2022 Australasian
Fleet Conference & Exhibition
AND FLEET AWARDS MAY 3-4 ROSEHILL GARDENS RACECOURSE SYDNEY

Will my EV catch fire?

Emma Sutcliffe

Project Director

EV FireSafe

AFMA
AUSTRALASIAN FLEET MANAGEMENT ASSOCIATION

evfiresafe.com

EV FireSafe

Enhancing safety for emergency responders at electric vehicle fires

Supported by:

Australian Government
Department of Defence

In partnership with:

DEAKIN UNIVERSITY

We're researching

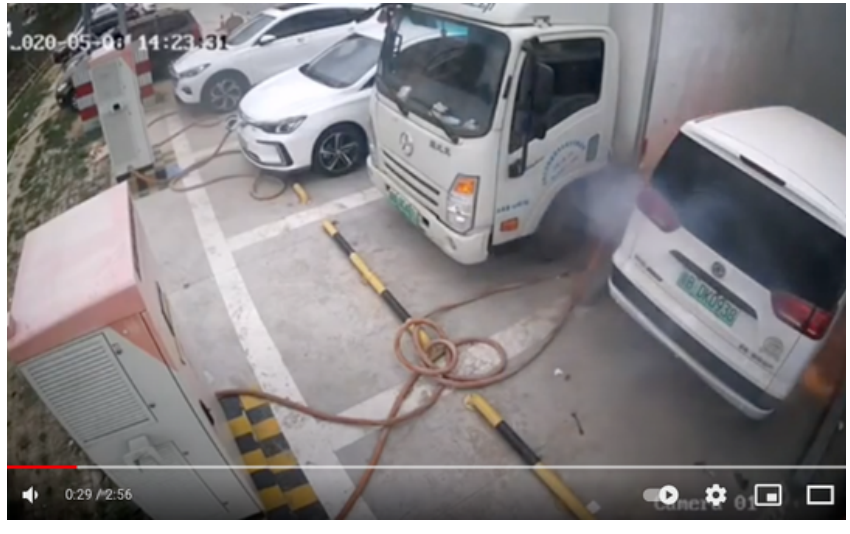
EV lithium ion battery fires

What do they mean for emergency responders?

+

connection to energised charging

What additional risks do emergency responders face?



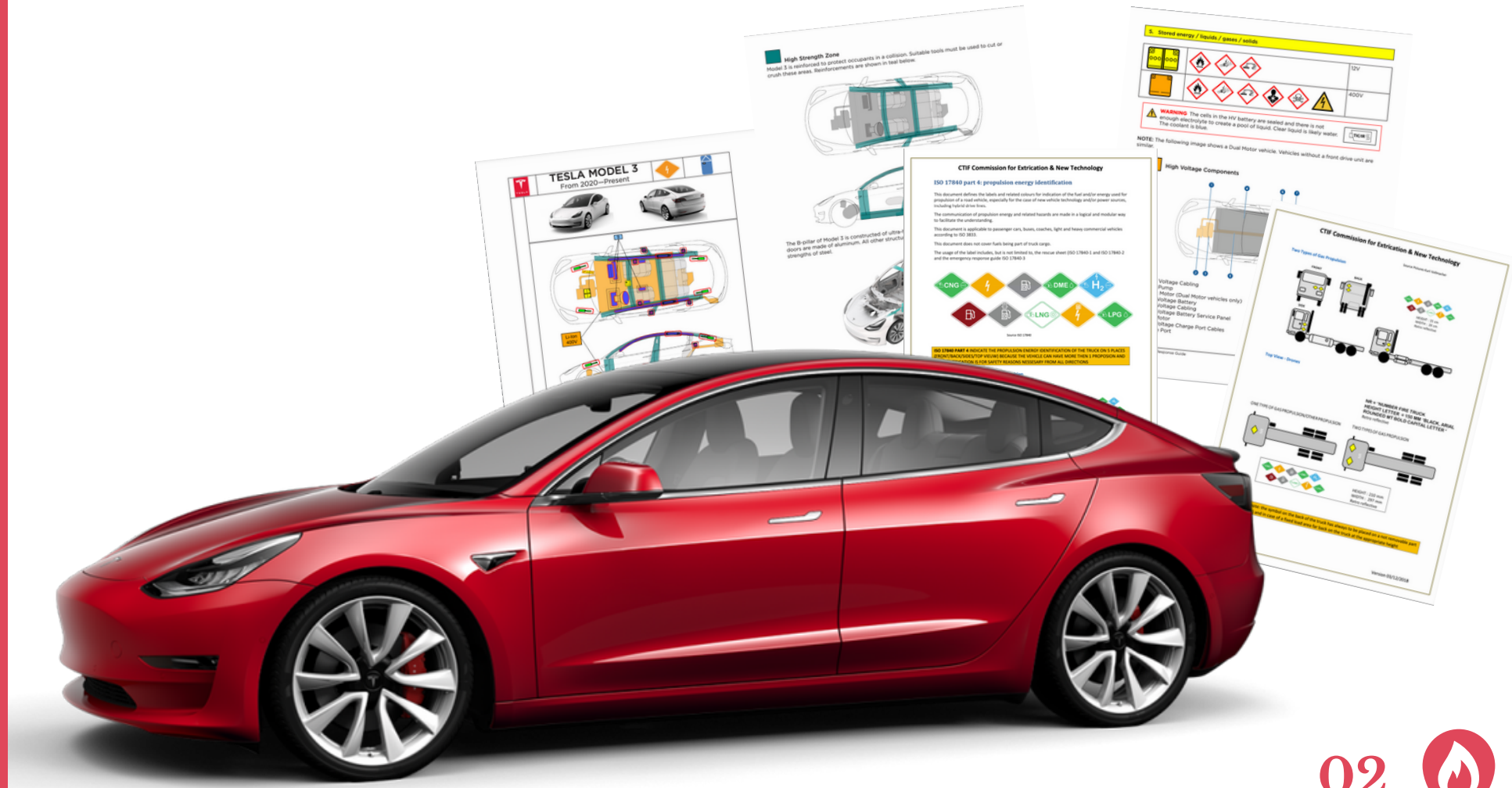
It all started with a bushfire

nine.com.au | 9NEWS

“The day’s not over. It’s still hot.”

Betty the Tesla Model 3

Experiencing EVs is one of the best ways to reduce firefighter FUD

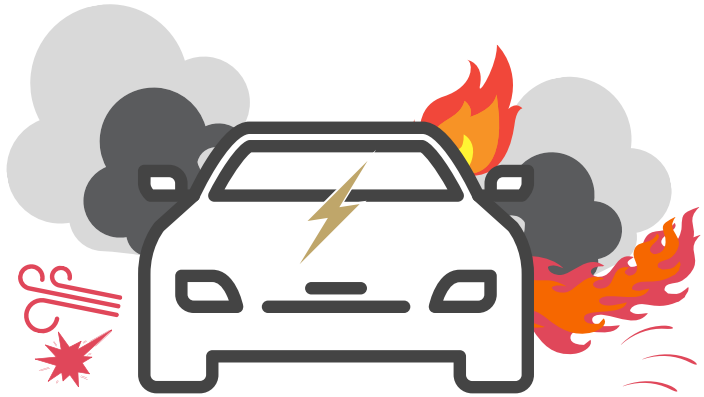


EV LiB fires are very rare

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

187 EV traction battery fires globally, 2010-today

+ 24 currently being cross checked

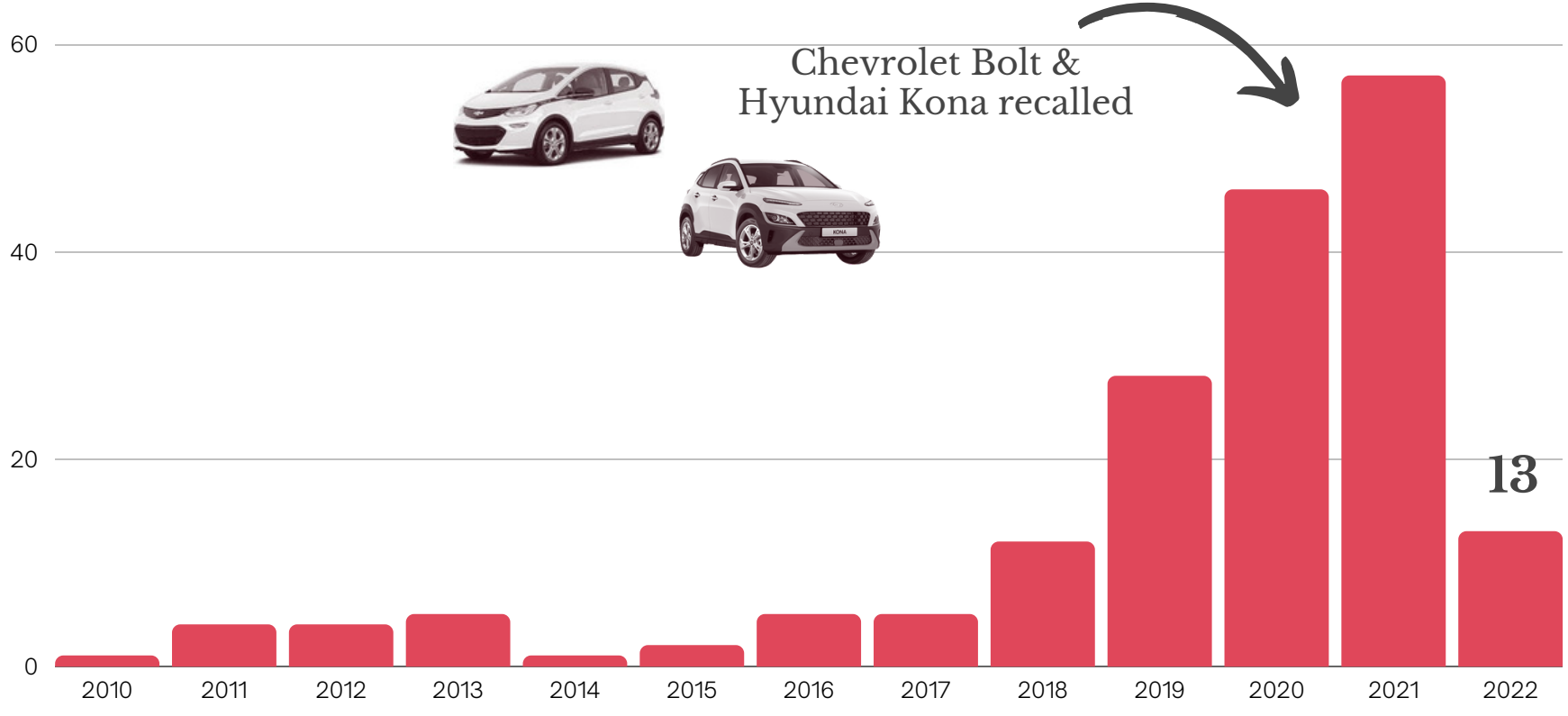


'In the world of clean energy, few areas are as dynamic as the electric car market. We estimate there are now **around 16 million electric cars** on the road worldwide...'

International Energy Agency, January 2022

*Not exhaustive. From more than one online source, interviews, first hand accounts, videos, images, academic & fire agency reports & online training

EV fires by year



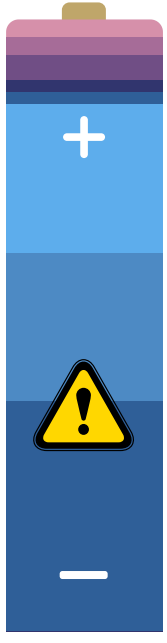
EV fires by manufacturer

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

60
40
20
0

Tesla
Chevrolet
Hyundai
BMW
Renault
Unknown
Nissan
Porsche
Jaguar LR
Mitsubishi
VW
BYD
Fisker
Mini
Audi
Peugeot
Lucid
NIO
Xpeng
Chery

Causes of battery cell abuse



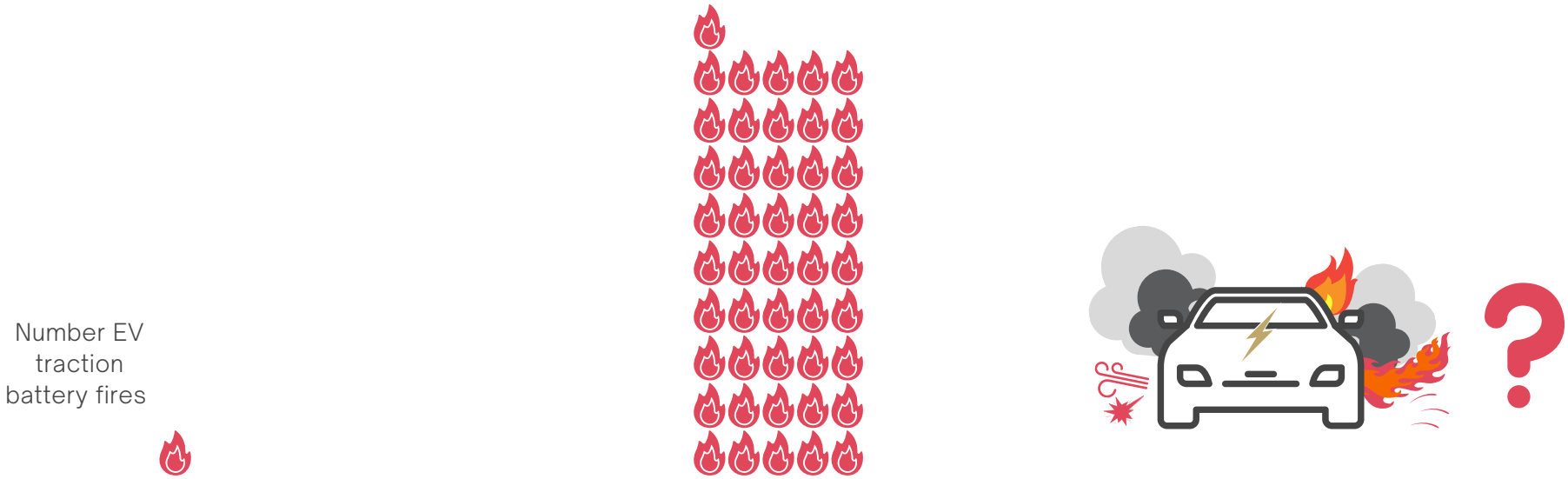
Overheating	1.57%
Submersion	1.57%
External fire	2.31%
Arson / malicious	2.31%
Workshop / repair	3.08%
Collision / debris	18.90%
OEM battery fault	18.90%
Unknown	29.13%

*Data current November 2021
^Percentage of incidents EVFS studied

EV & fire projections

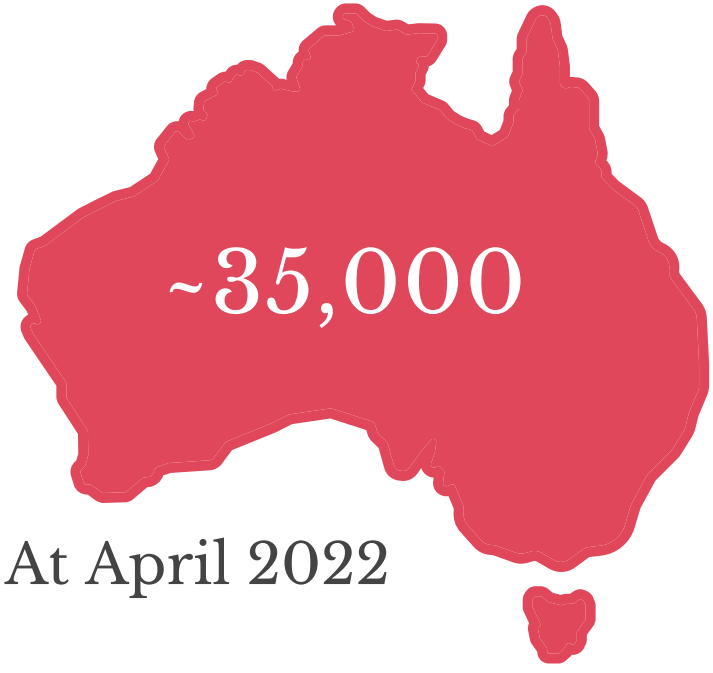
'The average age of electric vehicles in the US is 3.9 years of age and has been hovering between 3.8 and 4.1 years since 2016...'

IHS Markit, January 2021

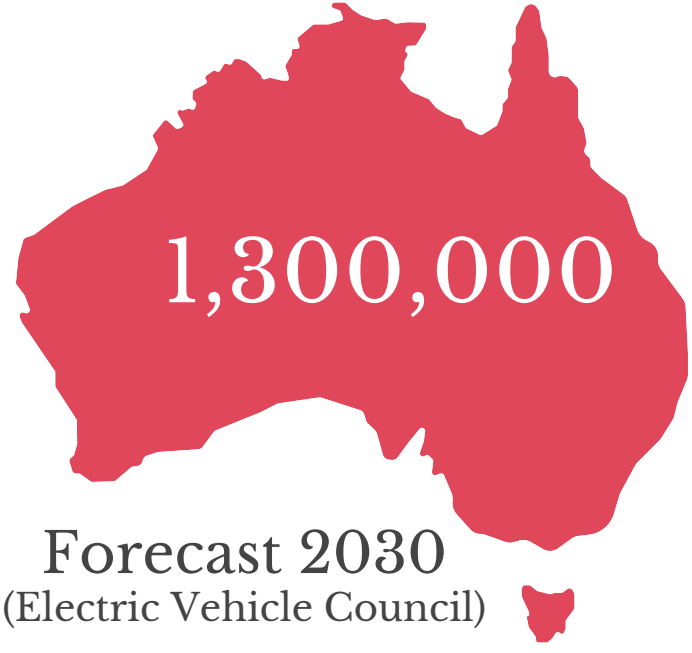


EVs in Australia

EV ownership* is concentrated in capital & major cities, but there are now EVs in every Australian region



At April 2022



Forecast 2030
(Electric Vehicle Council)

~70%

compound annual growth rate of EVs since 2010

*Doesn't include hydrogen fuel cell vehicles!

EVs in Victoria

'The **state of Victoria is Australia's largest and most important electric vehicle market**, with the most electric vehicle purchases in Australia between 2011 and 2021.'

Electric Vehicle Council, State of EVs Report 2021

At April 2022

Forecast 2030 for passenger EVs

Total number of all vehicles registered in Victoria, end 2021: 5.1 million

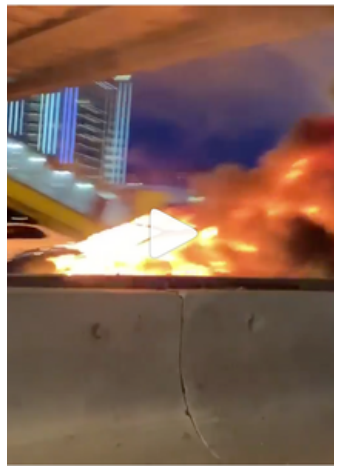
Age of ICE is over

Brands with EVs currently available in Australia

EV brands coming in 2022/3

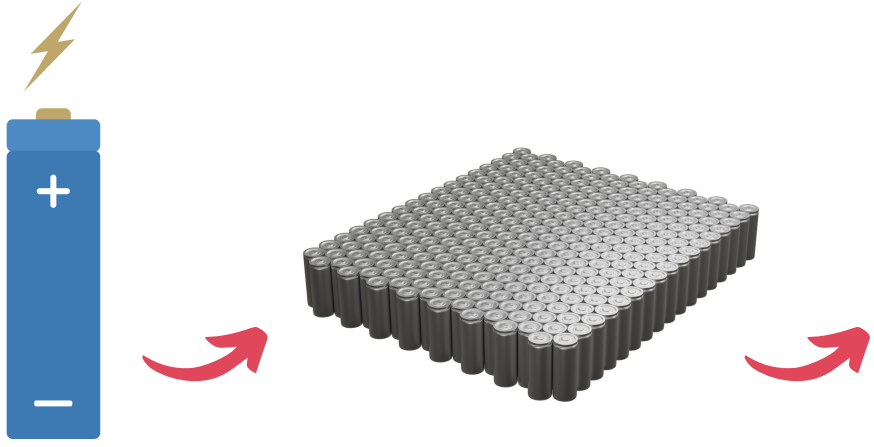
Brands not electrifying (yet)

New risks & challenges



Battery pack construction

An EV traction battery pack is typically constructed like this:



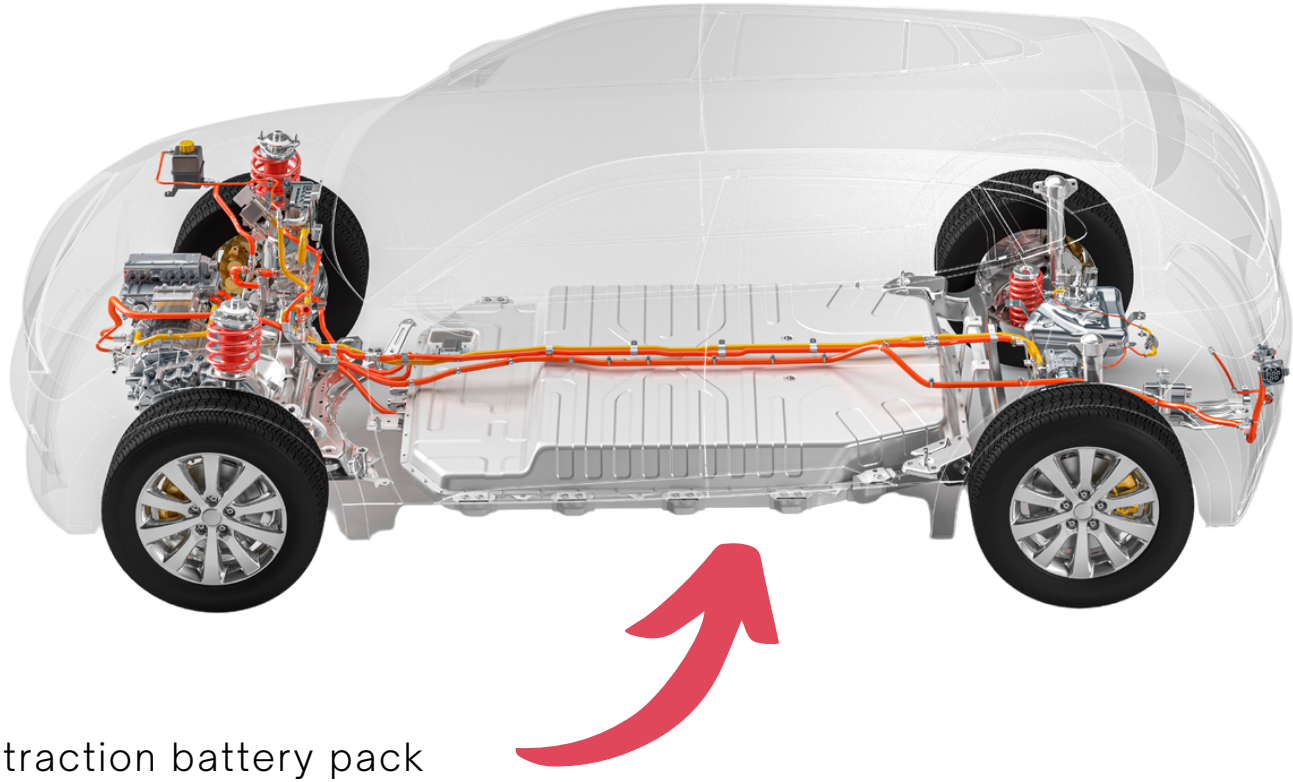
Lithium ion battery cell

Multiple cells make a battery module

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

Battery pack construction

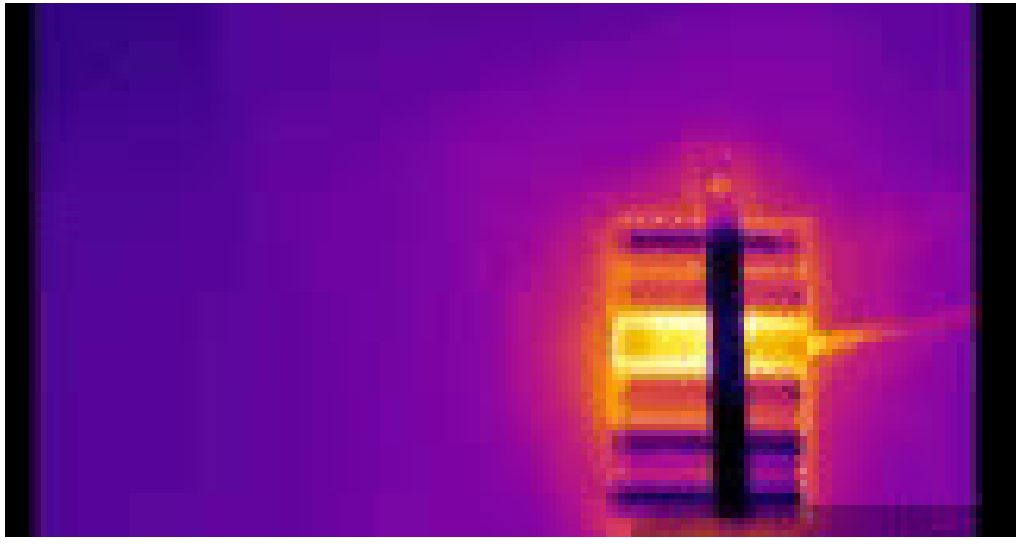
The traction battery supplies power for vehicle momentum & is usually located beneath the vehicle, along the floor pan



EV traction battery pack

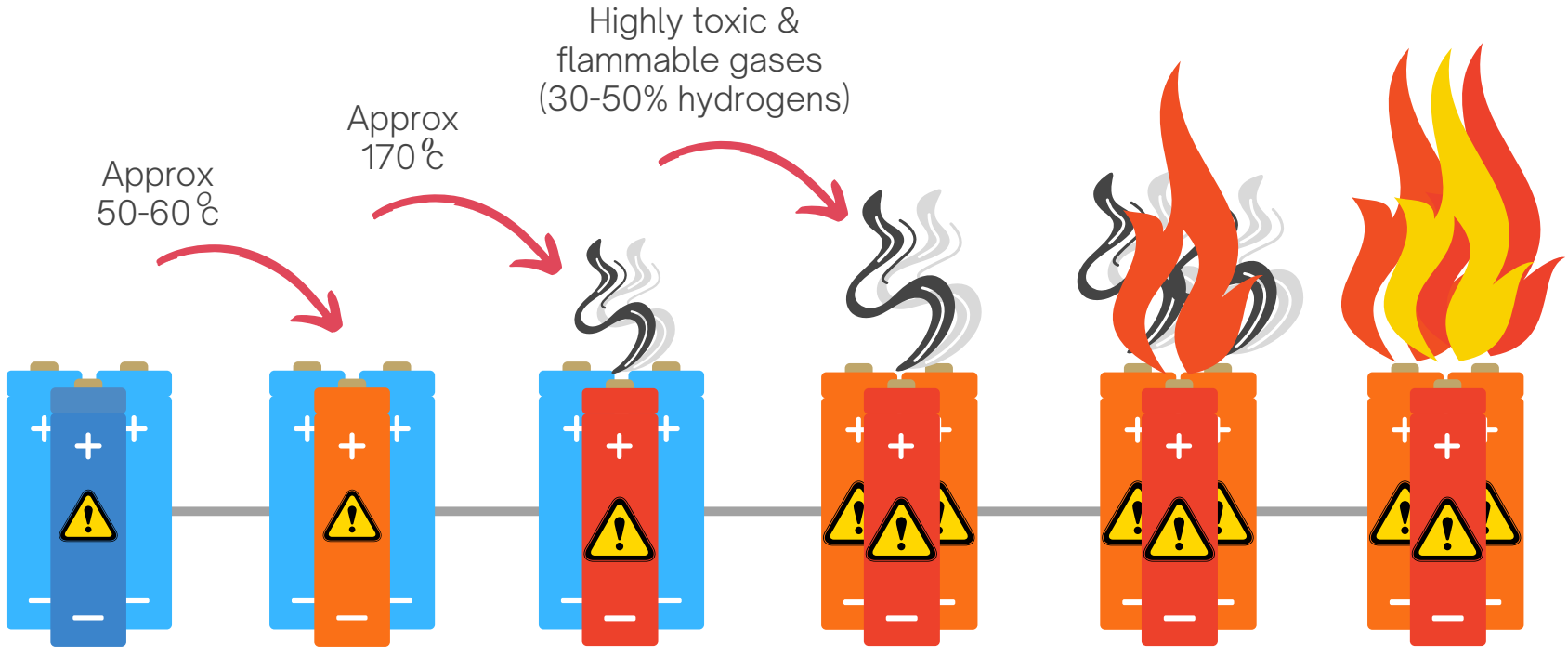
Thermal runaway

An unstable chemical process that is difficult to bring under control



Thermal runaway

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

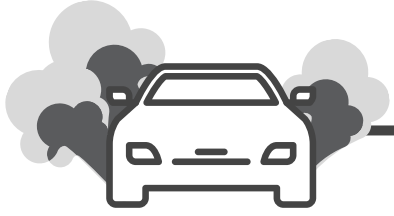


From outside the EV

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

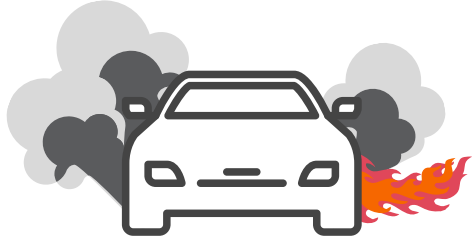
Dark vapour cloud,
light vapour cloud
(it's NOT smoke)

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



At this point, one of two things will occur

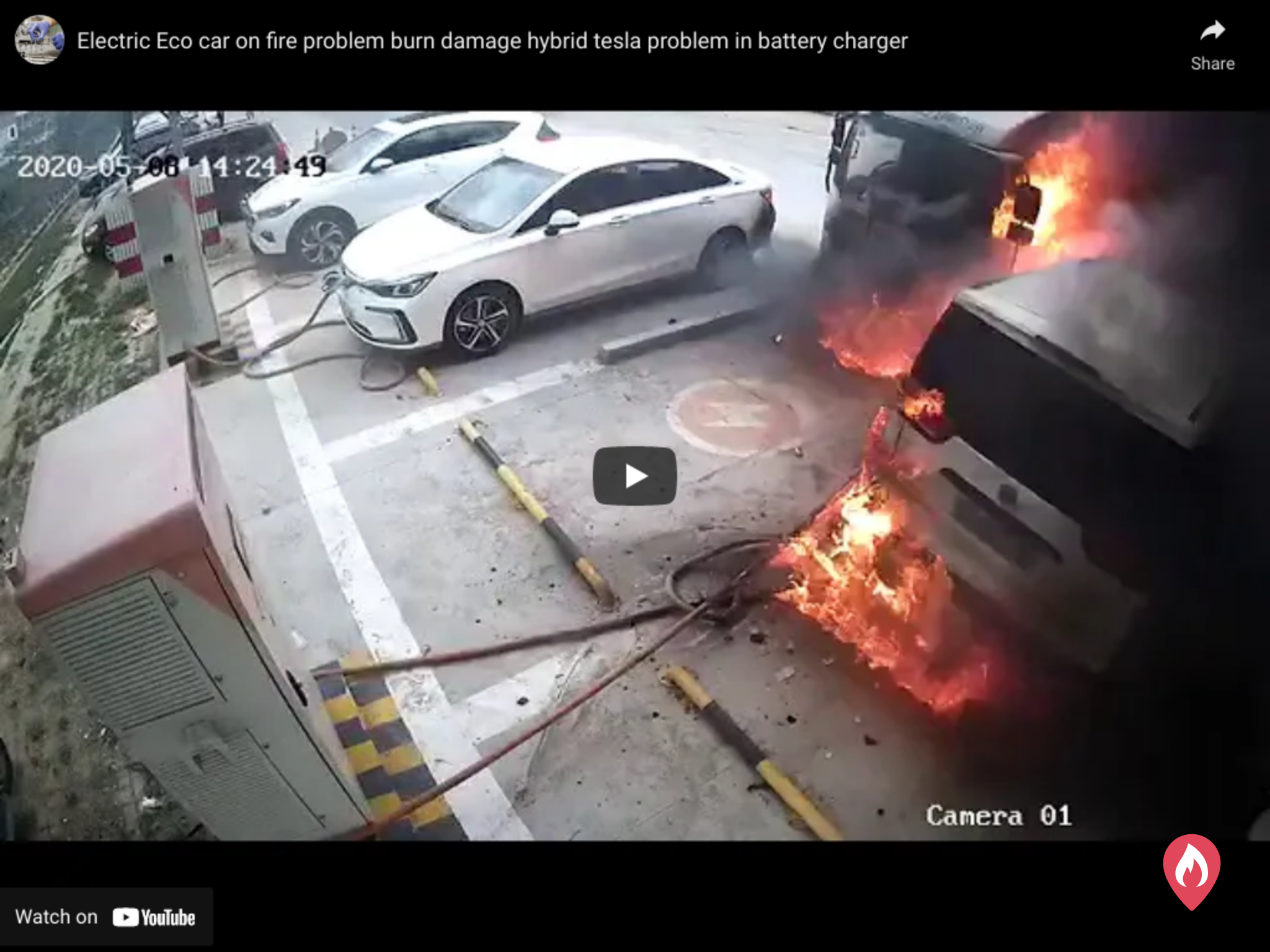
Ignition
Jet like, directional flames



~90%

Vapour cloud explosion
Violent deflagration

~10%


Electric Eco car on fire problem burn damage hybrid tesla problem in battery charger
Share
2020-05-08 14:24:49
Camera 01
Watch on YouTube

Vapour cloud explosion

VCE occurs ~10% of time

Total of **18 VCE incidents** globally since 2010:

64.3%

Underground / enclosed space

35.7%

Open air

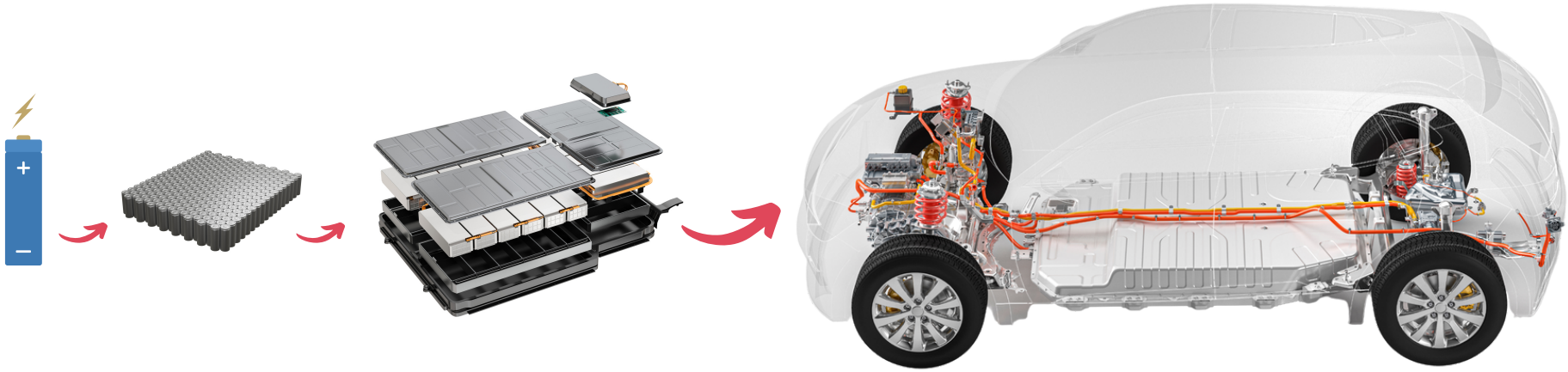
4 incidents verified of:

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

Vapour cloud explosion

EV fire suppression

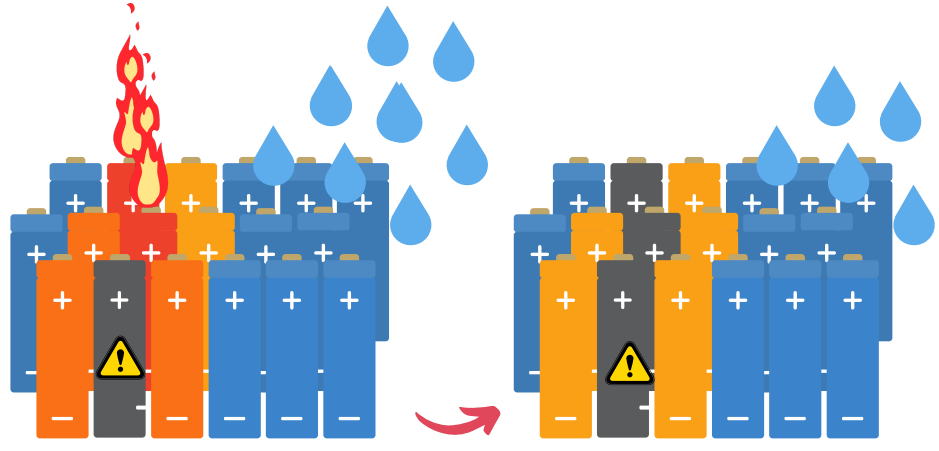
It doesn't actually take much water to cool the battery pack...the problem is getting it directly onto the cells to cool them down



EV fire suppression

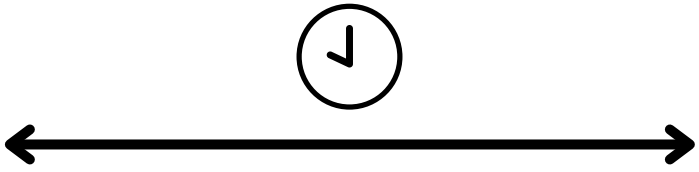
A stream of water onto the underside of the EV will dissipate heat
= slow & stop thermal runaway

Cooling battery cells within a pack may take several hours



Suppression = time, resources

Best case *Worst case*



10min

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

1,000L

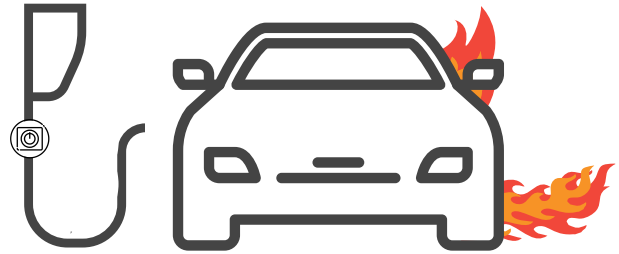
110,000L

EV fires at charging

Of all incidents, we found:

26.15% were connected to energised charging (34 incidents)

4.62% had been disconnected from energised charging within 60 minutes (6 incidents)

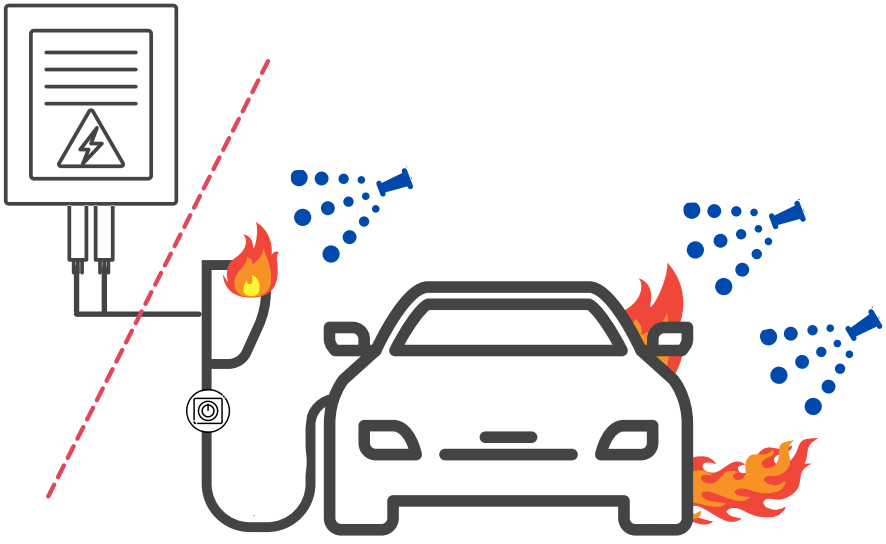


Charging wasn't necessarily the cause of fire, but consideration needs to be given to truck & water access at charging hubs

If connected to charging

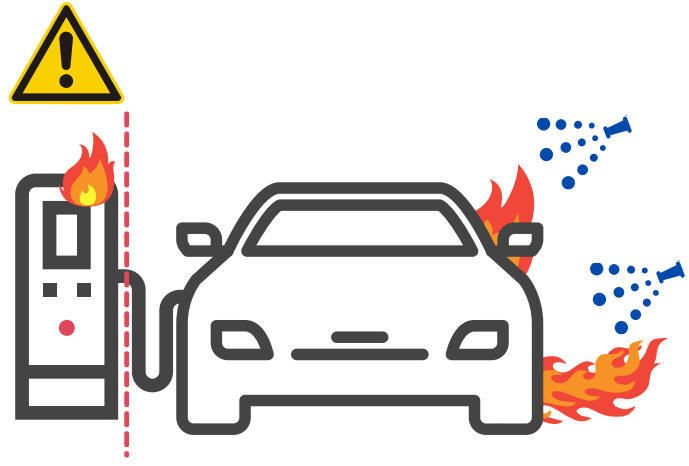
AC EV charging (7/22kW)

In theory, electrically compliant units installed to AS3000 will cut between car & distribution board
Average unit cost: $800-$1500

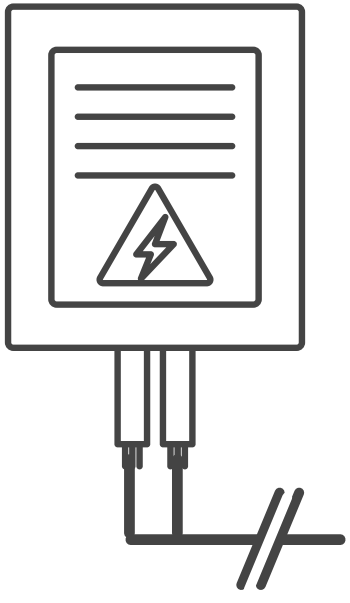


DC EV charging (25/350kW)

In theory, electrically compliant units installed to AS3000 will cut between unit & car
Average cost: $50,000 - $750,000



Best practice



Treat as an energised electrical fire & follow SOPs

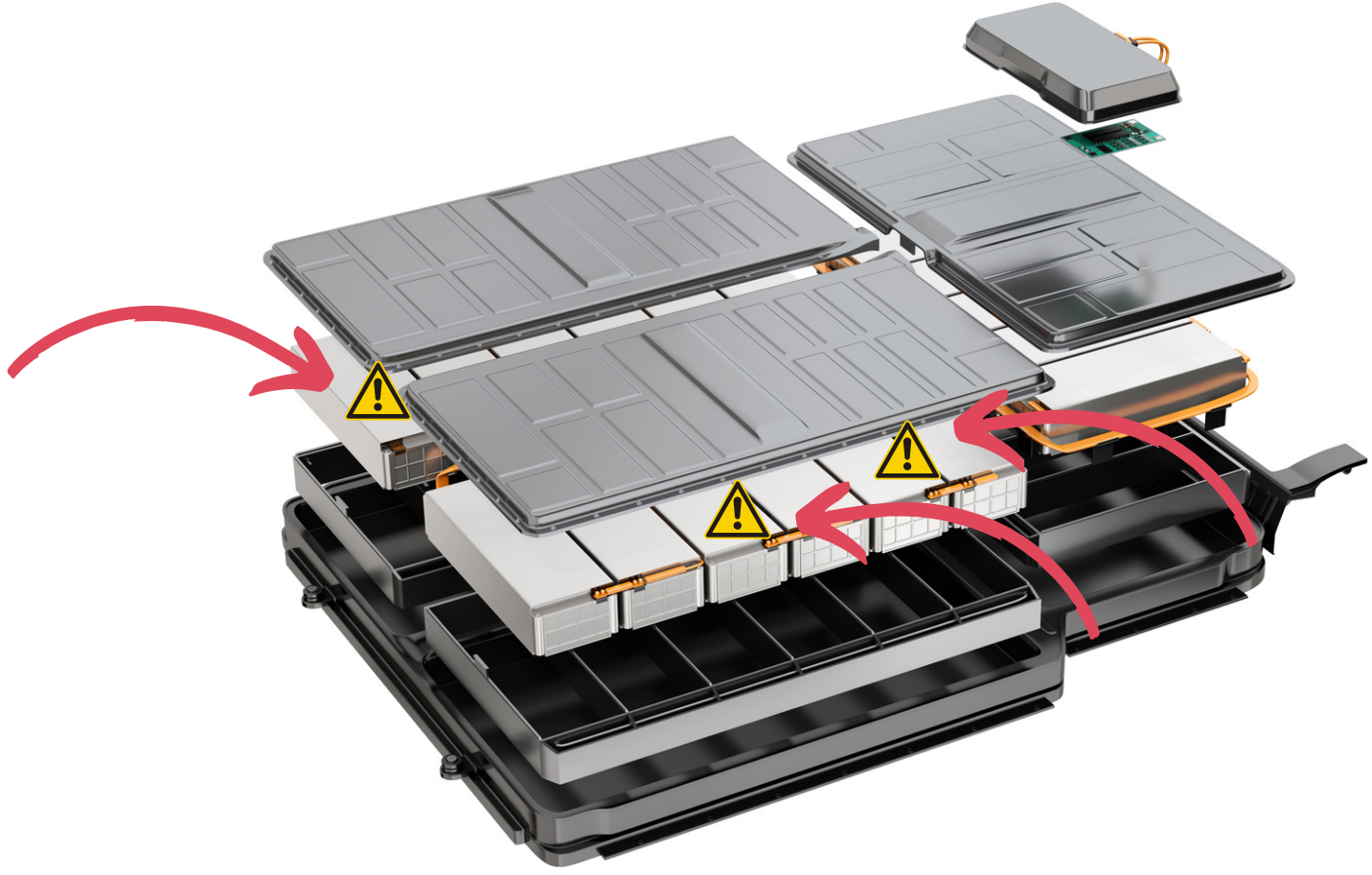
Don't touch anything until distribution board is located & cut

Reignition is a risk

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

Reignition = multiple cells abused

Reignition occurs when multiple battery cells are abused, but short circuit & go into thermal runaway at different times. The stranded energy inside the battery pack supports a second ignition.



Reignition occurred in ~10% of incidents

Upon impact

48 hours later

Ignition

Reignition (on scene)

Reignition on tow truck

Reignition in storage yard

Upon impact

68 days later

Ignition

Reignition in storage yard

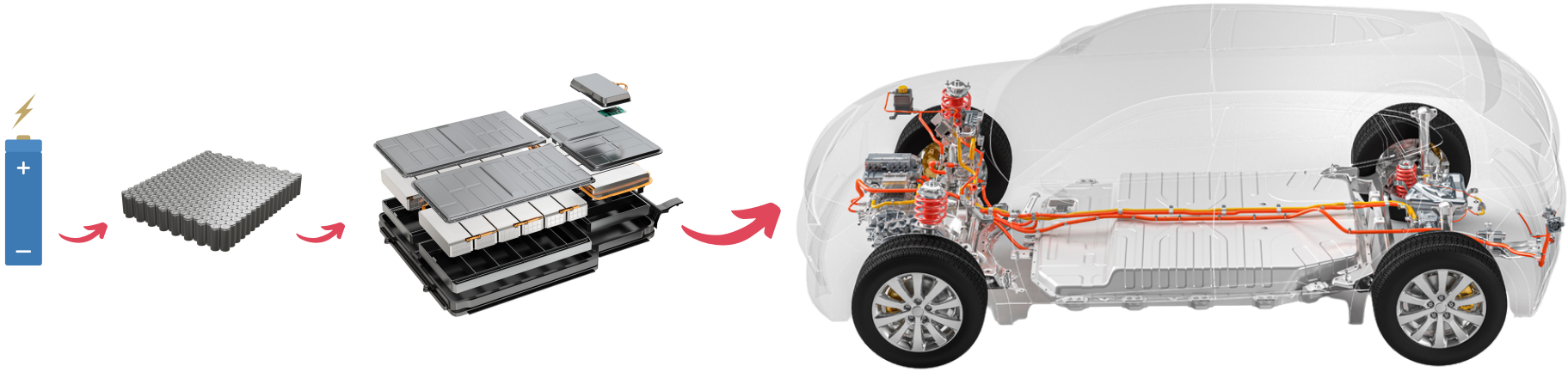
You're a vital link in the emergency response chain

1. Understand battery pack construction
2. Learn signs of thermal runaway
3. Make charging hubs safer
4. Conduct visual inspections
5. Know where ERGs can be found
6. Be alert, not alarmed

AUSTRALASIAN FLEET MANAGEMENT ASSOCIATION

Battery pack construction

Helps us understand where a battery problem is located.



Know signs of thermal runaway

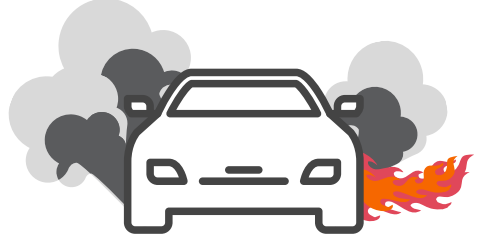
If these are seen or heard, EVACUATE the area immediately & call 000 for emergency assistance.

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

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

At this point, one of two things will occur

Ignition
Jet like, directional flames



~90%

Vapour cloud explosion
Violent deflagration

~10%

Safer charging hubs

Help emergency responders more effectively manage an incident involving an EV

Choose electrically compliant charging equipment & have it professionally installed

- RCM Tick & ask for proof of electrical compliance
- Install to AS 3000 Appendix P
- Review manufacturer usage instructions
- Know where the isolation switch is
- Regularly inspect for wear & tear

Consider your charging location

- Can a truck access the site?
- Where is the nearest fire hydrant?
- Where is the distribution board that will cut power supply & who would do that?
- Locate away from flammable infrastructure
- Where will gases vent to?
- Where will water run off?

If you have multiple charging units being installed, or have fast or rapid charging DC units, it may be a good idea to contact your local brigade or state fire agency to discuss preparing a Pre Incident Plan (PIP) or updating an existing one.

Visual inspections

Ask your manufacturer to provide you with a list of what to look for when conducting a visual inspection. This may include:

- Bulging or dark patches in the battery pack casing
- Damage to the vehicle body
- Damage to orange high voltage cables or components
- Wear & tear on the portable EVSE cables

A burnt EV showing area on the battery pack

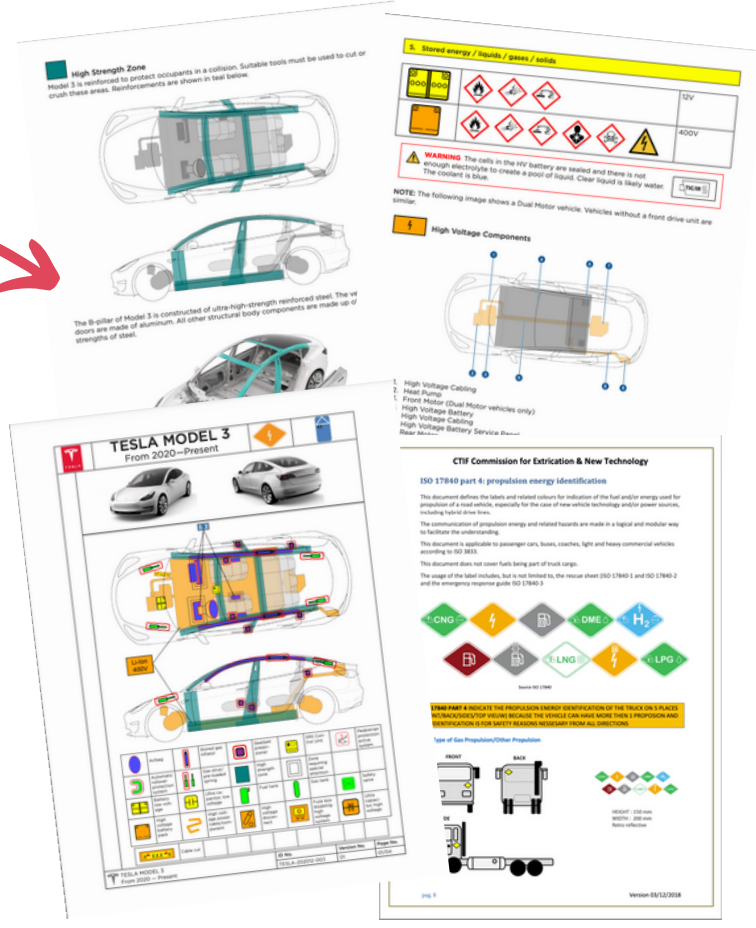
Know your ERGs

Your EV Emergency Response Guide is a vital tool for helping emergency responders manage an incident involving an electric vehicle.

The EV manufacturer can send this to you &/or you can do an online search.

Please note that Emergency Response Guides should follow ISO 17840 which provides standardised information for emergency agencies.

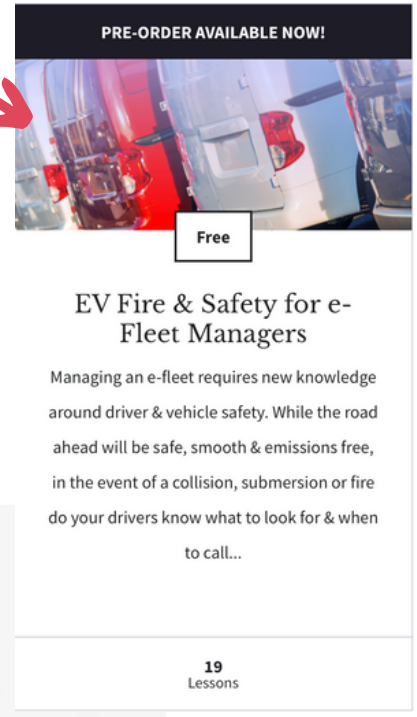
Images from the Tesla Model 3 Emergency Response Guide.



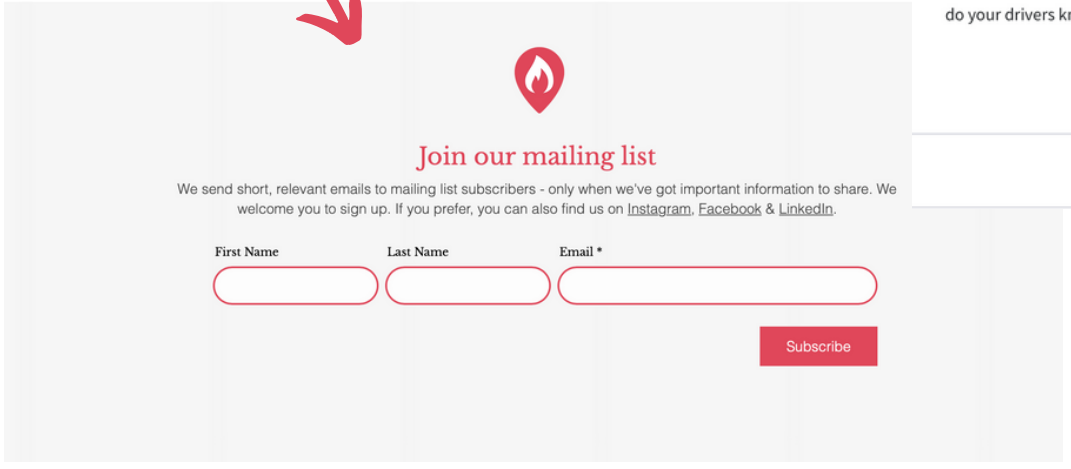
Be alert, not alarmed

EV battery fires are very rare. You can keep up to date with information, research & testing results as we progress our project.

Complete our short online EV Fire Safety for e-Fleet Managers course (launching mid-May).



Join our mailing list & keep up to date with the latest!

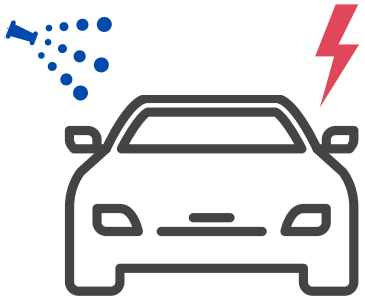


So much to learn & test...

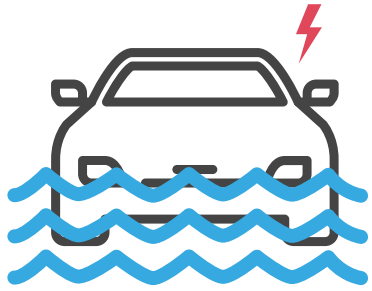
There are a range of other issues we haven't discussed today:

- EV identification & immobilisation
- HV system isolation
- Electrocution
- Stranded energy
- Extrication
- Vapour cloud venting underground
- Water run off
- Flame intensity & temperature
- Fire spread through buildings
- Induction & bi-directional charging

Eg: most surprising finding from our research - electrocution risk is lower than anticipated



Direct stream of water onto damaged HV cables, components or battery



Submersion

Extrication of driver / passengers

Stranded energy - remaining SoC in traction battery

...& knowledge to share...

evfiresafe.com

Our online knowledge hub has been referenced by:

- Country Fire Authority
- Fire Rescue NSW
- SA Metropolitan Fire
- NT Fire & Emergency
- Vic State Emergency Service (SES)
- EPA (Vic & NSW)
- Tesla
- National Fire Chiefs Council (UK)
- Comité Technique International de prevention et d'extinction de Feu (Global)
- Institute of Fire Engineers
- International Firefighter Magazine
- CNBC
- Arup Engineers

and more

...& collaboration

Global expert collaboration

Peer reviewed & connected with Prof Christensen, CTIF, SAE, CFA, FRNSW, VACC, EPA, AfMA, Vic DoT, EV manufacturers, charging, towing & conversions

Data analysis & knowledge sharing

Data-driven analysis of ignition vs vapour cloud explosion, thermal runaway, reignition
Case studies of previous incidents

Data-driven F2F & online education

Video, animation & graphic based online EV fire & safety training courses
Partnerships with JET Charge, VACC, Vic DoT

International media & speaking

CNBC, International Firefighter, The Driven
Presenting to Australian Fleet Management, Fire Protection Association Australia & Tall Buildings Fire Protection (UK) conferences

Socials & video content

Video intro to EV & battery tech
EV ID walkarounds with review of emergency response guides for emergency familiarisation

Paul Christensen
LITHIUM ION SAFETY

RI.
SE

IFV Instituut Fysieke Veiligheid

NFCC
National Fire Chiefs Council

IFE The Institution of Fire Engineers

CTIF

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 firefighter awareness

Brigade visits
Regular webinars

evfiresafe.com

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Scan with your smart phone camera to jump to the EVFS website