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Are electric vehicles a fire risk?

Summary of current research and data

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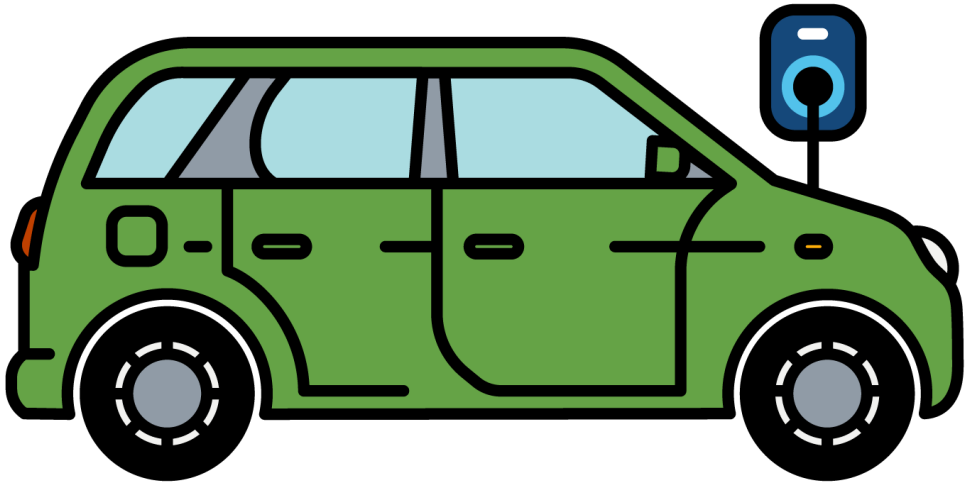

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Summary

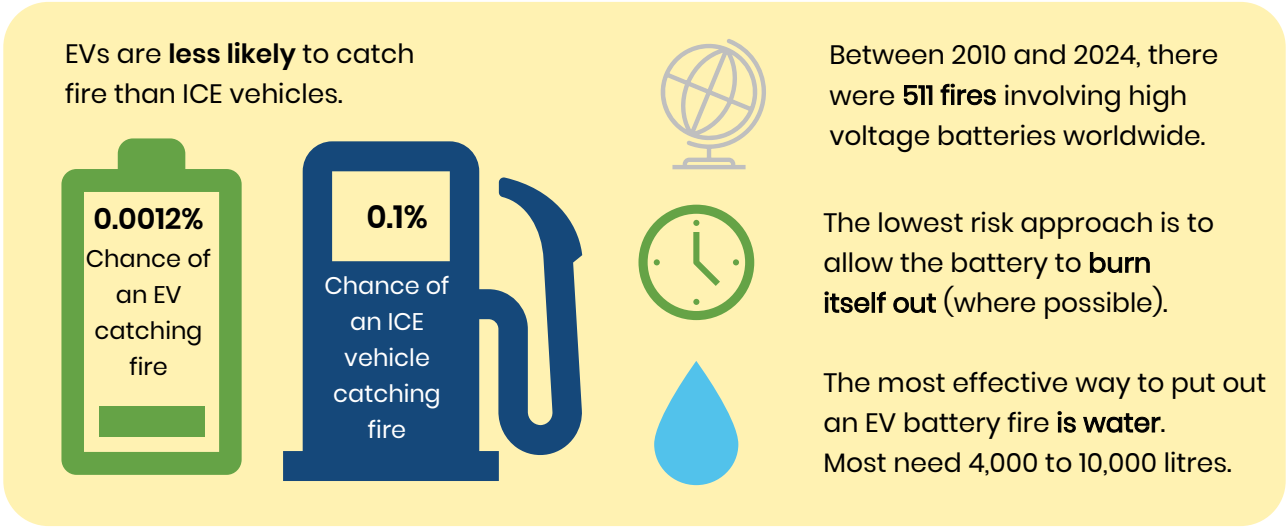
Fire risk from electric vehicles (EVs) has been a persistent concern since the early days of modern EVs, fuelled by online and mainstream media misinformation. Stories have included EVs bursting into flame while driving or charging, to EVs being the main cause of major fires and infrastructure collapses. There has also been some confusion in recent years between EV fires and fires involving other battery powered vehicles, such as ebike and escooters.

Studies have shown that EV fire properties are similar to those of ICE vehicles, with the battery pack representing a minor contribution. When EV fires involve the high voltage battery, they present different hazards for fire and rescue services – and can be more difficult to extinguish. However, current research indicates that the chance of an electric vehicle catching fire is considerably lower than for an internal combustion engine (ICE) vehicle which uses petrol or diesel.

A range of organisations have developed guidance on minimising the risk from EV fires, but there is no current legal standard for EV fire risk assessment or mitigation. Data on EV fires involving the high voltage traction battery has been collected and analysed by EV Firesafe.

This guidance will provide an overview of current research on EV fire risk and mitigation measures that councils, car park owners, operators or developers could implement.

We are not fire risk experts. We have provided links to further reading at the end, and to sources throughout. If you need more information, we recommend contacting the authors of the original work.



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What causes EV fires?

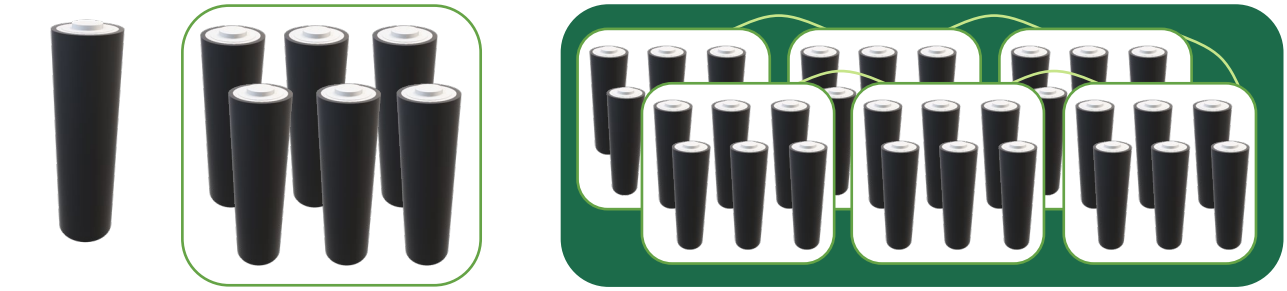
There are many similarities between ICE vehicles and EV fires, including how they start and are managed. The top three causes of vehicle fire are arson, electrical fault and accidents – which impact all vehicles. Some EV fires only affect the body, and these are treated like any vehicle fire.

Most EV fires start within the vehicle. Some then spread to the high voltage (HV) traction battery used for driving. Only 4% of EV fires were caused by an external fire spreading to the EV.

Makeup of EV high voltage batteries

High voltage battery packs in EVs are made up of individual battery cells contained within battery modules. Modules are connected in series to complete the battery pack.

Figure 1: the composition of an EV traction battery

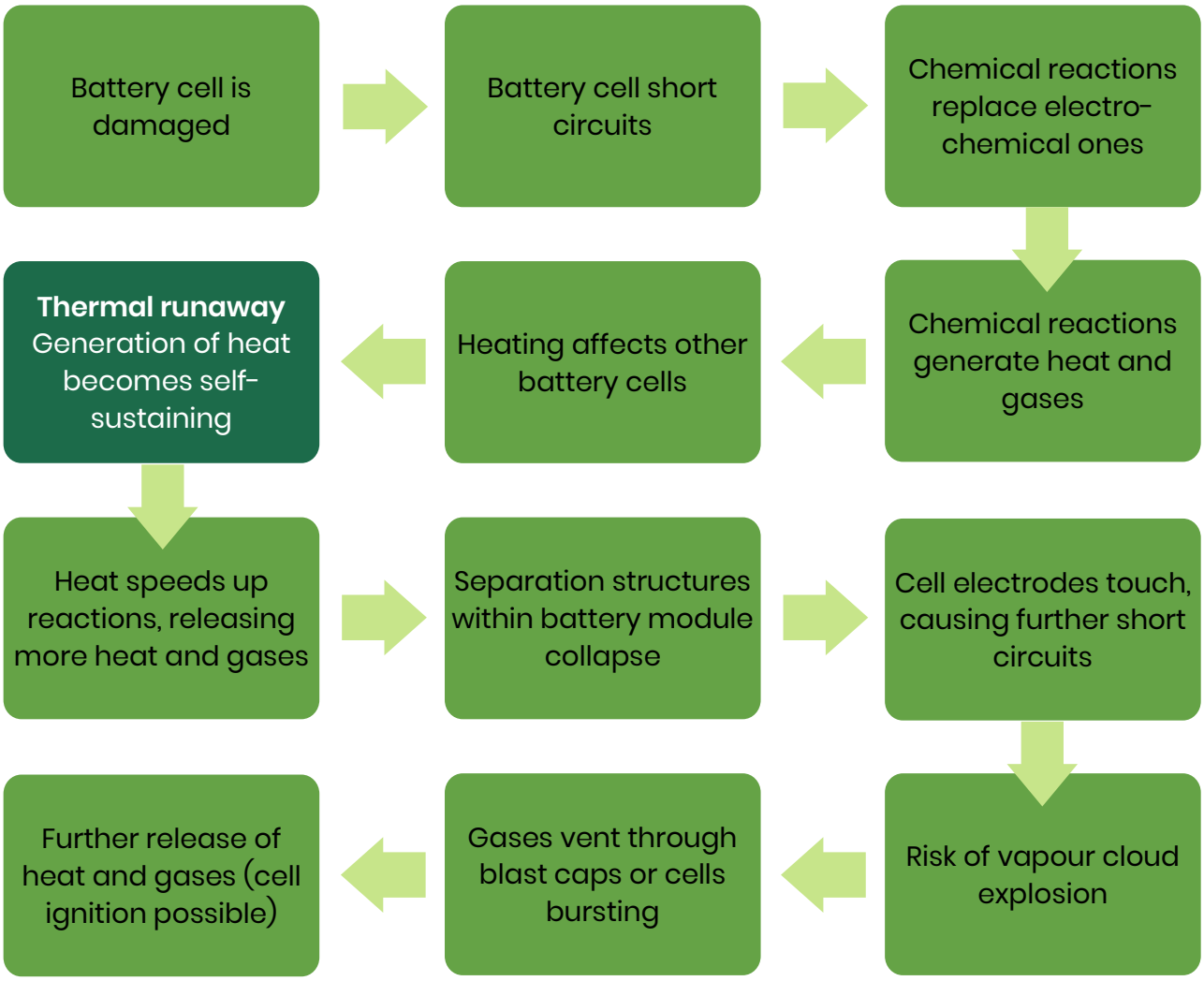


Battery cell **Battery module** **Battery pack**

EV fires involving the high voltage battery pack

When the HV battery is involved in a fire, the fire always starts in the same way. Cells release stored chemical energy leading to a chain of chemical reactions called **thermal runaway** – even when the original cause of the fire was different. Thermal runaway occurs when a battery cell creates more heat than it can dissipate, leading to rapid, uncontrolled release of heat and toxic gasses.

Figure 2: events leading to thermal runaway in the HV battery pack of an EV

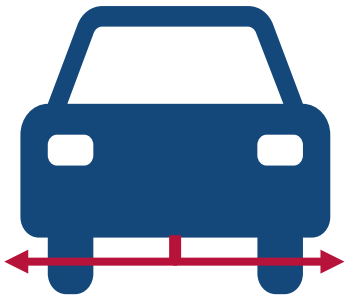


Risks from high voltage battery fires

Release of gasses (off-gassing)

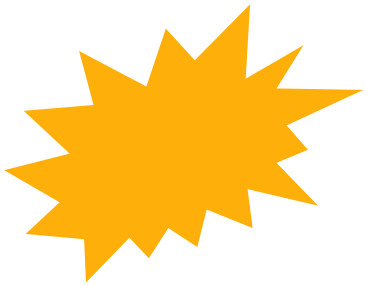
When heated, the electrolytes in the battery cells vaporise, forming a flammable cloud (often referred to as a vapour cloud). The makeup of this cloud, its toxicity and flammability, depend on a range of factors including the specific battery chemistry, form, state of charge and total capacity. All vapour clouds should be treated with caution.

Directional flames



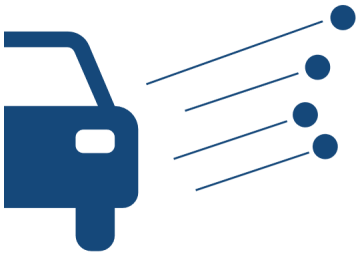
EV battery packs are often located under the floor of the vehicle. As gasses are vented from damaged battery cells, they can create directional 'jet like' flames issuing from underneath the vehicle and venting to either side. These flames are at a similar heat to those from an ICEV (800-1000°C) but can burn for longer.

Vapour cloud explosion



If the HV battery enters thermal runaway and begins off gassing in a confined space with limited ventilation (such as basement or multi-storey car parks), where gases are unable to escape, they can build up and may explode if the cloud comes into contact with an ignition source.

Debris projectiles



All vehicle fires will produce some debris and projectiles however EV fires may pose an additional risk as gasses vent from the HV battery, which may cause some additional debris as thermal runaway starts.

Secondary ignition

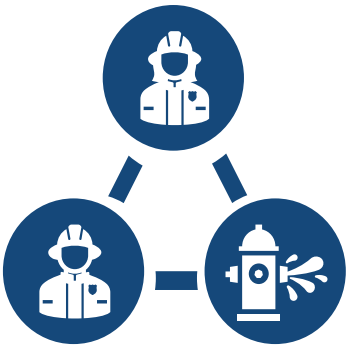
EV battery fires take longer to extinguish and may reignite either on scene, during transport or at the storage facility. On scene, EVs should be monitored for at least 60 minutes once the fire is suppressed. Recovery drivers should be briefed, and the vehicle should be loaded onto a flatbed where possible.

Once in storage, monitoring for heat, vapour and flames should continue. The EV should be stored away from structures and vehicles if possible.

Electrocution from high voltage components

The main mitigation steps against electrocution risk when dealing with a HV battery fire, are to wear appropriate personal protective equipment. Always assume the vehicle is energised and avoid contact with orange HV components. Research has found very little risk from suppression (if using an unbroken stream of water), extraction of vehicle occupants, submersion in water, as a result of stranded energy in the (damaged) battery pack or cells. There have been no reported cases or near misses globally in the data analysed by EV Firesafe.

Resource planning and provision



Among the gasses released by damaged HV batteries are oxygen and hydrogen, two fuel sources for a fire. This can mean that EV battery fires take longer to suppress and sufficiently cool the battery to control the thermal runaway.

EV fires can take several hours to suppress, requiring more water (10,000 litres on average) and resources (firefighters and appliances) than an ICE vehicle fire.

Managing suppression water runoff

Once used to suppress an HV battery fire, water will be contaminated with chemicals from the battery. These chemicals are often harmful to the environment, so runoff will need to be contained, monitored and treated appropriately before release. This is a concern for fire officers, site owners and occupiers.

It should be noted that fire water used to suppress an ICE vehicle fire is also contaminated and will require similar management to avoid a pollution incident.

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Guidance on minimising fire risk

In the UK, there is currently no legal minimum standard for fire safety of EV charging. There is also no single source of guidance that the industry recognises as a comprehensive best practice guide to HV battery fires or EV charging.

There are several guidance documents that make recommendations on fire safety when charging EVs, or when charging EVs in a covered car park. We have summarised the recommendations from these documents below.

Covered car parks – fire safety guidance for electric vehicles

In 2023, the Office for Zero Emission Vehicles (OZEV) produced fire safety guidance that outlines measures that car park owners and operators should reflect when retrofitting EV chargepoints or designing new car parks that include charging. It identifies a range of measures to reduce the risk and impact of EV fires:

To mitigate abuse (thermal, mechanical or electrical)

- Provide water-based fire suppression.
- Increase distance between parked cars.
- Provide fire resistant barriers.
- Provide thermal monitoring cameras.
- Install certified EV chargepoints.
- EVCPs installed by competent person.
- Provide manual power isolation.
- Automatic power isolation system.
- Implement vehicle speed limits.
- Design layout to avoid collisions.
- Provide secure parking.

To assist the fire service

- Provide sufficient firefighting water supply.
- Ensure burnt EVs can be easily removed.
- Provide additional detail in premises information plans.
- Install enhanced smoke management systems.
- Provide appropriate structural fire resistance.
- Consider EVCP locations.
- Provide water runoff control and containment.

To limit damage to vehicles, EVCPs, people and property

- Provide automatic fire detection and alarm.
- Provide manual firefighting measures.
- Provide crash protection.
- Ensure routine inspections.

- Provide security systems.
- Position EVCPs to use minimum cable.
- Install mode three or four EV chargepoints.
- Design the structure with risk in mind.
- Increase building separation distance.
- Provide audible and visual evacuation alarms.
- Maintain escape routes.

RC59: Recommendations for fire safety when charging electric vehicles

The Risk Insight, Strategy and Control Authority (RISCAuthority) published its recommendations through the Fire Protection Authority in 2023. RC59 identifies that the highest risk of thermal runaway is if a cell is unable to convert electrical energy to (stored) chemical energy during the charging process. This can occur if a cell is damaged or defective.

Site recommendations

- Install sprinkler systems, particularly in underground or basement car parks – this is the best form of active fire protection.
- Carry out a per-site risk assessment and develop an emergency plan.
- Ensure all staff are aware of EVCPs and isolation systems.
- Allow enough room around the chargepoint to park and plug in.
- Ensure chargepoint and cables do not interfere with emergency routes.
- Mark bays clearly and allow additional space between bays.
- Design all bays for disabled users, allowing greater vehicle separation.
- Consider if, when and how often sites will be staffed.
- Separate EVCPs from storage of flammable and combustible material.
- Install manual power isolation controls in safely accessible areas.
- Ensure automatic fire detection and warning systems are present.
- Provide appropriate manual firefighting equipment.
- Ensure good access to EVCPs for fire services in multi-storey car parks.
- Isolation systems should include a lock out and require manual reset.
- Provide 60-minute fire resistance between EVCPs and other areas.

Business continuity recommendations

- Include EV fires in emergency planning documents.
- Rehearse the emergency plan, assess results and amend process.
- Ensure information is available for the fire service, including power isolation location.
- Include details of specialist assistance in business continuity plans.

Other recommendations

- Ensure EVCPs are appropriate for the site and in good condition.
- Provide protection from accidental damage – but ensure that accessibility is not compromised.
- Ensure all chargepoints and sites comply with all relevant legislation.

Fire safety in parking garages with electric vehicles

In 2023, Siemens collaborated with Danfoss and the Danish Institute of Fire and Security Technology to produce a white paper on fire safety of EVs in parking structures. The paper focusses detecting and suppressing HV battery fires in car parks. The most important protection targets are:

1. Minimise risk to occupants and fire services from heat and smoke.
2. Minimise the risk of compromising structural integrity.
3. Minimising the time taken to resume normal operation following a fire.

The paper also notes the importance of rapidly raising the alarm and evacuating the structure, alerting the facility manager and preventing false alarms. Other recommendations include:

- Positioning detection systems above parking bays, not above lanes.
- Considering ventilation to ensure smoke is not diluted near detectors.
- Installing detection systems inside (rapid) EVCPs to detect internal fires.
- Implementing regular maintenance and inspections with trained staff.
- Ensuring car parks are fire-separated from the rest of the building.
- Separating larger car parks into multiple fire compartments.
- Integrating detection and suppression into wider building management.

European Parking Association Fire Safety Toolbox

In October 2024 the European Parking Association (EPA) worked with Arup to develop guidance on the range of possible mitigation measures to reduce the risk and impact of vehicle fires (all powertrains) in car parks. It draws on the OZEV guidance and RC59 (see above) alongside a range of other national guidelines from across the EU.

The toolbox summarises a range of potential mitigation measures for all car park types and rates them according to fire safety benefit, CAPEX and OPEX. Each measure is then rated as to whether the measure should be considered as a standard mitigation (regardless of the effort required) or requiring moderate or substantial effort above the standard expectation. This assessment is completed from both a life safety and asset protection view for both naturally ventilated and enclosed car park types.

Other battery fires

It is important to distinguish fires involving the HV battery of an EV from fires involving smaller forms of electric powered mobility. Some regulations, battery management and safety features that apply to EV traction batteries do not apply to devices such as electric bikes and electric scooters.

The guidance on charging batteries for these is well established – do not allow them to charge unsupervised or overnight and charge outside if possible. If they do need to charge indoors, ensure they are not blocking an exit.

As with EVs, there is limited information available, but data suggests that the greatest risk of fire with these devices is when charging. Where car parks make provision for users to charge ebikes or escooters, (See RC59) suggests:

- Vehicles must only be charged following manufacturer's instructions.
- Charging for EVs, ebikes, and escooters should be physically separated.
- Staff vehicles should be stored and charged separately and securely.

Department for Transport has published guidance on managing fire risk in premises for ebike and escooter batteries. The guidance has advice on how to mitigate risks and design safe charging locations, including:

- Educating users about the risks to encourage responsible use.
- Not permitting visibly damaged battery packs in premises or vehicles.
- Providing dedicated charging so devices can be used and charged safely.
- Provide separate, secure battery storage and charging facilities, such as lockers, ideally outside, while escooters or ebikes use existing stations.
- Upgrade or relocate existing cycle storage areas for enhanced fire safety.
- Ensuring that a battery fire would not obstruct a means of escape.
- Upgrading basement smoke control systems if charging will occur there.
- Linking fire detection to automatic vents and water-based fire suppression.
- Providing a means to raise the alarm to users, along with smoke detectors.
- Providing external power isolation to the storage/charging room.
- Considering implications of high-temperature fires on building structure.
- Planning for water run-off and contaminated water.
- Ensuring that the charging area is not used for purposes that increase risk.
- Ensuring minimum separation or fireproofing between charging batteries.

Further reading

EV FireSafe

Office for Zero Emissions Vehicles & ARUP, Covered car parks: fire safety guidance for electric vehicles

Fire Protection Association, RC59: Fire safety when charging electric vehicles

Siemens white paper: Fire safety In parking garages with electric vehicles

EPA Fire Safety Toolbox v1 October 2024 - shared via personal communication 1/11/2024.

Department for Transport, E-cycle and e-scooter batteries: managing fire risk for premises

IZEVA research brief, Approaches to mitigate electric vehicle fire risks in enclosed spaces, February 2024