Lithium Ion Battery Fires in the News

Technology Innovation Spotlight

KEY TAKEAWAYS

- While lithium ion battery fires have gained media attention, the technology's overall safety record is **strong and continuously improving**.
- The likelihood and severity of fire and explosion associated with lithium ion batteries can be reduced through **good design**, which is already commonplace in batteries designed for **electric vehicle (EV) and grid storage**.
- Batteries used in passenger electric vehicles and grid storage are subject to **safety certification and testing** that substantially **reduce** the frequency and severity of failures.
- Micro-mobility products have exhibited **higher rates of failure** and failure intensity, most likely related to **less mature** quality control implementation, **fewer** regulatory safety protections, and common use of **unapproved** aftermarket components.

NEXT STEPS

Lithium ion battery safety is an active ongoing area for research, policy development, and education. EPRI is presently conducting research such as:

- Evaluation of battery cell and system failure characteristics to inform safety mitigation technologies.
- Development of incident response guidelines.
- Stakeholder safety training and education.

For more information, visit EPRI's Energy Storage Safety Wiki Page and EPRI Technical Update, *Lessons Learned: Lithium Ion Battery Storage Fire Prevention and Mitigation—2021* (3002021208).

Like all energy equipment, lithium ion batteries provide great value, but present risks. Battery risks have been reduced over time through product engineering and controls, and failure prevention and mitigation continues to improve. This brief puts the frequency of lithium ion battery failures in perspective, highlighting the safety differences across diverse applications – micro-mobility, EV, and grid-connected battery systems.

INTRODUCTION

Lithium ion batteries are used in a wide range of applications (e.g., stationary battery energy storage, EVs, consumer electronics, micro-mobility devices), driven by their high energy density, lightweight design, and decreasing costs. While all these applications use the same underlying battery cell technology, the full system design and architecture, manufacturing quality, safety requirements, and safety features of the products they are integrated into differ widely. The causes, frequency, and severity of failures consequently vary by product and application. Global lithium ion battery capacity is expected to increase 10-12x by 2030[1, 2] driven by transportation electrification and grid decarbonization. However, recent fires arising from lithium ion battery failures have created public concern and highlighted deficiencies in product engineering.

Lithium ion batteries can fail through thermal runaway, producing flammable gases that may lead to fire or explosion risks.[3] These risks can be managed through rigorous engineering and controls, just as hazards from natural gas, electrical equipment, and other energy infrastructure are managed.

FAILURES IN CONTEXT

News reports of battery fires in grid and mobility applications make for eye-catching headlines, but a review of the data paints a far more nuanced picture:

1. **Grid Scale Storage:** The failure rate for grid-scale Battery Energy Storage Systems(BESS) has decreased due to safety improvements, driven in part by increased regulation. EPRI's BESS Failure Database[4] tracks failure events in grid-scale storage worldwide. Over the last 4 years, there have been on average 10 such failure events annually, even as global battery deployments have increased 20-fold [5] (Figure 1).

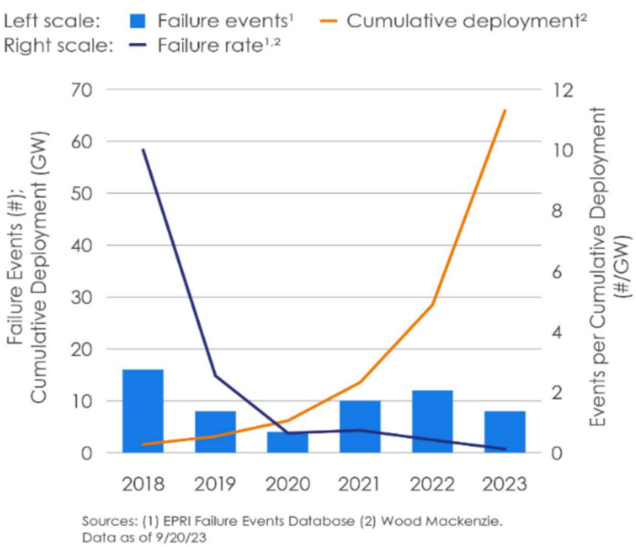

Figure 1. *Stationary BESS deployment and failure statistics*

Grid-scale storage is subject to a large family of codes and standards such as NFPA 855[6] and UL 9540.[7] These regulations impose clearance and separation distances, fire suppression, and venting or explosion control for BESS, among other requirements intended to reduce risk.[8] In addition, the failure events in 2018 and 2019 led to EPRI's BESS Fire Prevention and Mitigation Project,[9, 10] and other voluntary industry efforts to improve safety.

Lessons learned from failure events have been incorporated into newer BESS deployments, and ongoing efforts such as the NY Inter-Agency Safety Task Force bring together diverse groups of stakeholders to continue to improve stationary BESS safety. EPRI recommends conducting a full Hazard Mitigation Analysis,[11] developing an Emergency Response Plan, conducting failure air plume modeling,[12] and training first responders to address the public health and safety impacts of grid scale BESS failures.[13]

2. **Passenger EVs:** A comparison of several fire incidence datasets in Table 1 suggests that EV fires are far less likely than fires in vehicles powered by internal combustion engines (ICE), even after accounting for the significant difference in miles driven. While ICE vehicle fires are sufficiently commonplace to be considered unremarkable, EV fires are still rare enough that they attract special attention from the media. In addition, the long experience with ICE vehicle fires has led to well-established protocols, but the relative novelty of EV fires has left some first responders as yet unprepared.

In the U.S., passenger EV models are rapidly gaining consumer acceptance and are expected to continue to grow in numbers because of their superior performance as well as their climate and air quality benefits.

Electric utilities, automakers, and entities like the National Fire Protection Association (NFPA) have been working together on EV fire safety since the late 1990s. Codes and standards such as GTR 20[16] and SAE J2344[17] have been implemented. While EV fires are rarer than ICE vehicle fires, different challenges and risks exist in the response to lithium ion battery fires. Appropriate first responder training is necessary to address electrical, chemical, fire, and explosion hazards, and to avoid circumstances under which the battery could re-ignite. Existing training resources include those provided by standards organizations including NFPA,[18] as well as the vehicle manufacturers themselves.[19] The industry continues to improve best practices around fire response.

Table 1. *Fire incidence rates from two studies with different methods and metrics*

VEHICLE TYPE	LIKELIHOOD OF FIRES IN SWEDEN, 2018 TO 2022[14]	LIKELIHOOD OF FIRES IN U.S., 2012–2021[15]
EV	1 in 30,550 EV	1 in 210 million miles (Tesla vehicles)
ICE	1 in 1,294 ICE	1 in 19 million miles†
Approximate Incidence Ratio	23:1	11:1

† Unclear if refers to "all vehicles" or "non-EVs"

There have been reports[20] of fires in flooded EVs during natural disasters. As with all electrical equipment[21,22] batteries are susceptible to failure during extreme weather events such as floods. While management of floodwater-related fires in ICE vehicles is well understood, some work must be done to train disaster response personnel in appropriate protocol for EVs.

3. **Micro-mobility:** Fires from failures of electric bicycles, scooters and other micro-mobility devices are increasing. From January 1 to June 30, 2023, the vast majority of lithium ion battery fires in transportation applications, as well as the vast majority of injuries and fatalities, occurred in these vehicles[23] (Figure 2).

January - June 2023	Battery Fires	Injuries	Fatalities
Passenger EVs	44	15	4
Electric Buses	3	0	0
Electric Trucks	2	0	0
Micromobility	500+	138	36

Figure 2: *Global battery fire statistics in electric transportation (Source: EVFireSafe.com)*

Data specific to New York City is presented in Table 2.

Table 2. *Injuries from micro-mobility fires in New York City*[24]

	2019	2022	2023
Micro-mobility Fire Injuries	13	147	87 by July 27

Recent fatal incidents involving micro-mobility devices while charging in high-density residences prompted proposed bans in New York City public housing.[25, 26] Safety standards exist for these devices (e.g., ANSI/CAN/UL 2272,[27] 2271[28] and 2849[29]), but some manufacturers fail to adhere to these standards.[30, 31] Representatives from a battery industry consortium have publicly recognized concerns about the prevalence of aftermarket and third-party components, which may not meet product certification standards, and which may result in a significantly higher probability of failure resulting in fire during charging.[32] This consortium has also recently initiated investigations of the increased safety risks. This is crucial, as electric scooters, hoverboards, and bikes are often charged indoors, potentially with charging devices not designed for the product, significantly increasing the risk of injury and death in the event of a failure. A great need exists for public education on safe practices for operating, charging, and repairing micro-mobility devices by authorized entities.

CONCLUSION

Lithium ion batteries enable important technologies and services, including consumer electronics, transportation, and a decarbonized power grid resilient to extreme weather. Fire and explosion hazards associated with lithium ion batteries can be mitigated. Large-format batteries used in passenger EVs and grid-scale storage are subject to certification and testing that reduce the frequency and severity of failures. Even with the rapid growth in deployments, failure incidents in these applications are infrequent. Regardless, failures are an avoidable tragedy, and the lessons learned must be applied to further reduce the possibility of future incidents. With proper installation and planning, failures that occur can be managed safely. Lessons learned from events have been applied to new storage facilities and are being integrated into building and fire codes and standards. In contrast, the U.S. Consumer Products Safety Commission reports suggest micro-mobility products require increased implementation of quality controls and certification to reduce the increasing frequency of failure incidents. Lithium ion battery safety is an ongoing focus area for research, regulatory development, and continuing education.

REFERENCES

For more information and references, visit https://msites.epri.com/ms/sectors/0tiz12/technology-innovation-spotlight-report#230548828-161089571.

About EPRI

Founded in 1972, EPRI is the world's preeminent independent, non-profit energy research and development organization, with offices around the world. EPRI's trusted experts collaborate with more than 450 companies in 45 countries, driving innovation to ensure the public has clean, safe, reliable, affordable, and equitable access to electricity across the globe. Together, we are shaping the future of energy.

EPRI CONTACTS

POORVI PATEL, *Manager Strategic Insight*
704.232.4551, ppatel@epri.com

LAKSHMI SRINIVASAN, *Principal Team Lead*
202.291.7512, lsrinivasan@epri.com

STEPHANIE SHAW, *Technical Executive*
650.855.2353, sshaw@epri.com

EPRI PRINCIPAL INVESTIGATOR

ABHISHEK JAGDALE, *Strategic Insight Engineer II*
360.310.6564, ajagdale@epri.com

CONTACT STORAGE SAFETY

Storage-Safety@epri.com

For more information, contact:

EPRI Customer Assistance Center
800.313.3774 • askepri@epri.com

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EPRI

3420 Hillview Avenue, Palo Alto, California 94304-1338 USA • 650.855.2121 • www.epri.com