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Impact of Fire Risk on Consumer Buying Behavior towards Electric Vehicles

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Abstract

Electric and hybrid vehicles are becoming more and more popular. As gas and fuel prices become higher and higher consumers are definitely interested in Electric vehicles (EVs) as a sustainable mode of transportation due to their cheaper technology. However, accessibility, convenience, and price remain significant concerns for potential buyers. The first electric vehicle was a three-wheeler that was launched in India in 1996. Electric vehicle sales in India have reached a historic milestone this year, crossing the 2 million mark for the first time. Consequently, the penetration of EVs in India's overall vehicle market has increased to approximately 8%, up from 6.8% observed during the previous year to carry forward the momentum of EV adoption. Electric vehicles have come a long way since their first introduction, but this rapid growth has presented certain challenges, especially regarding fire safety. Although any fuel based car or truck has certain inherent safety issues, EVs have some specific fire safety problems related to their electric mechanism. From 2010 to June 2023, 393 electric vehicles out of 30 million caught fire worldwide. As electric vehicle numbers grow, the fire risk will also increase. Hence it's crucial for consumers to understand the fire risk associated with buying these EVs while contributing to a sustainable transportation future. One of the primary objectives of this article is to identify the fire risk of EV, its causes and impact on buying behavior of consumers. This article will also help manufacturers in addressing the fire risk and challenges of EV market proactively.

Keywords*: Electric Vehicles, Fire Risk, Fire Safety, Consumer Buying Behavior*

1. Introduction

India's Electric Vehicle (EV) sector is experiencing rapid growth, fuelled by government incentives, rising environmental concerns, and technological advancements. With initiatives like the Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME) scheme, India aims to significantly increase EV adoption, revolutionizing its transportation landscape towards sustainability and innovation. 2024 was a positive year for sales of electric vehicles (EVs) in India with the growth of 27% that the industry observed as compared to sales in the year 2023. In the year 2024, total 19,49,114 EVs were sold across India out of which 18,39,898 two-wheelers and three-wheelers together have an overwhelming 94% share of total EV sales in India.[1]

Table 1. Electric Vehicle Retail Sales

ELECTRIC VEHICLE RETAIL SALES IN INDIA FROM JANUARY 1 TO DECEMBER FIRST-HALF 2024													
INDIA EV INC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
CY2024	1,45,064	1,41,740	2,13,068	1,15,898	1,40,661	1,40,137	1,80,168	1,57,266	1,60,470	2,19,548	1,92,722	1,42,372	**19,49,114**
CY2023	1,02,885	1,07,216	1,40,922	1,11,362	1,58,467	1,02,644	1,16,623	1,27,212	1,28,555	1,40,386	1,54,157	1,41,957	15,32,386
% change	41%	32%	51%	4%	-11%	37%	54%	24%	25%	56%	25%	0%	27%
Data: Vahan, January 4-2025													

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As the EV market continues to grow in emerging Indian markets, it's crucial for consumers to understand the risks and protection associated with owning an electric vehicle. With the development of EV ecosystems progressing rapidly, consumers and manufacturers must be proactive in addressing the risks and challenges of EV ownership while seizing the opportunities to contribute to a sustainable transportation future. Following are the risks Associated with Owning an Electric Vehicle. [2]

- **Limited Range and Battery Replacement Costs**
  One of the drawbacks associated with driving an EV is the limited range and potential battery replacement costs.
- **Charging Infrastructure**
  Electric vehicles rely on charging infrastructure, and the limited public charging infrastructure can be a concern for potential EV consumers.
- **Fire Risk**
  EV batteries can overheat and catch fire, especially during accidents or improper charging.

With more of consumers considering the switch to electric vehicles, all the above risks question about their safety especially when it comes to the risk of fire and hence it's important to know why and how often these incidents actually happen. There have been several incidents of electric vehicle (EV) fires in India, including in Bengaluru and other cities. Electric vehicle fires stem from thermal runaway, which occurs when a battery cell short circuits and heats up uncontrollably. This may happen in a serious crash if the battery is damaged and compromised. Though EV fires are less likely to occur than other vehicle fires, an EV fire burns at a hotter temperature, releases flammable gasses and runs the risk of reignition even after being extinguished. [3]

Common Causes of Electric Vehicle Fires:

- **Thermal Runaway:** This is the most common cause of fires in EVs. It occurs when the battery overheats, leading to a self-sustaining reaction that can result in a fire.
- **Collisions:** In severe accidents, damage to the battery can lead to short circuits or punctures, increasing the risk of a fire.
- **Charging Issues:** Improper charging practices, such as using defective chargers or charging in extreme temperatures, can also lead to overheating and fires.

2. Literature Review

The global shift towards electric vehicles has been marked by a significant milestone in 2023, with over 14 million light-duty EVs, including battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs), sold worldwide. This transition, though promising for environmental sustainability, has raised concerns over the potential fire risks associated with lithium-ion batteries, especially in enclosed spaces like garages. From 2010 to June 2023, there were 488 light-duty EV fires reported globally, of which 393 were confirmed as lithium-ion battery fires. In a new report published by the International Council on Clean Transportation (ICCT), the number of electric vehicle (EV) fires and their relation to the global EV market share have been presented. Based on the data up to June 2023, report highlights a significant rise in EV fire incidents that correlates with the rapid expansion of EV adoption by consumers worldwide. [4]

While precise yearly data on electric car fires in India is limited, studies suggest that EV fires are indicating a rate of around 0.0012%. According to a 2024 report from the National Fire Protection Association (NFPA), the data shows that out of every 100,000 electric vehicles, approximately 25 catch fire annually. [5] While the risk of fire in electric vehicles (EVs) is relatively low, EV fires can present unique challenges, as they are not extinguishable using a traditional fire extinguisher. There are practical steps consumers can take to further minimize that risk and ensure their safety.

First and the foremost is to always use the manufacturer-recommended charging equipment. Charging EV with the proper equipment, especially in well-ventilated areas, helps prevent overheating and reduces the likelihood of charging-related fires. It's also important to avoid overcharging of the battery. But it is highly recommended to charge electric vehicles at a certified public charging station. The availability of public charging stations reduces concerns about running out of power and making EVs more practical for fire safety, increasing their

appeal. A well-developed charging network encourages more people to consider EVs, reducing the risk of fires and leading to increased sales and a faster transition to electric mobility.

Indian consumers have given more priority for public than home charging (58 percent and 42 percent, respectively) despite home charging is cheaper, more convenient, and more accessible. But 38 percent of consumers feel their nearby areas lack a sufficient network of charging infrastructure. Even though Indian consumers have limited access to home charging, two-thirds of the Indian consumers would prefer to buy an EV even if they could not charge at home. Hence, public charging station is the biggest influencing factor for further EV adoption. Consumers prefer public charging stations due to their charging speed (49%), costs (41%) followed by their fire safety features (28%). [6]

3. Methodology

The availability of an adequate charging infrastructure is vital for the extensive adoption of electric vehicles. However, in India, the charging infrastructure is still relatively underdeveloped and limited which can cause challenges and inconvenience for EV owners. The establishment of an extensive and reliable charging network is crucial to encourage more people to switch to electric vehicles. [7]

To verify the impact of public charging stations in the context of EV sales growth, the coefficient of correlation is calculated between the EV sales and operational public EV charging stations on the basis of data compiled in the following table showing state wise EV sales and operational public EV charging stations (OPCS) as on 02.02.2024.

Table 2. State wise EV sales and operational public EV charging stations

S. No.	State Name	EV Sales	OPCS	S. No.	State Name	EV Sales	OPCS
1	Uttar Pradesh	369102	582	12	Andhra Pradesh	56492	327
2	Maharashtra	241941	3079	13	Chhattisgarh	48794	149
3	Karnataka	179037	1041	14	West Bengal	45625	318
4	Tamil Nadu	131482	643	15	Punjab	44473	158
5	Bihar	112854	124	16	Haryana	42986	377
6	Rajasthan	109393	500	17	Jharkhand	25980	135
7	Madhya Pradesh	100314	341	18	Uttarakhand	19834	76
8	Kerala	83187	852	19	Jammu & Kashmir	13209	47
9	Delhi	80302	1886	20	Goa	11480	113
10	Gujarat	75760	476	21	Tripura	9616	18
11	Assam	68129	86	22	Chandigarh	6197	12
Total EV Sales		**18,76,186**		**Total OPCS**		**11,340**	

Data: Ministry of Heavy Industries, Posted On: 06 FEB 2024 3:02PM by PIB Delhi

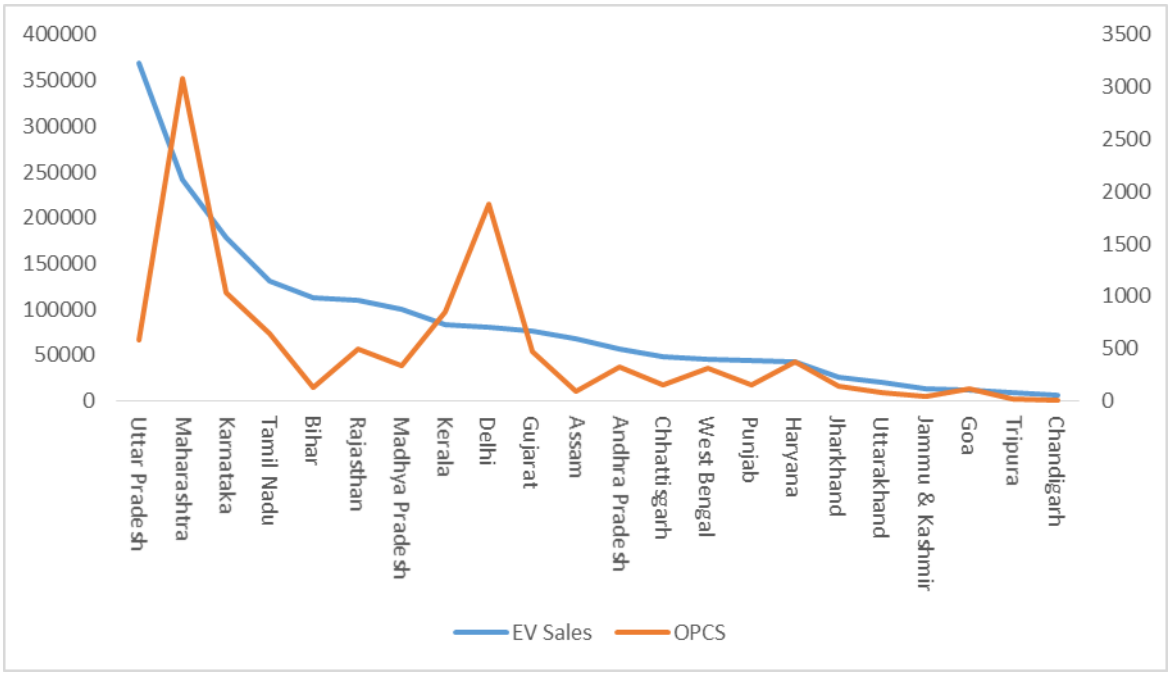

Fig. 1 EV sales and operational public EV charging stations

4. Results

In 2024, India saw a surge in EV sales, accompanied by a record expansion of public charging stations, suggesting a positive correlation between infrastructure and sales with 0.54 as a coefficient of correlation. It indicates that when charging infrastructure is more readily available, consumers are more likely to consider EVs as a feasible option. Hence deployment of public charging infrastructure in anticipation of growth in EV sales is crucial for widespread EV adoption by consumers. The result also shows that in India, there were around 165 electric vehicles per public charging point in 2024. However, it is expected that the public charging infrastructure will improve in the coming years, which in turn, will influence the rate at which EVs are adopted by consumers. A further discussion on the adequate charging infrastructure is given below.

5. Discussion

As the market penetration of EVs increases, public charging becomes increasingly important to support EV adoption by consumers who do not have access to private home or workplace charging options. If the total number of EVs per charging point is considered, the global average was about ten EVs per charger. Countries such as China, Korea and the Netherlands have maintained fewer than ten EVs per charger throughout past years. In countries that rely heavily on public charging, the number of publicly accessible chargers has been expanding at a speed that largely matches EV Sales. However, in some markets having widespread availability of home charging, the number of EVs per public charging point can be even higher. For example, in the United States, the ratio of EVs per charger is 24, and in Norway it is more than 30. However, the optimal ratio of EVs per charger will depend upon local conditions and consumers' need. [8]

India has established an objective to elevate the proportion of Electric Vehicle (EV) sales to 30% in private cars, 70% in commercial vehicles, 40% in buses, and 80% in two-wheelers and three-wheelers by the year 2030. This equates to an ambitious objective of 80 million EVs on Indian roads by 2030. To achieve this target, several policies have been implemented. To encourage the purchase of hybrid and EVs, the National Electric Mobility Mission Plan (NEMMP) was launched in 2013. Additionally, the Government of India, initiated the Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME) scheme to encourage the adoption of EVs by providing a range of incentives. Under this scheme, consumers are eligible for subsidies on electric scooters and motorcycles ranging from $24 to $380, and that of up to $1840 lakh for electric cars. But on the infrastructure side, a recent Confederation of Indian Industry (CII) report emphasized the necessity of establishing at least 1.32 million charging stations in India by 2030 to facilitate the rapid growth of electric vehicles, targeting 60 EVs per charger with over 4,00,000 installations annually. [9] Charging infrastructure

development is crucial for strengthening the appeal of EVs ensuring convenient and accessible charging options. As part of this initiative, the government has actively released tenders to expand the charging facilities across the country, contributing to the growth of electric mobility. This indicates growth in EV sales can only be sustained if charging demand is met by accessible and affordable infrastructure, through publicly accessible charging stations. [10]

6. Conclusion

The cases of EV fires have increased globally, especially with electric two-wheelers. Experts have identified potential fire incidents during charging due to battery defects, short circuits, overheating, voltage fluctuations and even negligence. As India's EV ecosystem expands exponentially, fire cases during charging have become a worrying trend. Addressing these concerns, governments and research institutions worldwide have initiated various measures and research programs aimed at mitigating EV fire risks. These initiatives range from developing efficient firefighting techniques and safety standards for EV batteries to revising building legislation to accommodate the unique needs of electric vehicles and their infrastructure. Manufacturers of EVs need to study the common causes of fire incidents and should set protocols and solutions in their EV models to prevent such incidents and protect people and property. The Ministry of Road Transport and Highways in India has taken initiatives in this regard to enhance fire safety standards for electric vehicles by introducing significant amendments to the Automotive Industry Standards. The Ministry also constituted an investigating team of independent experts to investigate the root cause of fires and recommend remedial measures. It has been observed a significant positive correlation between charging infrastructure and EV sales. The government plans to install EV chargers at most existing petrol pumps across the country. Parking spaces in apartment buildings, offices, malls, and other private establishments will also need charging facilities. Such infrastructure will not only allow easy EV charging access for consumers but also enhance fire safety**.** [11] One of the key findings of this work is to emphasize the importance of charging infrastructure development to minimize the risk of fire and enhance the adoption of EVs by the consumers.

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