What’s behind the EV fires?

At the end of March 2022, multiple cases of electric 2-wheeler catching fire were recorded across India. Come April, an electric 2-wheeler dealership was engulfed in fire and this put serious questions to the safety of EVs. Ola, Okinawa and Pure EV being the names in this list from the recent incidents took the media by a whirl. Questions around the suitability of product/battery for India, reliability of product developments cycles in start-up, robustness of regulations and quality standards being followed have taken the centre stage in E-mobility forums.

It is important to put these incidents in perspective and analyse recent trends to understand if these are specific to India, or to newer OEMs, or to automotive industry alone (context: batteries are used in a variety of other applications).

Firstly, the cases concerning EV fire in 2021 across the globe help us understand that EV fires are not unique to India, but have happened globally. In fact, these are not the very first cases, rather the bane of EV fires has existed ever since the mass production of EVs began in 2010. The list below provides recent examples of such incidents globally.

Location	**EV Brand / Model**	**Month**
America		
Illinois, USA	Chevrolet Bolt	Jul, 2021
Oregon, USA	Jaguar I-Pace	Aug, 2021
Georgia, USA	Chevrolet Bolt	Sep, 2021
Asia		
Chungcheongnam-do South Korea	Hyundai Kona Electric	Jun, 2021
Saga, Japan	Nissan Leaf	Aug, 2021
Russia	Nissan Leaf	Sep, 2021
Beijing, China	BYD Qin	Nov, 2021
Europe		
Skjeberg, Norway	Porsche Taycan	Apr, 2021
Müllingen, Germany	Hyundai Ioniq	Jun, 2021
Oslo, Norway	Hyundai Kona Electric	Jul, 2021
Warsaw, Poland	BMW i3	Jul, 2021
Groningen, Netherlands	VW ID.3	Aug, 2021
Kellmünz, Germany	VW ID.3	Aug, 2021
Kremenchuk, Ukraine	Nissan Leaf	Sep, 2021
Lunner, Norway	VW ID.3	Sep, 2021
Brühl, Germany	VW ID.3	Sep, 2021
Dumbrăviţa, Romania	VW e-Golf	Sep, 2021
Székesfehérvár, Hungary	Jaguar I-Pace	Oct, 2021
Chester, United Kingdom	BMW i3	Oct, 2021
Kristiansand, Norway	BYD Tang	Nov, 2021
Ravensburg, Germany	VW ID.4	Nov, 2021
Australia		
Victoria, Australia	Porsche Taycan	Oct, 2021

Table 1. Non-Exhaustive List of EV Fires in 2021

Secondly, EV fires are not unique to start-ups, but have happened across companies at various levels of maturity. Table 1 shows that OEMs such as BMW, BYD, GM Chevrolet, Hyundai, Jaguar, Nissan, Porsche and Volkswagen have experienced fire in one or more of their EV models. These major players being the early movers in the EV segment in their respective geographies, struggled with the EV fire incidents. Given that the Indian EV market is currently dominated by start-ups, the correlation between incidents of EV fire and start-ups is nothing but natural.

Lastly EV fires are not specific to EV industry, but have been a phenomenon across industries using Lithium-ion Battery (LiB). The widespread applications of LiB are not only limited to the EVs but across numerous essential devices. Continuous research and developments efforts in increasing energy storage efficiency and environmental sustainability of LiB has led to growing interest in their high potential. However, the exponential growth is hindered by the safety concerns raised by incidents of explosion and fire accidents in LiB powered devices including cell-phones, computer, e-cigarettes, hover boards and EVs.

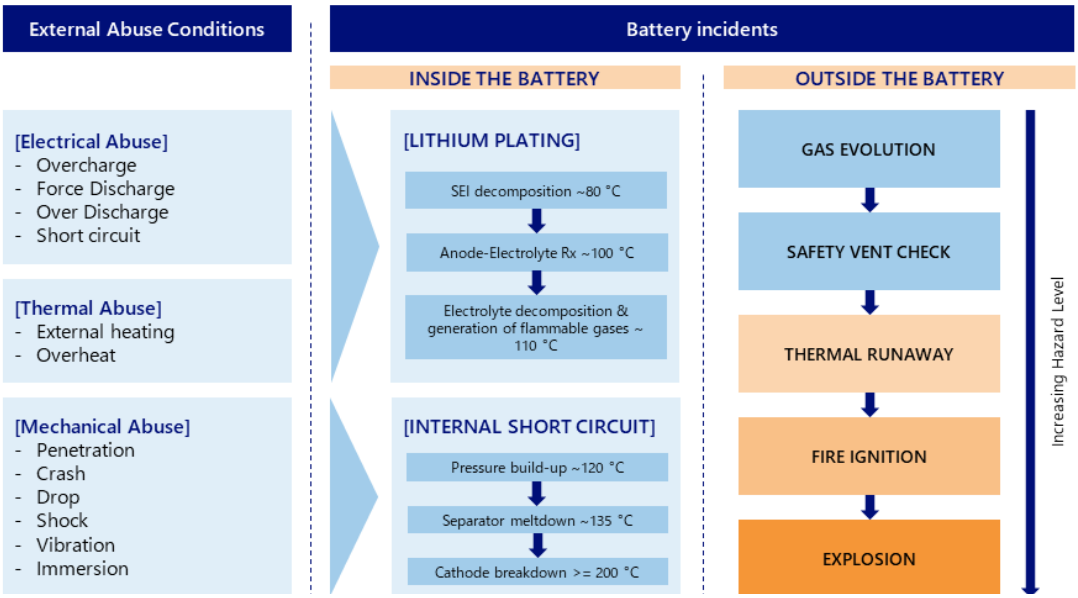
The case of Samsung Galaxy Note 7

Samsung Galaxy Note 7 is a discontinued Android-based cell-phone by Samsung Electronics. It was unveiled on 2 August 2016, officially released on 19 August 2016 and formally recalled worldwide on 10 October 2016. The recall resulted after several incidents of phone overheating and fire incidents. Following the recall, Samsung, along with UL LLC, Exponent, and TÜV Rheinland, performed internal testing and analysis to determine the exact causes of the defects. Samsung released its official findings on 23 January 2017. The investigation found that the battery failures were caused by short-circuiting of the battery electrodes as a result of manufacturing defects. Samsung also announced that all of its future battery-operated products would be subject to an "enhanced" eight-point inspection and testing protocol, including stricter visual inspections, as well as charge and discharge tests, Total Volatile Organic Compound tests, and accelerated usage tests.

Reasons for the fire incidents

The recent unfortunate incidents of fires in the electric vehicle segment has been analysed by multiple industry stakeholders and various technological challenges in usage of batteries have been analysed.

Indian OEMs and Battery manufacturers have a had a limited learning curve when it comes to battery manufacturing. There is stiff competition and every OEM is trying to adopt the batteries which offer very high energy density, Fast charging, application support (OTA, Real time data etc.), high no of battery cycles, lightweight and low cost batteries. In an effort to achieve the above there has been quality compromised in different ways and even there are OEMs importing batteries that are not tested in Indian conditions. There is the possibility of external abuse of batteries such as electrical, thermal, and mechanical abuse resulting in battery fire incidents.



In this whitepaper, we try and analyse some other peripheral challenges peculiar to the EV industry in India.

Yet-to-be-mandated regulations

Although there are stringent regulations for electric batteries in India, they have not been mandated yet. Until 2020, the AIS 156 and AIS 038 Rev 2 standards which cover both electric vehicles and batteries had not been introduced in the Indian market. Even today they have not been mandated and as a result many manufacturers continue to follow the older AIS 048 standard.

While the AIS 048 standard covers traction battery safety requirements for all L, M and N category vehicles, it has fewer compliance requirements and tests compared to the more stringent AIS 038 Rev 2 standard (for M & N category vehicles) and AIS 156 standard (for L category vehicles such as 2W, 3W and quad-cycles). AIS 048 standard covers testing at the cell, module and battery pack level, but does not cover any environmental test item, i.e. tests concerning impact of external environmental conditions such as temperature, humidity, vibrations. On the other hand, the AIS 038 Rev 2 and AIS 156 standards are equivalent to EU standards and include environmental and thermal propagation tests that cover the battery system, subsystem and entire vehicle.

Most importantly, these new standards have an additional fire resistance test which includes the EV battery being subjected to direct and indirect flame for over two minutes. It is expected that the implementation of the AIS 038 Rev 2 standard and the AIS 156 standard would reduce fire related accidents in India in the future.

Parameters		AIS 048	AIS 156	AIS 038 Rev 2
Introduction year		2009	2020	2020
Category (vehicle)		L, M and N	L	M and N
Scope of standard		Battery safety	Battery safety Vehicle safety	Battery safety Vehicle safety
Electrical Abuse Tests	Nail Penetration test	✓ (difficult for high energy density cells)	X	X
	Over-charge test	✓	✓	✓
	Short Circuit test	✓	✓	✓
Mechanical Abuse Tests	Roll-over test	✓	X	X
	Mechanical Shock test	✓	✓	✓
	Thermal Shock and Cycling test	X	✓	✓
	Vibration test	✓	✓	✓
	Mechanical Integrity test	X	X	✓
Environmental Tests	Fire Resistance test	X	✓	✓
	External Short Circuit Protection	X	✓	✓
Thermal Propagation Test	Over-temperature Protection	X	✓	✓
	Thermal Propagation test	X	X	✓

Table 2. Relative comparison of EV battery safety standards

While the AIS 038 Rev 2 and AIS 156 were prepared in September 2020 with significant inputs from the UN R136 regulations, the implementation of these standards have not yet become mandatory for electric vehicle manufacturers. The vehicles that have caught fire in India so far were mainly tested for the old standard (AIS 048) which only highlights the need for the tougher standards to be implemented properly.

According to a notification by the Ministry of Road Transport and Highways (MoRTH) dated 27 December 2021, the older standard (AIS 048) will be cancelled from Dec 2022 and the new standards (AIS 038 Rev 2 and AIS 156) will become mandatory from 27 December 2022.

Lack of awareness among users

India is an early stage market for electric vehicles and is dominated by start-ups in both – vehicle and battery manufacturing. Many firms have installed fast charging stations with high power output to charge electric batteries quickly. Experts from the electric vehicle space recently voiced their concerns about the batteries being overstrained due to rapid charging, which can be detrimental to the health of the battery by making the battery behave erratically and this could adversely impact thermal management.

Further, instances such as charging the batteries to 100% at high temperatures (typically above 50 degrees Celsius) or running the batteries to extremely low charge levels (deep discharging) can degrade the battery health significantly and also cause significant heating which may lead to thermal runaways. Creating awareness among consumers about good practices such as not charging up to 100% during high temperatures and avoiding deep discharges could help in preventing fires.

Business considerations leading to safety oversight

Cost-related considerations

Most players currently import the battery packs and have not invested enough in R&D of thermal management systems. Companies have not invested in active cooling systems as this adds to the already incompetent initial cost of EVs compared to ICE vehicles. Additionally, in the case of 2W and 3W category of vehicles, there is a space constraint as well for installation of such systems.

Time-to-market related considerations

India is a highly competitive 2W market and launching products at the right time is crucial to their success. Also being a price-sensitive market, many manufacturers use cheaper cells and in such cases, conducting thorough internal tests of the vehicle before rolling them out to market becomes very important. Rushing to market with a cheaper alternative of an electric battery might lead to safety issues. Thorough testing also important because of the variety of possible conditions on the Indian roads – high range of temperature, vibrations due to uneven terrain and other weather related challenges.

Product-related constraints

Electric vehicle battery manufacturers have been striving to increase the density of the electric batteries to achieve low weight and store much higher amount of energy than laptops and other household appliances by mechanical processes such as dense packing. This high density packing increases the risk of fires. There is a need to revisit the optimum product balance and battery chemistry with due consideration to safety while optimizing weight and efficiency.

Unfavourable external environmental conditions

In India, electric vehicles and their batteries are exposed to a wide range of temperature, dust, humidity and vibration due to terrain. There have been multiple comments from experts that suggest that purely high ambient temperatures are not the cause behind these fire related incidents and that these fire incidents are mainly caused due to internal or external short-circuits (internal defects or packaging issues) that cause thermal runaways.

Hence, to summarise, these incidents are understood to be mainly due to manufacturing or design related issues within the batteries than due to the external conditions such as high ambient temperatures. The underlying reasons behind these issues seem to be – cost-effective business considerations of manufacturers, less emphasis on battery testing and non-mandatory compliance with stringent regulations that have failed to keep pace with the recent technological developments. Recent incidents of fire however have definitely shifted the focus in the electric vehicle segment from price to safety.

Where does the buck stop?

Before giving any conclusions on who should be the torch bearers for leading the EV Industry towards a safer haven, we would first like to detail out the stakeholders involved in different stages of the value chain of EV business – right from R&D to the user stage.

Battery R&D, design, manufacture	OEM	Charging Infrastructure	Customers
• CATL • LG Energy Solutions • Panasonic • BYD • SK On	• Ather • Hero Electric • Ola • Okinava • Pure EV	• Delta Electronics • Mass-Tech • Amara Raja • Exicom • P2 Power Solutions • Magenta Groups • TATA Power	• Zomato • Swiggy • Amazon • Individual customers
Key responsibilities: • Battery R&D • Dimensions, size, weight of batteries • Electrical and mechanical connections	Key responsibilities: • Design of EV • Placement of battery • BMS • Liquid cooling system • Testing and certification • User training	Key responsibilities: • Set up of station • Proper electrical wiring • Charging of batteries on demand	Key responsibilities: • EV maintenance • Safe handling • Charging by home chargers

Table 3. Stakeholders in the EV value chain

From a legal point of view, the process of handling any mishap and the consequent liability is determined by two laws in India: Consumer Protection Act and Motor Vehicles Act (MVA), amended from time to time. In case of an incident, the very first task at hand is recalling the faulty EVs from roads to avoid similar incidents.

Previously, the product manufacturers, i.e. the OEMs were given the freedom to voluntarily recall faulty vehicles from roads. Later, MoRTH introduced a vehicle recall portal, wherein the vehicle users can lodge complaints of faulty vehicles and the vehicle would have to be recalled by the OEM. The OEM would have to pay the cost of vehicle to the user or replace the faulty vehicle with a fine. However, no fine is levied in case the recall order has been initiated by the OEM.

The recall order can also be issued suo moto by Central Consumer Protection Authority if there have been cases of defects in the vehicle. In addition, the product user can also claim compensation for any injury, illness, death or mental agony suffered due to the faulty product.

The second law governing the liability of any fault in a product is Consumer Protection Act, that puts liability of the product on 3 stakeholders – Product manufacturers, product sellers and product service providers. In case of EV, there is significant overlap between the manufacturers, the sellers and the service providers, most roles being served by the OEM Brand.

It is largely clear that the entire onus for defect in the vehicle lies with the OEM under the existing Indian laws. The problems, as seen in the recent fire incidents however, may lie with multiple stakeholders. The problems are multi-dimensional, and the causes for the fire incidents may range

from battery design, battery assembly to improper charging. It may be due to dysfunctional BMS, or the fact that E-2W cannot incorporate a liquid cooling system.

For example, in the recent Okinawa fire case, overcharging of the scooter was pointed out to be the foremost reason behind the incident. Overcharging leads to build up of Lithium across the electrodes that leads to an internal short circuit. Hence, proper functioning of charging infrastructure is necessary to avoid such incidents. If charging is done for a longer time than required or if the temperature of the battery inside the EV at the time of charging is already high, it increases the chances of the battery catching fire. Battery swapping is proposed to be a solution to this problem. If the battery is charged in a controlled environment outside the EV with continuous monitoring by the service provider, it is expected to reduce the chances of fire.

However, eventually it is the OEMs who are responsible for testing the batteries before integrating them with the EV. The BMS and other safety components like the busbar are also manufactured by the OEMs or sourced from domestic startups. They function like an MCB and give warning to the user about the possibility of thermal runaway due to overcharging or improper use that leads to overheating of batteries. The fact that these incidents have so frequently taken place indicates that somewhere these safety systems have failed to deliver.

Going one step backwards, we should not overlook the fact that most of the batteries in India are imported from China, South Korea and other South Asian countries. Improper design in terms of loose electrical wiring and placement of cells by the manufacturers in these overseas plants may also be one of the causes of the incidents. The MVA dictate that in case Indian laws do not apply on the manufacturer of any product, the product seller in India would be held responsible for any default in the product. Hence, lack of jurisdiction of Indian laws over these battery manufacturers makes the importing OEMs responsible for the incidents.

Hence, the buck stops with the OEM in various possible scenarios. Undoubtedly, there can be irregularity on part of multiple stakeholders, but the central point of accountability hovers around the OEM, that has to check and balance these irregularities at every point.

Course of action

Investigation Probes

EVs being a new and popular concept for the Indian masses, the recent fire incidents have gardened considerable media attention. To prevent further fire accidents and also to flush out the anxiety that these incidents would have created on users about the OEM brand and EVs in general, it becomes imperative to conduct thorough investigations to identify the reason behind such accidents and introduce measures to prevent/correct them. In fact, the ministry of road transport and highways (MoRTH) has constituted an expert committee to examine EV manufacturing issues, especially those related to two-wheelers, and to recommend changes to the upcoming 'quality-centric' guidelines for manufacturers of electric vehicles (EVs).

Recall of EVs

Based on the Motor Vehicle laws for the geography in question EVs might be recalled in cases of multiple EV fire incidents. The case of Chevrolet Bolt and Hyundai Kona Electric are particularly notable. After more than 18 battery-related Chevrolet Bolt fire between 2019-2021, GM had to recall more than 140,000 Bolts. The problem was traced to the manufacturing defects at the plant run by its battery supplier, a subsidiary of LG Chem. Similarly, 90,000 Hyundai Kona Electric were recalled after around 15 reported fire incidents. In a first of its kind incident in India, Okinawa recently voluntarily recalled 3000 e-scooters from roads, citing consumer safety.

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