



evfiresafe.com

EV FireSafe

Enhancing safety for emergency responders at **electric vehicle** fires

Emma Sutcliffe
Project Director

Supported by:



Australian Government
Department of Defence

In partnership with:





We're researching

EV lithium ion battery fires

What do they mean for emergency responders?

+

connection to energised charging

What additional risks do emergency responders face?

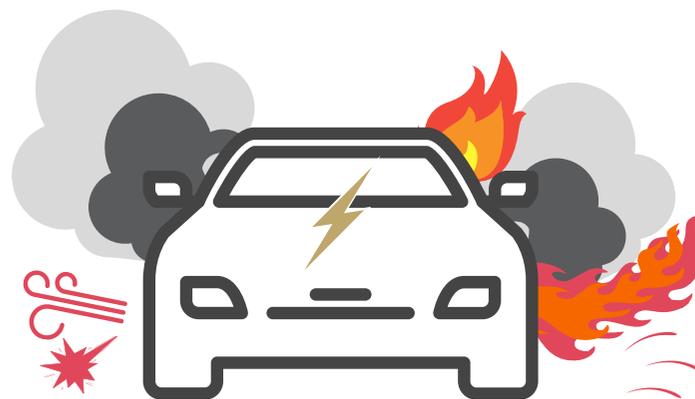


EV LiB fires are very rare

In passenger plug-in EVs, we have verified*:

232 EV traction battery fires globally, 2010-today

+ 43 currently being cross checked



'In the world of clean energy, few areas are as dynamic as the electric car market. We estimate there are now **around 16 million electric cars** on the road worldwide...'

International Energy Agency, January 2022



EV fires by year

8 in April '22

Fault:

Chevrolet Bolt

Collision:

Tesla

Tesla

Tesla

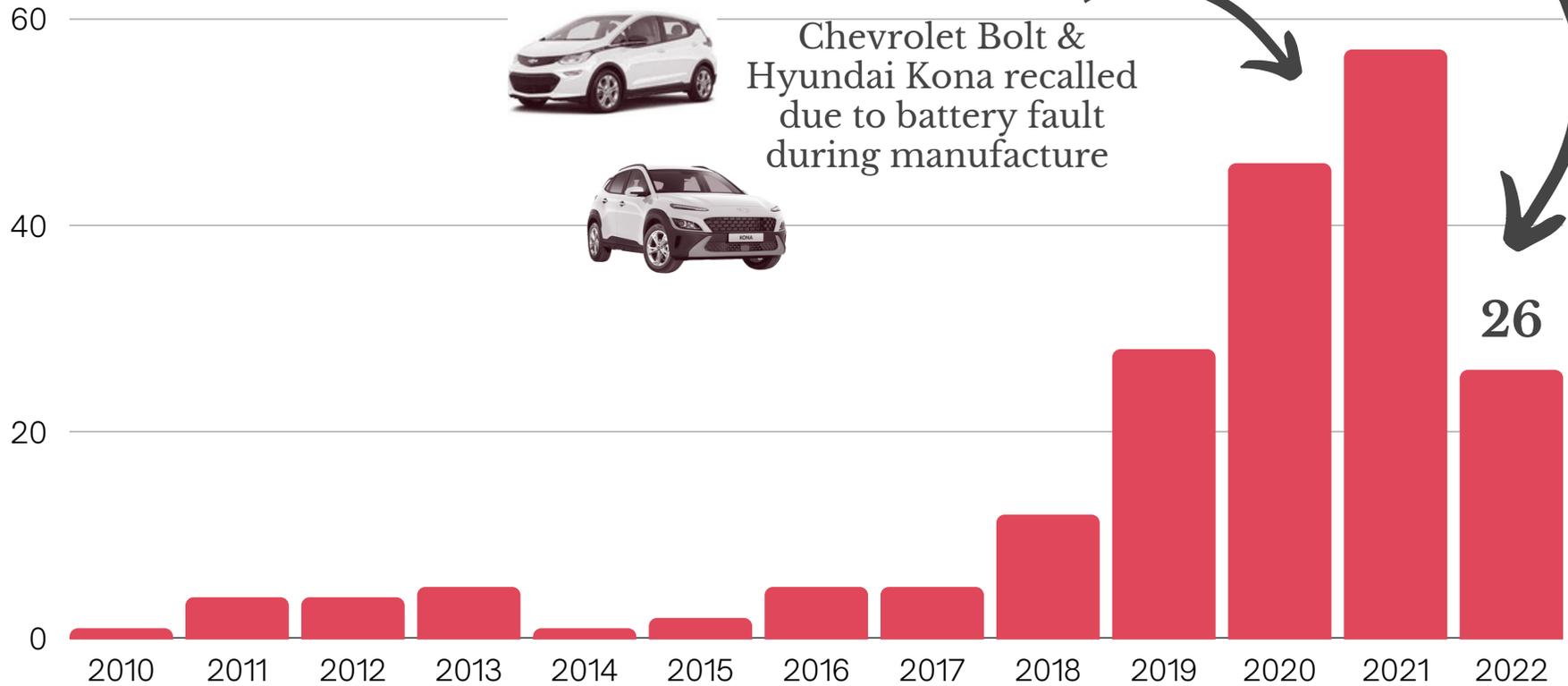
Unknown:

Tesla

Mini EV

BYD Tang

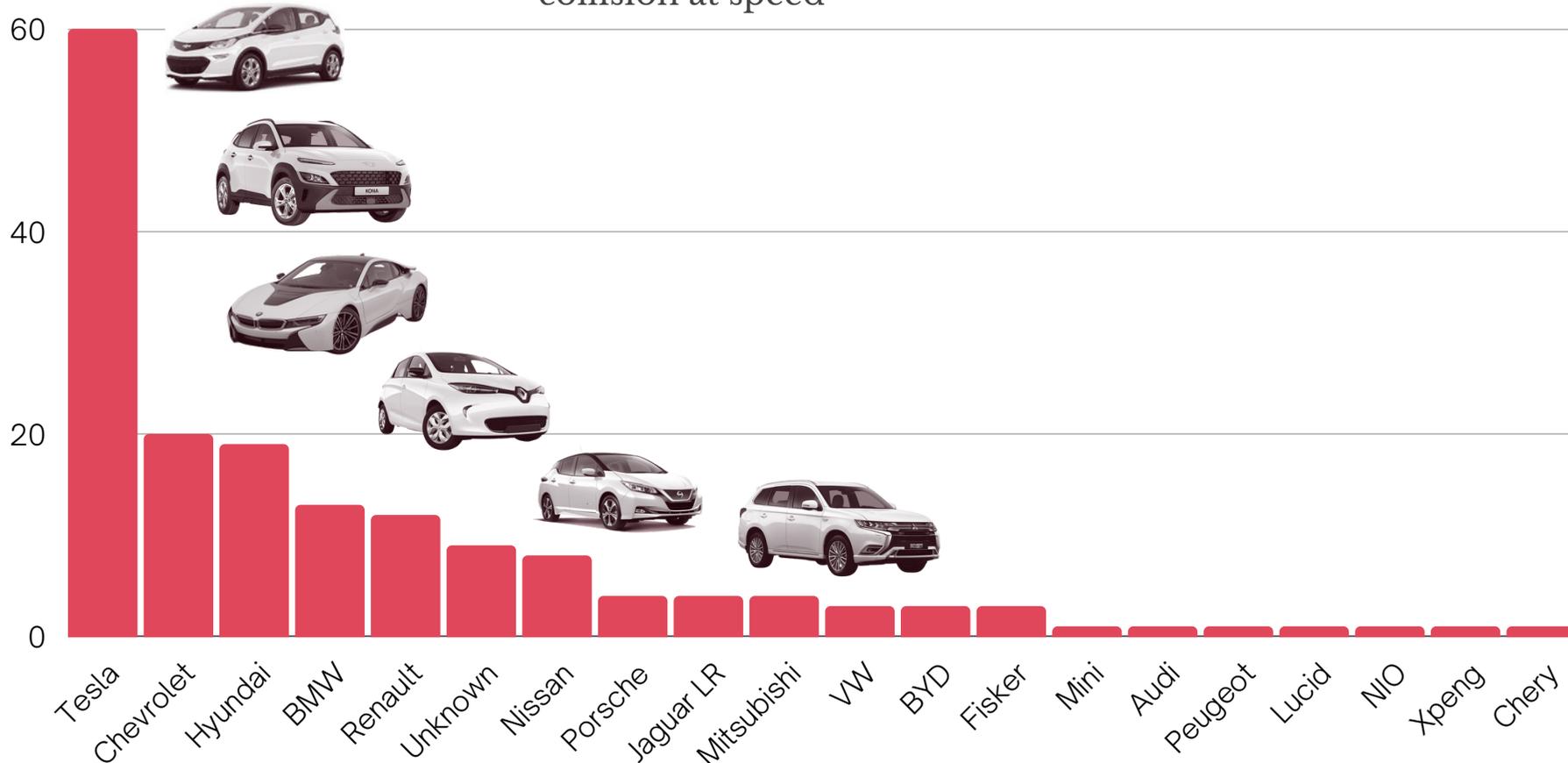
Lincoln Aviator



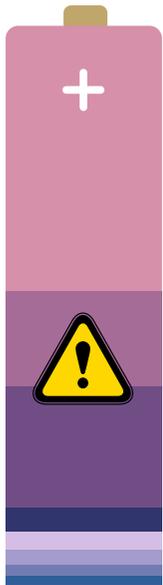
EV fires by manufacturer



Most number of EVs
on the road
Most number of
'collision at speed'



Causes of battery cell abuse



Unknown	41.98%
Collision / debris	19.34%
OEM fault	15.09%
Arson / malicious	3.77%
Repair / workshop	2.83%
External fire	2.36%
Overheating	1.89%
Submersion	1.42%

*Data current June 2022

^Percentage of incidents EVFS studied



New risks & challenges

Potential longer response time & more resources



Two concepts for EV fires

Battery pack
construction



Thermal
runaway



Battery pack construction

An EV traction battery pack is typically constructed like this:



Lithium ion
battery cell



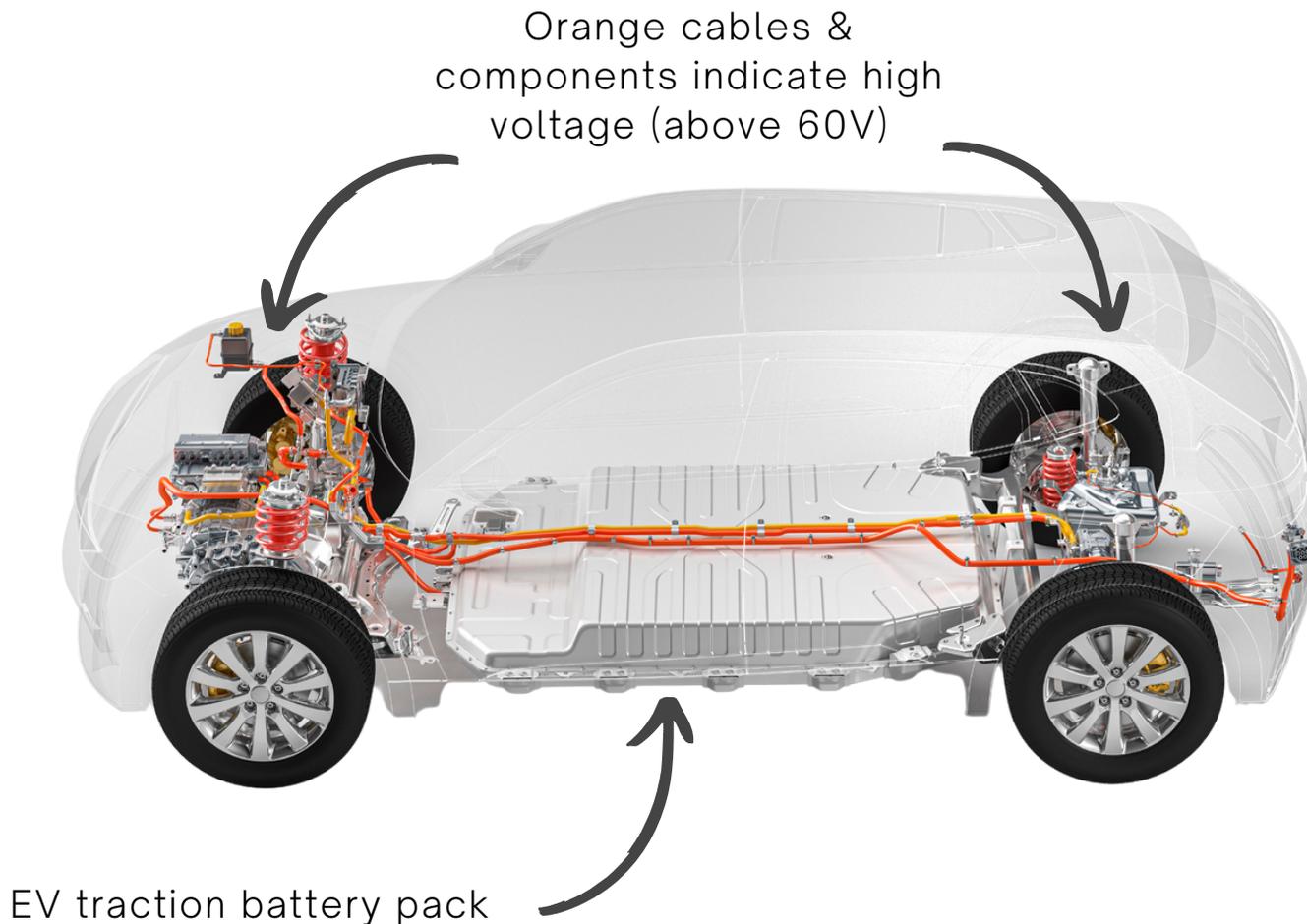
Multiple cells make a
battery module



Multiple modules make a
battery pack, which is
enclosed in protective
battery casings

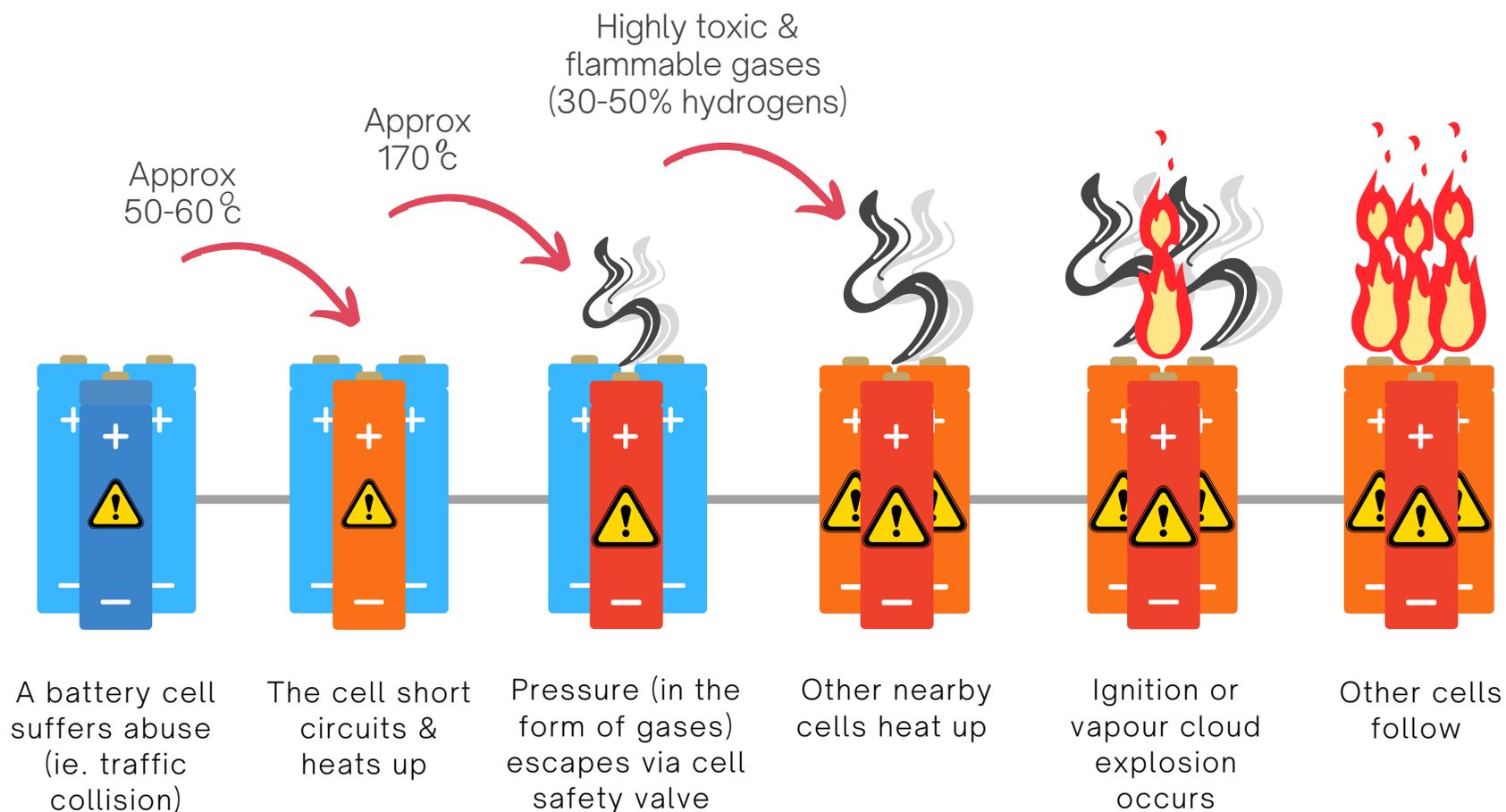
Battery pack construction

In passenger EVs, the traction battery supplies power for vehicle momentum & is located beneath the vehicle, along the floor pan



Thermal runaway

Thermal runaway occurs when a battery cell suffers abuse, short circuits, heats up & bursts.



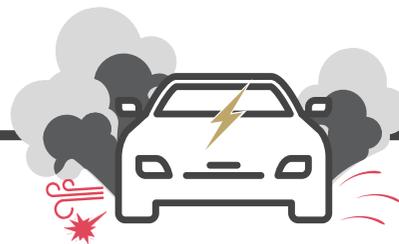
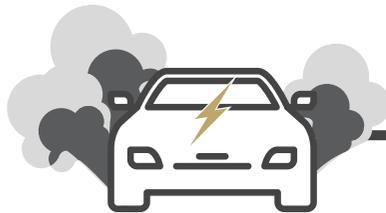
From outside the EV

From an emergency responder perspective, thermal runaway looks & sounds like this

Dark vapour cloud,
light vapour cloud
(it's NOT smoke)

Hiss/whistle - gas venting
Projectiles - cell debris
Popping - blast caps

At this point, one of
two things will occur



Ignition
Jet like, directional flames

Vapour cloud explosion
Violent deflagration



~90%



~10%



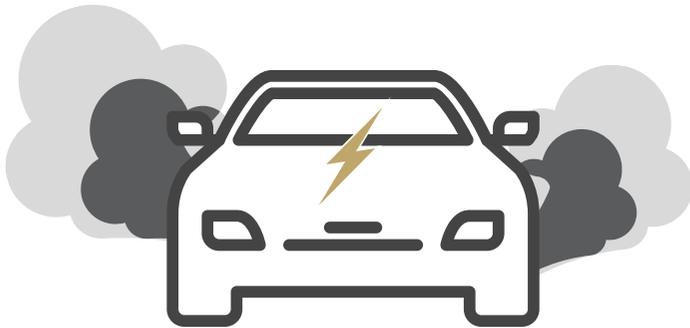
2020-05-08 14:24:49



Camera 01



Vapour - it's not smoke!



An EV battery in thermal runaway releases **toxic & flammable gases** including:

30-50% hydrogen
7-30% carbon monoxide
2-15% methane

"Approximately 300-6000 litres of vapour per 1kWh of battery capacity is released."

Professor Paul Christensen



Tesla Model 3

The lowest range Tesla Model 3 has a **54kWh** battery capacity.





Charging electric bike explodes causing fire to burn through garage in eastern China

newsflare



Share



Camera 01

Watch on YouTube

Vapour cloud explosion

Total of **14 VCE incidents** globally since 2010:

64.3%

Underground /
enclosed space



35.7%

Open air



4 incidents verified of:

- vapour cloud explosion
- in an enclosed space
- while connected to energised charging



Vapour cloud explosion



<https://www.evfiresafe.com/post/electric-car-explosions>

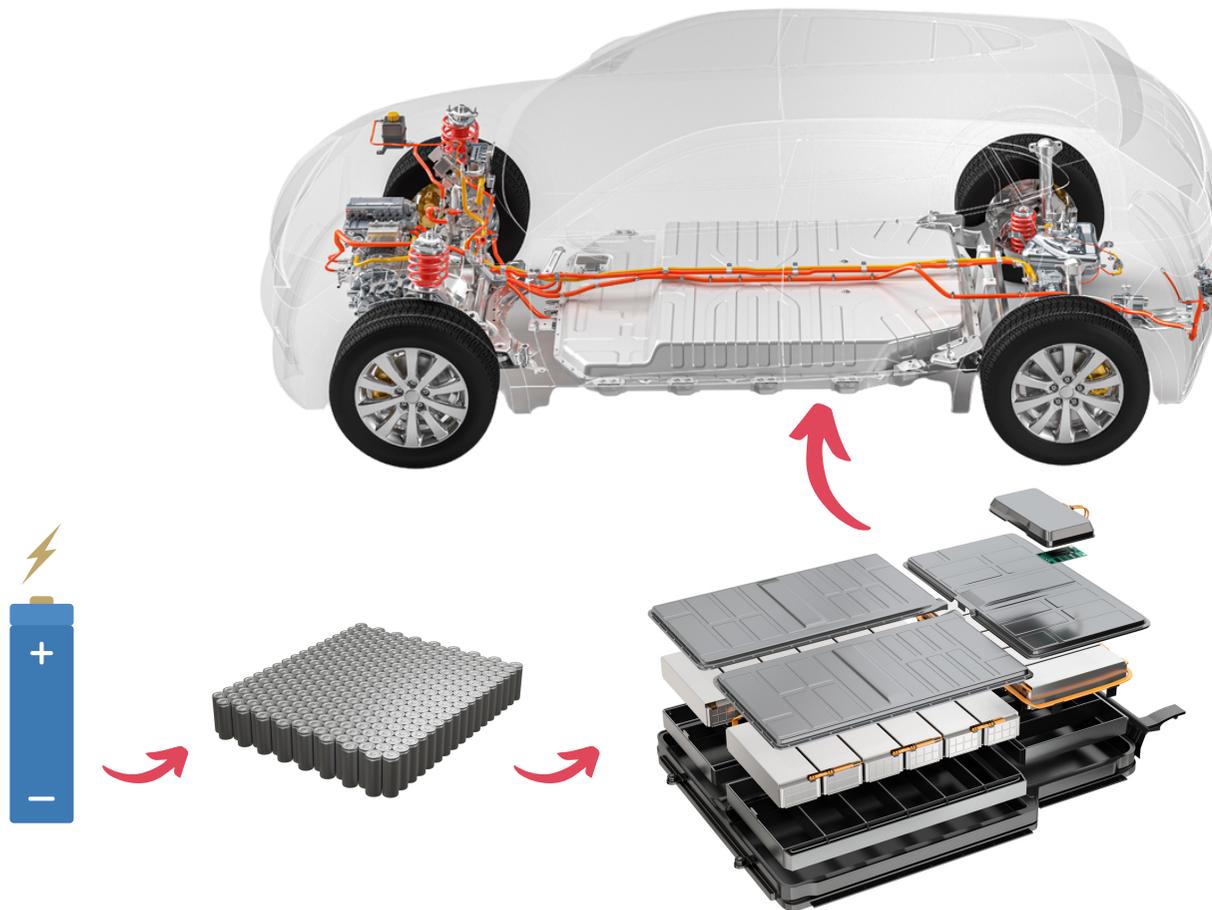
Vapour cloud explosion



<https://www.evfiresafe.com/post/electric-car-explosions>

EV fire suppression

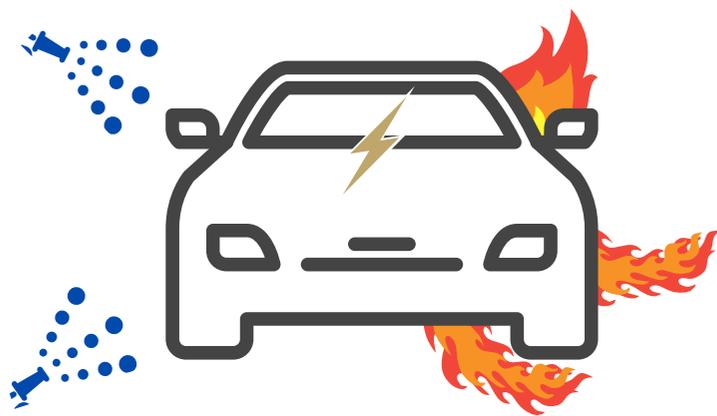
It doesn't actually take much water to suppress a battery pack fire...the problem is getting it directly onto the cells to cool them down.



Cooling the battery pack

Recommended by all EV manufacturers & best practice by most international agencies is to cool the battery pack to slow & eventually stop the process of thermal runaway

A stream of water onto the underside of the EV will
dissipate heat
= slow & stop thermal runaway



Cooling battery cells within a pack may
take several hours



Suppression = time, resources

Suppression time depends on a range of factors, but 3-5 hours common

Best case

Worst case



10min

3-5 hours (>50 hours to clear highway)



1,000L

110,000L





**GREATER
MANCHESTER**
FIRE AND RESCUE SERVICE

Case study

November 2020, Audi e-Tron, charging at time of thermal runaway

'Initial attempts to use dry power unsuccessful. Hose reel underneath the EV, go-jacks to move vehicle away from adjacent property.

Audi tech requested to isolate HV system.

Minimum **30 hours initial**, then intermittent cooling & temperature monitor using TIC on an hourly basis.

Used 10 pumps with 4 officers over the 30 hour period.

Both Audi & recovery company refused to move the EV for 48 hours due to reignition risk.'

Greater Manchester Fire & Rescue Service



Emerging products



Fire blanket



Water lance



Cold Cut



Emergency Plug

International best practice



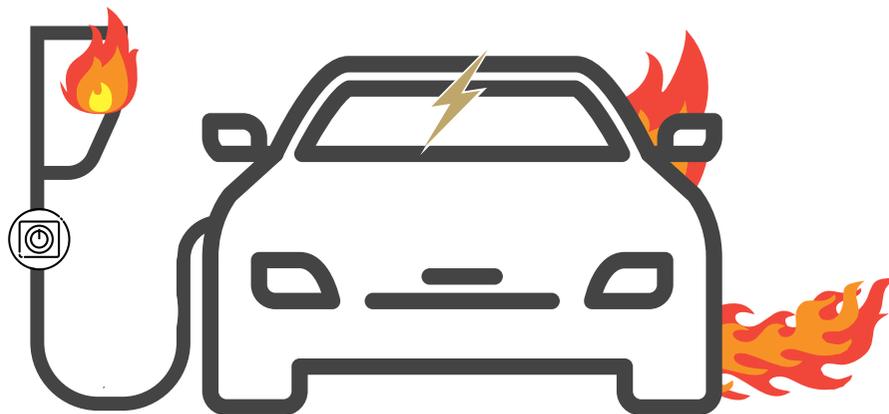
Can it burn out?

Submerge entire EV (not recommended by Tesla due to risk of reignition)



EV fires at charging hubs

Our research indicates **approximately a third** of global EV LiB fires occur while the vehicle is connected to energised charging.



Charging wasn't necessarily the cause of fire, but indicates consideration should be given to **emergency vehicle access, water supply, gas venting & water run off** at charging hubs



Thermal runaway + charging

AC EV charging (7/22kW)

In theory, units will cut between EV & DB
Average unit cost: \$800-\$1500

DC EV charging (25/350kW)

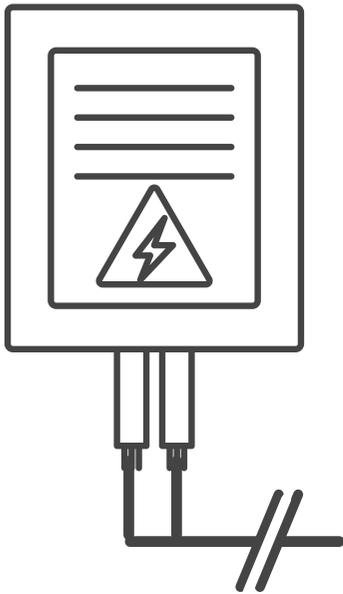
In theory, units will cut between unit & EV
Average cost: \$50,000 - \$750,000



Theory based on **RCM Tick** (electrically compliant) unit
that's installed to **AS/NZS 3000 Appendix P**



International best practice



Treat as an energised electrical fire & follow SOPs

Don't touch anything until distribution board is located & cut



Collision risk at charging





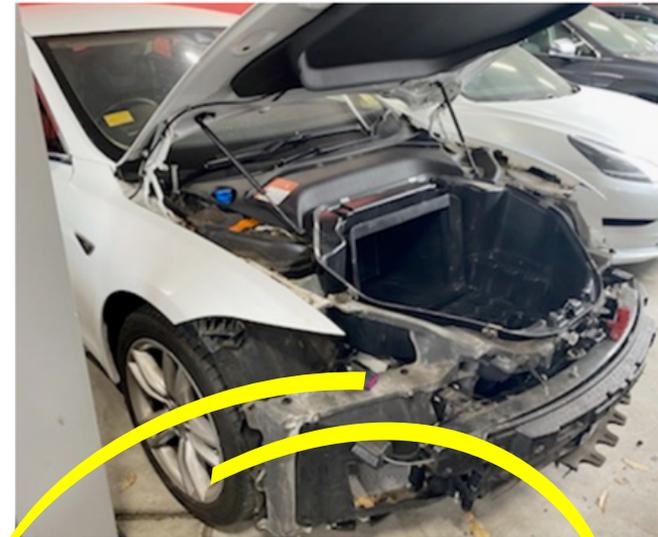
Daylesford, Victoria - details to follow!

Courtesy Allianz



\$16,673 – CRASHED AT CHARGING STATION

Driver was driving into the Tesla charge station and while doing so they have driven over a concrete bollard which has caused some damage to the undercarriage.



- Charging stations are a new exposure site
- Unlike petrol station (pumps) they are not drive forward in and forward exit
- Tesla is typically reverse in

Vehicle: Tesla 'S'

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CLASSIFICATION: CONFIDENTIAL

Sensible considerations

Emergency response

Can an emergency vehicle reach the charging site?
Where is the nearest hydrant?
Where is power supply be shut down from?
Where will gases vent to?
Where will water run off to (waterways)?
Building plans clearly displayed

Site management

RCM Tick compliant units
Qualified installer to AS 3000
Site fire safety assessment
Regular inspection for wear & tear
Replacement of damaged units & cables
Impact protection - wheel stops, bollards

Know the signs of thermal runaway!





Spread of fire in structures



"Electric vehicles: Observations during the fire indicate that **electric vehicles did not contribute to the fire development** beyond what is expected from conventional vehicles."

'Investigation of massive fire in a multi-storey car park in Norway'
The fire at Stavanger airport Sola, 7 January 2020, Fire spread and contribution from electrical vehicles

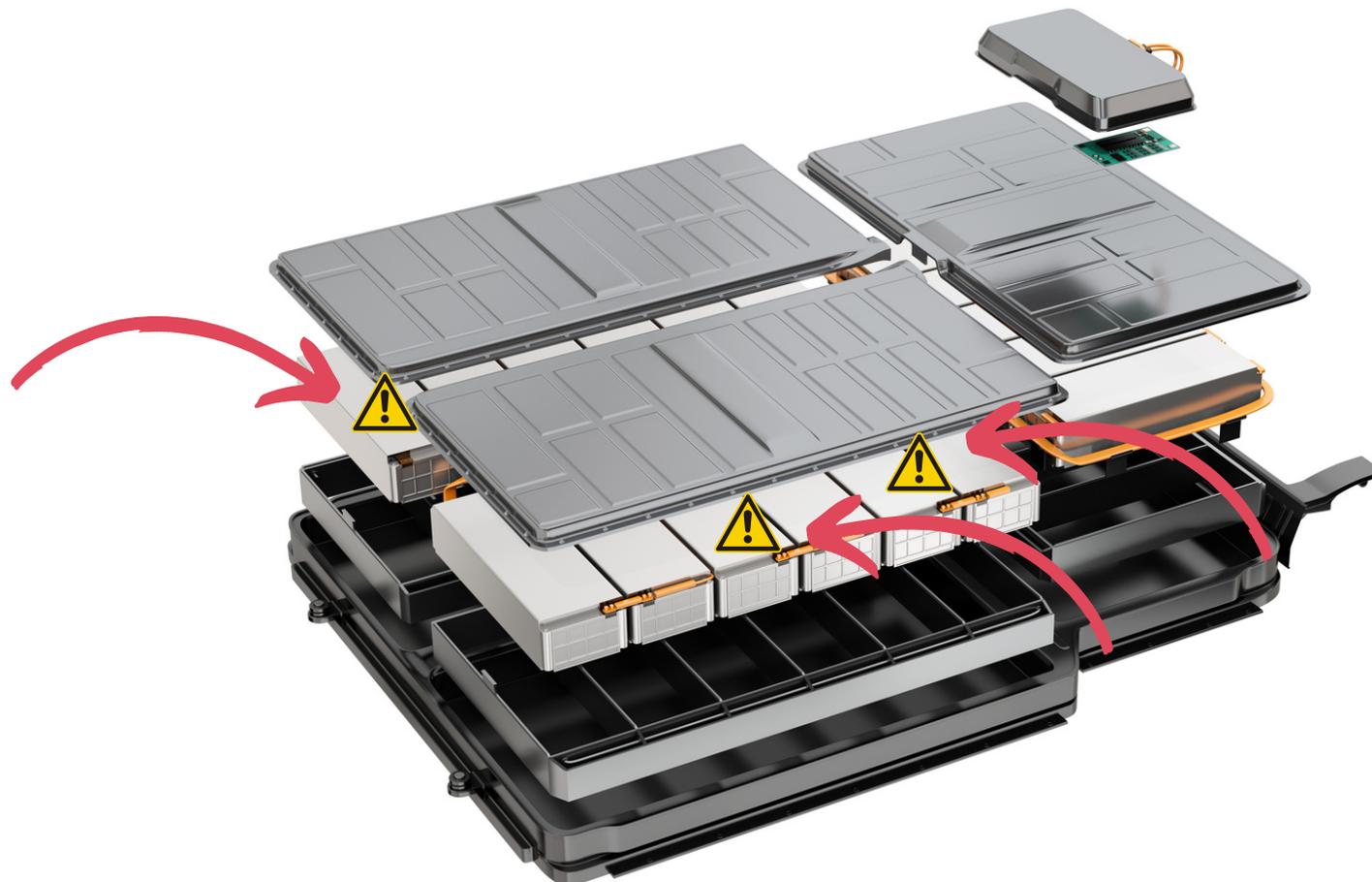
Secondary ignition risk

In 6 cases Damage caused to tow truck
In 4 cases Injuries to drivers, one hospitalised

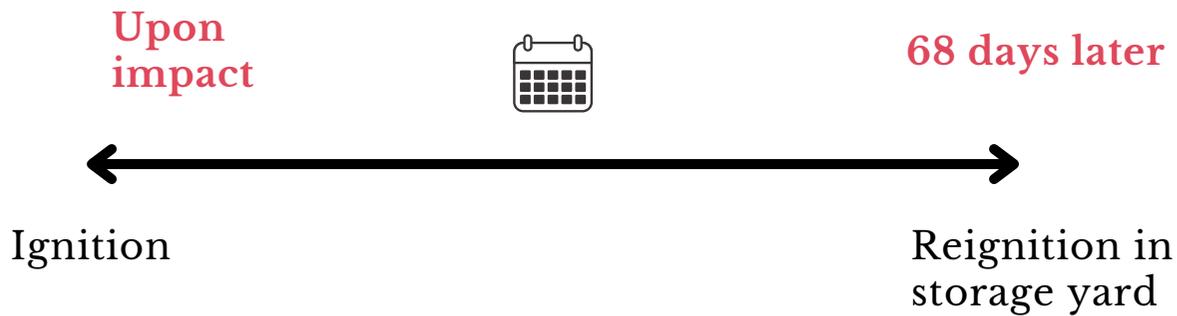
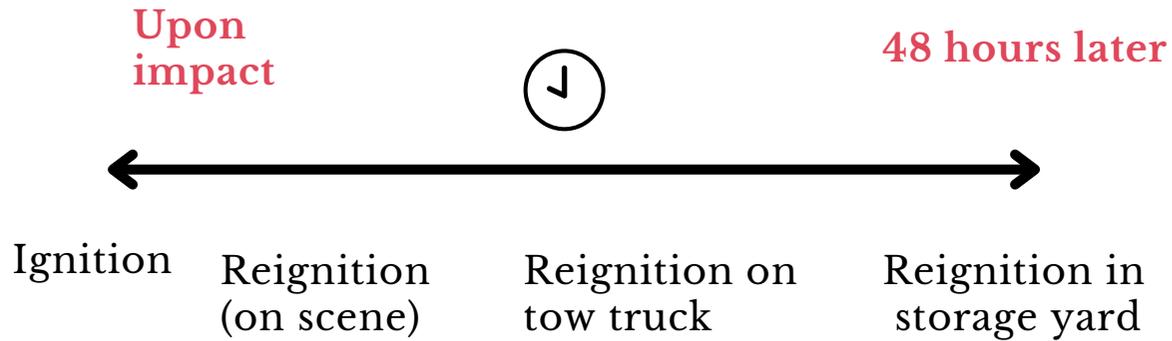


Reignition = multiple cells abused

Reignition - or secondary ignition - occurs when multiple battery cells are abused, but short circuit & go into thermal runaway at different times. Cells may also be affected by fire & short circuit later.



Occurred in ~10% of EV fires



Challenges & opportunities

Electric vehicles aren't coming; they're already here & they're across every transport sector.

Heavy commercial



Last mile delivery



Light commercial



e-Scooter



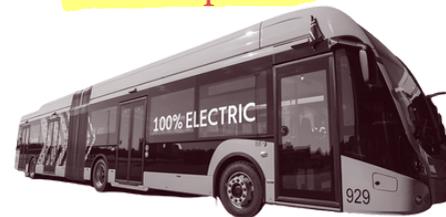
Tradies & mining



Motorbikes



Public transport



e-Bike





Bulk import of e-bikes in private home mid-May 2022, Sydney

Image: Station Officer Ian Robinson, FRNSW

Queensland man dies in caravan fire after shielding heavily pregnant girlfriend from the blaze



"Any of you people that have E-scooters out there, you be careful with these batteries and these chargers," Mr Bickel said.

"I've just lost my son."

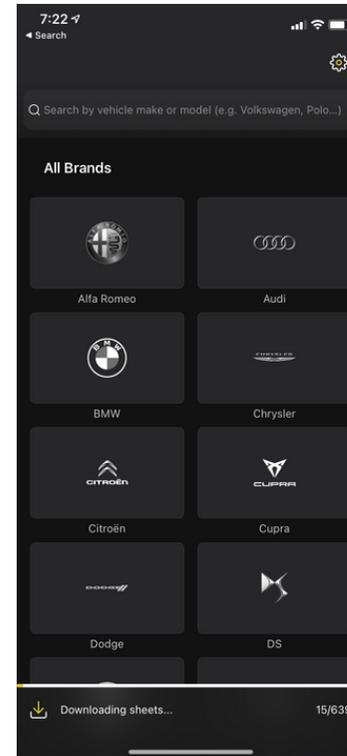
Useful (free) resources



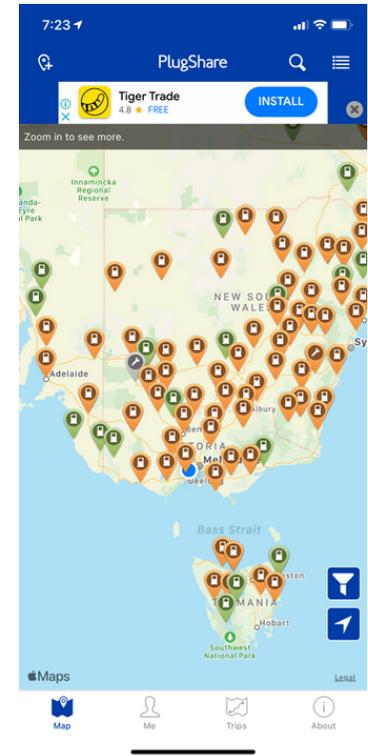
[evfiresafe.com](https://www.evfiresafe.com)



@evfiresafeproject



ANCAP
Rescue app



PlugShare
app

Next steps



Defence funding (Milestone 2)

Battery cell & EV
charging fire testing

2022-'24

Testing AC/DC charging
with Fire Rescue NSW
SARET Program



Work with policy makers

Charging site owners
Charging suppliers
Secondary responders
Vehicle transport &
storage
Fleet managers
Mechanics/repair
Battery recycling



Build awareness

Regular webinars
Look at road crash
rescue

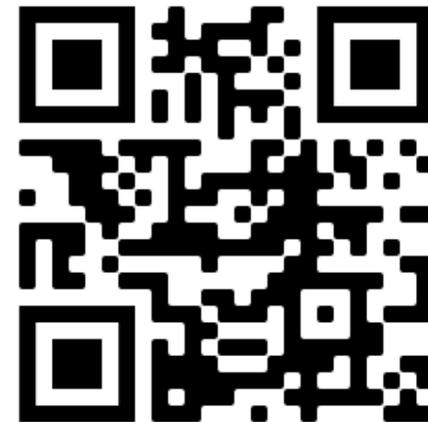




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Many thanks for your
kind attention.

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