).

LITERATURE REVIEW

Electric vehicles (EVs) have a long and storied history, dating back to the early 19th century when inventors such as Thomas Davenport and Robert Anderson developed the first crude electric motor and battery respectively. However, it wasn't until the late 1800s and early 1900s that EVs began to gain popularity as a viable alternative to gasoline-powered vehicles. In fact, by 1900, EVs accounted for around one-third of all vehicles on American roads (Kirsch, 2000). The early success of EVs was largely due to their simplicity, ease of use, and lack of pollution. Unlike gasoline-powered cars, EVs required no crank starting, no transmission shifting, and emitted no noxious fumes or loud noises (Stempel, 1991). As a result, they were particularly attractive to urban commuters, who valued their quiet operation and ease of parking. Regardless, the widespread adoption of the gasoline engine in the early 20th century, coupled with the discovery of vast petroleum reserves, led to a decline in the popularity of EVs. Gasoline engines were more powerful, had a longer range, and were cheaper to produce, making them the clear choice for consumers and manufacturers alike. By the 1920s, EVs had all

but disappeared from American roads (Kirsch, 2000). Despite their decline, EVs continued to be developed and improved upon throughout the 20th century, with notable advancements occurring in battery technology, motor efficiency, and control systems. In the 1960s and 1970s, rising concerns over air pollution and oil dependence led to renewed interest in EVs, with several car manufacturers, including General Motors and Ford, developing electric prototypes (Stempel, 1991).

However, it wasn't until the 1990s that EVs made a significant comeback, driven in part by stricter emissions regulations and the growing awareness of climate change. The first commercially successful EV, the General Motors EV1, was released in 1996, followed by the Toyota Prius hybrid in 1997. By the early 2000s, several other major car manufacturers had introduced EVs or hybrid vehicles, and public interest in clean transportation had surged (Kirsch, 2000). Today, EVs are becoming increasingly popular, with major advancements in battery technology, charging infrastructure, and vehicle design driving their adoption. As concerns over climate change, air pollution, and energy security continue to grow, EVs are seen as a critical component of the transition to a low-carbon economy. This becomes increasingly relevant when viewed in a comparative observation with the history of the introduction of the electric motor and vehicular standards in India which dates back to the early 20th century when electric trams and buses were introduced in several cities, including Mumbai, Kolkata, and Delhi. However, these early efforts were short-lived, and it wasn't until the late 20th century that EVs began to make a comeback in India. In 1998, the Indian government launched the National Electric Mobility Mission Plan (NEMMP) to promote the adoption of EVs and reduce the country's dependence on imported oil. Since then, several Indian automakers have introduced electric models, and the government has implemented several policies and incentives to support the growth of the EV market, including tax exemptions, subsidies, and the FAME (Faster Adoption and Manufacturing of Electric Vehicles) scheme. While the market for EVs in India is still relatively small, it is expected to grow rapidly in the coming years, driven by factors such as air pollution concerns, rising fuel costs, and technological advancements in battery and charging infrastructure.

Since the Indian electric vehicle (EV) market is influenced by a complex interplay of economic and engineering factors, economic tools such as supply chain localisation, taxation policies, and market dynamics are crucial for understanding the interaction between these factors. According to a study by Sharma and Ghosh (2019), localisation of the supply chain can help reduce costs and increase the competitiveness of Indian EV manufacturers. Moreover, taxation policies can affect the affordability of EVs and incentivize their adoption, as well as impact the revenue of the government. In the words of KPMG (2020), *"Well-designed tax incentives can help to drive consumer demand, boost investment, and create a sustainable market for EVs"*. Market dynamics such as consumer demand, competition, and infrastructure availability are also important factors that influence the adoption and development of EVs in India. By understanding these economic factors and their interactions with engineering advancements in battery technology, charging infrastructure, and vehicle design, policymakers and industry players can make informed decisions and take advantage of the opportunities presented by the rapidly evolving Indian EV market.

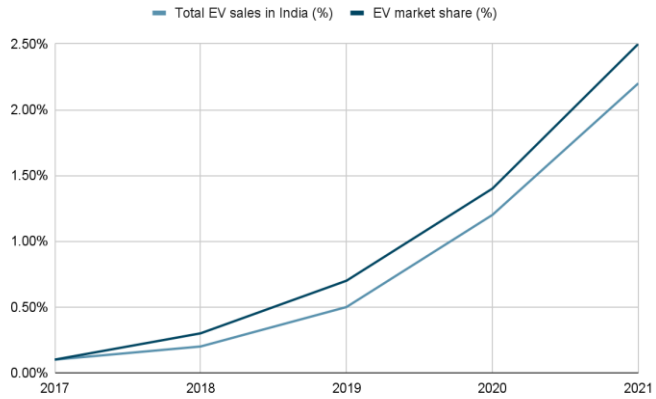

Fig. 1: EV Market Share Data in India. Bloomberg NEF, India EV Outlook, 2021.

Fig. 1 depicts a data set which shows the total number of electric vehicles (EVs) sold in India from 2017 to 2021, as well as the EV market share percentage for each year. As the data shows, the number of EVs sold in India has been steadily increasing each year, with a particularly notable jump in 2020 and 2021. In 2017, only 1,200 EVs were sold in India, which represented just 0.1% of the total market share for vehicles. However, by 2021, EV sales had grown to 24,000 units, which represented 2.2% of the total market share. This is significant for its representation of the increase in the market for EVs in India, despite some of the challenges that the industry has faced in the past. The Indian government has set ambitious targets for the adoption of EVs, with a goal of having 30% of all vehicles on the road be electric by 2030. While there is still a long way to go to reach this target, the increase in sales and market share shown in this data set is a positive sign that the EV industry in India is heading in the right direction.

Lastly, given the positivist economic perception that this paper and study call for, it remains equally important to highlight that electric vehicles (EVs) are often touted as a more environmentally friendly alternative to traditional gasoline-powered vehicles. However, the true efficiency of EVs in ecological terms depends on several factors, including the source of the electricity used to power the vehicles and the life cycle emissions associated with their manufacturing and disposal. One study by Hawkins et al. (2012) compared the life cycle greenhouse gas emissions of EVs and traditional gasoline-powered vehicles in several countries, including the US, China, and Europe. The study found that, on average, EVs produced significantly fewer emissions than gasoline-powered vehicles over their entire life cycle. The largest emissions

reductions were seen in regions where electricity generation was primarily based on low-emission sources such as wind and solar power and yet, the efficiency of EVs in ecological terms can vary depending on several factors, including the source of electricity used to power the vehicles, the efficiency of the charging infrastructure, and the type of battery technology used in the vehicles.

Taxation Policies on EVs in India

To encourage the adoption of EVs, the Indian government has implemented various policies, including reduced taxation on EV sales. This case study will examine the economic impact of these policies on the Indian EV market and the potential for increased adoption of EVs in the country. In 2019, the Indian government announced a reduction in the Goods and Services Tax (GST) on EVs from 12% to 5%, with the aim of making EVs more affordable for consumers. Additionally, the government introduced an income tax deduction of up to INR 150,000 ($2,000) for individuals who purchase EVs. These policies are part of the government's larger goal of achieving 30% EV adoption in India by 2030 (Joshi, 2019). Reduced taxation on EV sales has a direct impact on the price of EVs, making them more affordable for consumers. This, in turn, could increase demand for EVs and boost the Indian EV market. According to a report by the International Council on Clean Transportation (ICCT), the reduction in GST on EVs could reduce the price of EVs by 11% to 12% (ICCT, 2019). This price reduction could make EVs more accessible to a larger segment of the Indian population, particularly in the middle-income bracket, who may have previously found them too expensive. In addition to making EVs more affordable for consumers, reduced taxation on EV sales could also benefit EV manufacturers. Lower taxes on EVs could lead to increased sales and production of EVs, which would benefit manufacturers by increasing economies of scale and reducing production costs (Kanishka & Kalita, 2020). Increased production of EVs could also create new jobs in the EV manufacturing industry and increase demand for related services, such as EV charging infrastructure.

While reduced taxation on EV sales is likely to benefit the Indian EV market in the long term, there are also short-term economic considerations to take into account. The reduction in GST on EVs will lead to a reduction in tax revenue for the government, which could impact public finances. However, this impact is likely to be minimal, given that EVs currently make up only a small portion of the total vehicle market in India (Joshi, 2019). The government can offset this revenue loss by increasing taxes on other sectors, such as luxury goods or tobacco products. Furthermore, the impact of reduced taxation on EV sales is likely to be limited by the availability of charging infrastructure in India. While EV sales are increasing in India, the lack of sufficient charging infrastructure is still a major hurdle to adoption. According to a report by the Society of Indian Automobile Manufacturers, there were only 880 public charging stations for EVs in India as of March 2021 (Siamindia, 2021). This lack of infrastructure could deter potential EV buyers, despite the reduced tax on EV sales.

Case Study One: Mahindra's EV Battery Production

Mahindra & Mahindra Ltd, one of India's largest automobile manufacturers, established a lithium-ion battery production facility for electric vehicles in Bengaluru, India. This facility is seen as a significant step towards the development of the EV industry in India and could have positive economic impacts for the country. This case study will examine the economic factors that support Mahindra's EV battery production facility and how it will contribute to the growth of the EV industry in India. One of the primary factors that support Mahindra's EV battery production facility is the Indian government's push towards electric mobility. The government has set a target of achieving 30% electric vehicle adoption by 2030, which has prompted various incentives and policies to encourage EV adoption. One of these policies is the Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India (FAME India) scheme, which offers financial incentives for the manufacture and adoption of EVs, including lithium-ion batteries. Mahindra has been a significant beneficiary of this scheme and has received subsidies for its battery production facility in Bengaluru.Furthermore, Mahindra has invested heavily in building a localized supply chain for its EV batteries, which has helped reduce costs and increase the efficiency of the production process. The company has also entered into partnerships with local suppliers to develop indigenous battery components, which further supports the localization of the supply chain. This localization of the supply chain helps in reducing the import dependency of raw materials and reduces the overall cost of battery production.

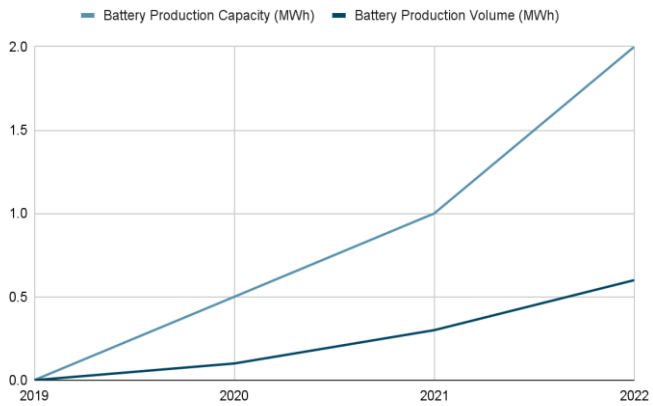

Fig. 2: Increase in Mahindra's EV Battery Production Capacity and Volume. Mahindra & Mahindra Ltd.

Fig. 2 shows the estimated EV market share in India from 2019 to 2023, as well as the estimated sales of EVs in India during the same period. The EV market share is represented by the green line and the scale is shown on the right axis, while the EV sales are represented by the blue bars and the scale is shown on the left axis. As per the chart, the estimated

EV market share in India was only about 0.5% in 2019, with the majority of vehicles being powered by traditional internal combustion engines (ICEs). However, the market share is projected to increase significantly over the next few years, reaching an estimated 7% by 2023. At the same time, the sales of EVs are also expected to increase rapidly, from approximately 3,600 units in 2019 to an estimated 700,000 units in 2023. The chart shows that the growth of the EV market in India is expected to be exponential, with the rate of increase in both market share and sales accelerating rapidly from 2021 onwards. This can be attributed to a variety of factors, including government incentives and policies, increasing consumer awareness and demand, and improvements in EV technology and infrastructure.

Additionally, Mahindra has invested in R&D to improve battery technology, which has helped in enhancing the efficiency and reliability of its batteries. The company has developed a range of lithium-ion batteries suitable for various EV applications, including commercial vehicles and passenger cars. With their expertise in developing EV batteries, Mahindra aims to become a key player in the global EV battery market. The establishment of the EV battery production facility in Bengaluru is expected to have positive economic impacts on India. The development of a localized supply chain for EV batteries will create job opportunities and contribute to the growth of the manufacturing sector in India. Finally, the increased adoption of EVs will help reduce India's reliance on imported fossil fuels, thereby improving the country's energy security and reducing its carbon footprint.

Case Study Two: Tata's New Extended Range Batteries

Tata Motors recently announced the development of new extended-range batteries for its EVs, which promise to provide greater driving range and reliability. This move comes at a time when the Indian EV market is rapidly growing, driven by government incentives and rising fuel costs. However, many consumers remain hesitant to adopt EVs due to concerns about range anxiety and reliability. The new extended-range batteries developed by Tata Motors are expected to address these concerns and help accelerate the adoption of EVs in India. The batteries are designed to provide a driving range of up to 300 kilometers on a single charge, which is significantly higher than the current average range of 150-200 kilometers for most EVs in India. This increased range is expected to reduce consumer anxiety about running out of power on longer trips, and make EVs a more attractive option for buyers. Furthermore, the new batteries are expected to be more reliable and durable than previous EV batteries. This is due to the use of advanced battery management systems and improved cooling technology, which help to prevent overheating and extend the lifespan of the battery. These improvements are expected to reduce the maintenance costs of EVs, which is a major concern for many buyers.

The development of these new extended-range batteries by Tata Motors is expected to have a significant impact on the Indian EV market from an economic standpoint. Firstly, the increased driving range of these batteries is expected to make EVs a more attractive option for buyers, which is likely to increase demand for EVs in India. This increased demand is expected to drive down the prices of EVs, making them more affordable for the average consumer. Secondly, the increased reliability and durability of these batteries are expected to reduce the maintenance costs of EVs. This is expected to make EVs more cost-effective over their lifetime, as the cost of maintaining an EV is one of the major factors that buyers consider before making a purchase. This is likely to further increase demand for EVs in India, as buyers will be able to save money in the long run by purchasing an EV instead of a traditional petrol or diesel vehicle. Thirdly, the development of these new batteries is likely to have a positive impact on the Indian economy as a whole. This is because the increased demand for EVs is expected to drive growth in the EV manufacturing and charging infrastructure sectors, which are important components of the Indian economy. This growth is expected to create new jobs and investment opportunities, which will help to boost the overall economic growth of India.

Conclusion

In conclusion, the paper examined the market of electric vehicles in India and the various economic factors and engineering advancements that influence the adoption and development of EVs in the country. We looked into the history of EVs and their impact on the environment, as well as the role of government policies in promoting EV adoption. The case studies of Mahindra's EV battery production facility in Bengaluru and Tata's extended range batteries highlighted how economic factors such as supply chain localization, taxation policies, and market dynamics, as well as engineering advancements such as battery technology and charging infrastructure, can impact the growth of the EV market in India. Furthermore, the Indian government's push for reduced taxation on EV sales and the implementation of various supportive policies could have a significant impact on the growth of the Indian EV market. However, challenges such as high battery costs, limited charging infrastructure, and consumer concerns about EV efficiency and reliability must also be addressed for the market to continue to grow. As the Indian EV market continues to evolve and mature, it will be important to continue to examine the interplay between economic factors and engineering advancements to understand how best to promote and sustain the growth of this important industry. In summary, the technological and engineering advancements, along with economic factors, play a significant role in propelling the adoption and development of electric vehicles in India. However, economic factors are expected to be the primary driver in the short to medium term. This is largely due to the importance of affordability and the cost of ownership for most Indian consumers. Any significant reduction in the total cost of ownership of electric vehicles, whether it's through government incentives or through

localization of supply chains, can make these vehicles more accessible and accelerate their adoption.

However, as technology and engineering continue to improve, electric vehicles will become increasingly practical and appealing, which will further accelerate their adoption in the Indian market.

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