



evfiresafe.com

EV FireSafe

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

EV fire information pack for
volunteer emergency brigades

Supported by:



Australian Government
Department of Defence

In partnership with:



Welcome to EV FireSafe

We've been researching EV traction battery fires & what they mean for Australian emergency responders.

Electric vehicles are less likely to catch fire than internal combustion vehicles, but they present new challenges & risks for emergency responders, secondary responders, EV drivers & the public.

This free presentation provides a look at what we know, & includes a snapshot of the EV sector in Australia & international best practice examples. It's suitable for volunteer emergency brigades & anyone wanting to know more about EV traction battery fires.

Please note that this pack is provided for information only & you should follow your agency or organisation SOPs at an incident involving an electric vehicle.





Electric vehicles in Australia

- When we talk about an 'electric vehicle' we mean:
 - BEV - Battery Electric Vehicle with a fully electric drivetrain
 - PHEV - Plug-in Hybrid Electric Vehicle with a petrol & electric drivetrain
- What are the most common EVs in Australia?
- How many EVs are here & how many are coming?
- Electrification is across all transport sectors



What is an EV?

BEV - Battery electric vehicle

ALL plug in to charge up

PHEV - Plug in hybrid electric vehicle

ALL have lithium ion traction battery

These are the most common electric vehicles in Australia (2021)



Nissan Leaf
BEV



MG ZS EV
BEV



Tesla Model 3
BEV



Hyundai Ioniq
BEV



Hyundai Kona
BEV



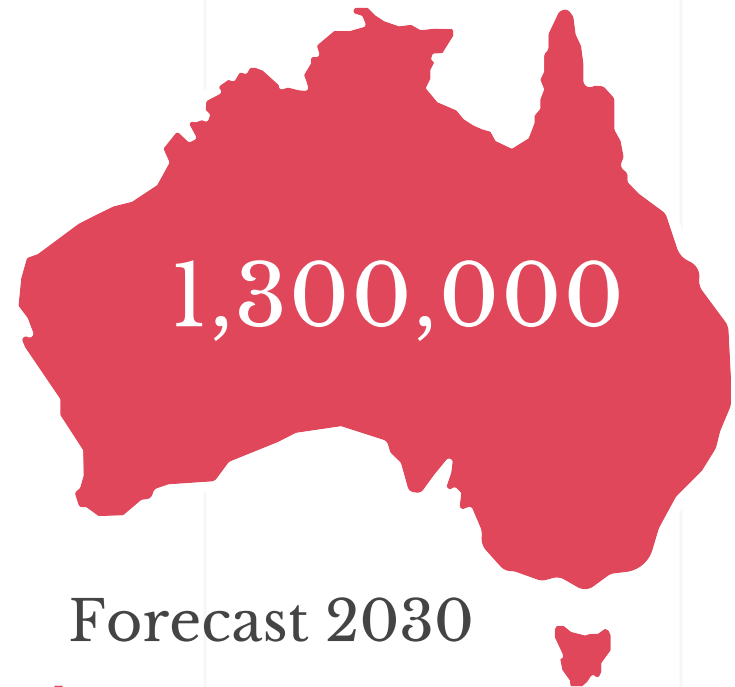
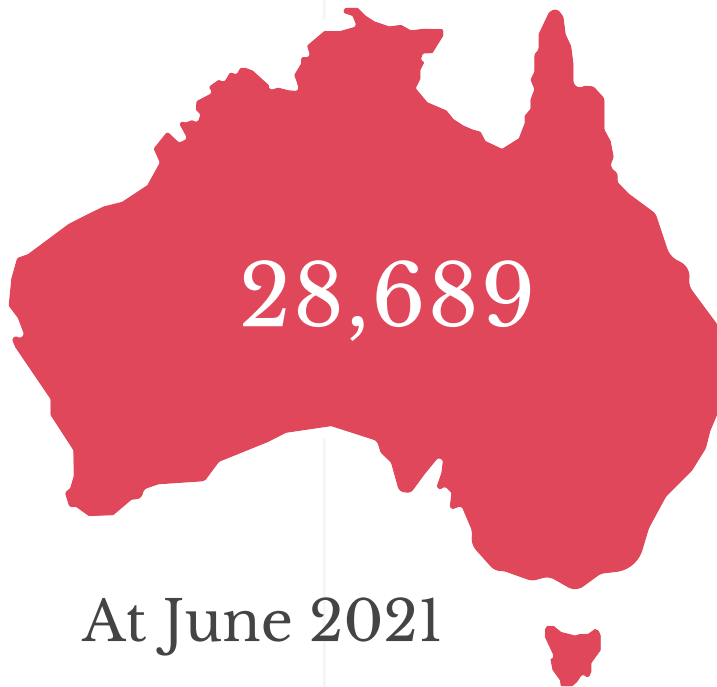
Mitsubishi
Outlander PHEV

See 3.2 What is an EV?



EVs in Australia

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



~70%

compound annual growth
rate of EVs since 2010



EVs across all sectors

All these vehicles are electric & currently in operation in Australia

Heavy commercial



Last mile delivery



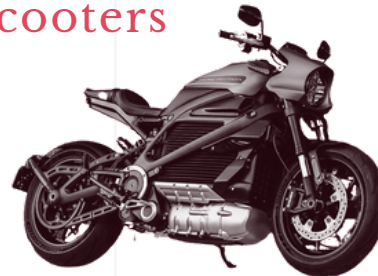
Light commercial



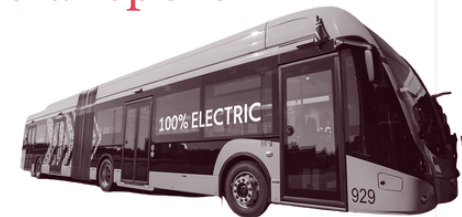
Tradies & mining



Bikes & scooters



Public transport





Electric vehicle identification

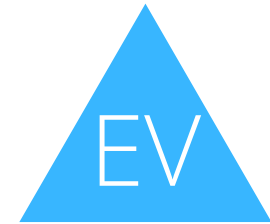
There are a number of ways to identify an EV, but emergency responders should familiarise themselves with electric makes & models available in Australia

- Primarily:
 - ask the driver & passengers (if possible)
 - look for the blue 'EV' triangle badge on numberplates
- Identification may not be possible if the vehicle is fully involved in fire



Blue 'EV' badge

The blue triangle 'EV' sticker is mandatory in many states & becoming standard nationally



See 3.6 Identifying an EV



On all **EVs**

Blue triangle EV badge





EV ID not always helpful

By the time emergency responders arrive on scene, it may not be possible to see identifying features





Electric vehicle identifying thermal runaway

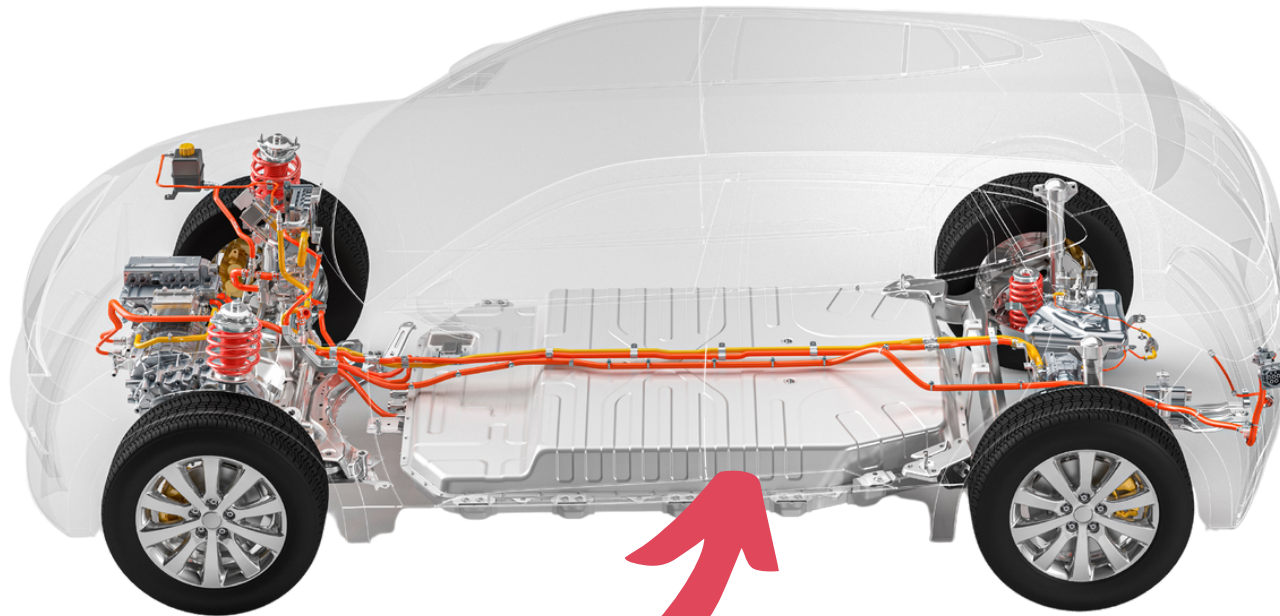
Understanding an EV battery & the characteristics of an EV battery fire will help you determine you're dealing with an electric vehicle incident

- What is an EV traction battery & how is it constructed?
- All EV fires start with thermal runaway
- What is thermal runaway & what does it look like from a firefighters perspective?
- Risk of vapour cloud explosion



EV lithium ion traction battery

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



Traction battery pack

See 3.4 What is a traction battery?

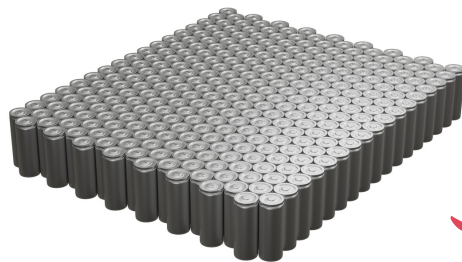


EV lithium ion traction battery

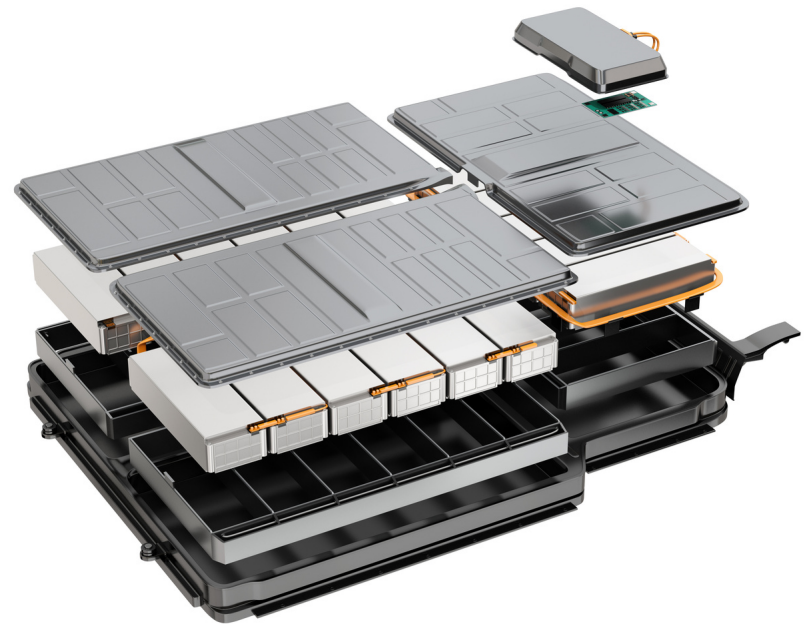
A traction battery pack is typically constructed like this:



Lithium ion battery cell



Multiple cells make a battery module

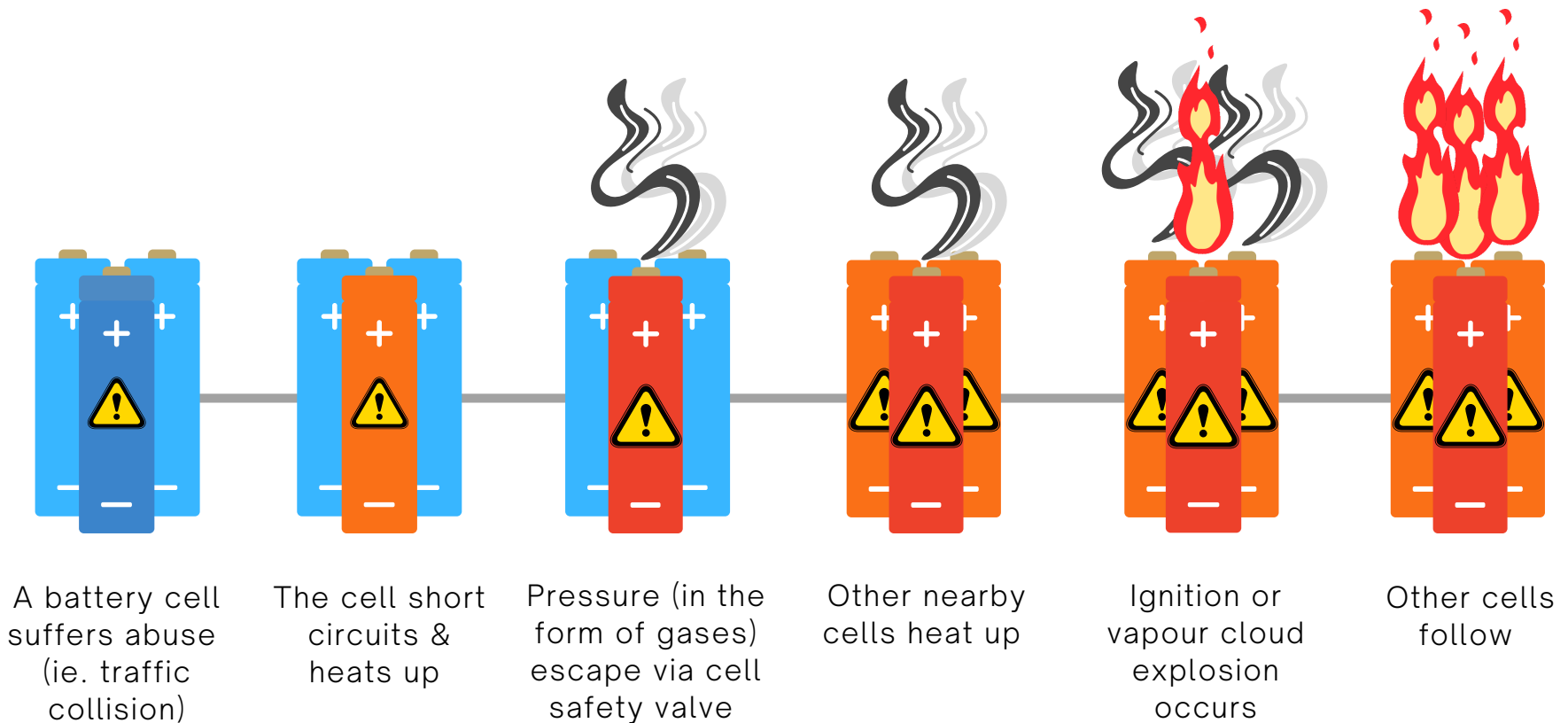


Multiple modules make a battery pack, which is enclosed in a battery casing



All EV fires start with thermal runaway

Thermal runaway occurs when a battery cell suffers abuse, for example from a traffic collision. This causes a short circuit, which heats up the cell & dissipates that heat into other surrounding cells.





Thermal runaway

is an unstable chemical process that is difficult to bring under control.

It looks & sounds like this:

See 4.2 What is thermal runaway?



Dark vapour cloud,
light vapour cloud





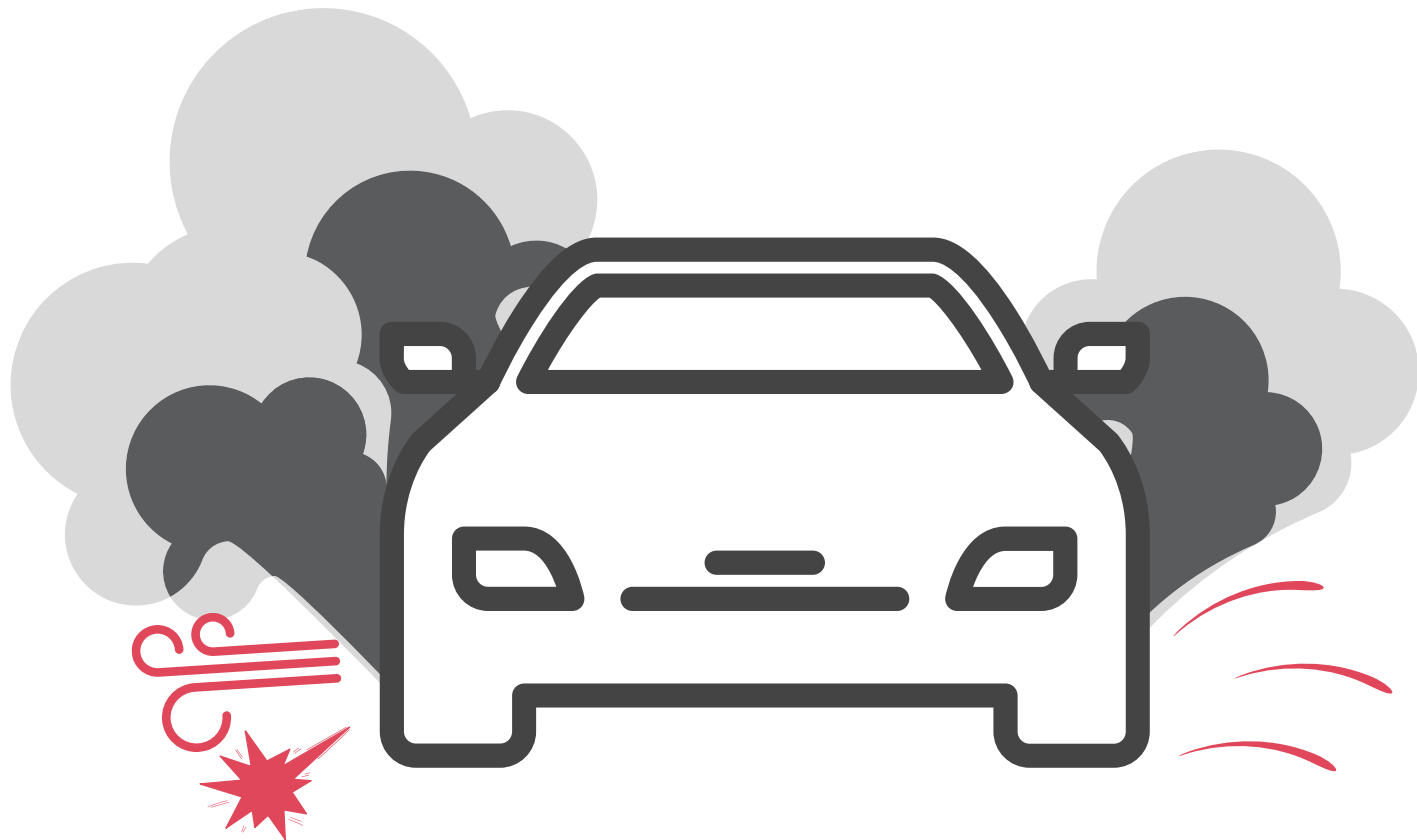
(It's NOT **smoke**)

The vapour cloud is often mistaken for smoke, but it is a highly flammable & toxic mix of gases, primarily hydrogens.





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





One of two things will occur

~90% of the time the
gases will ignite

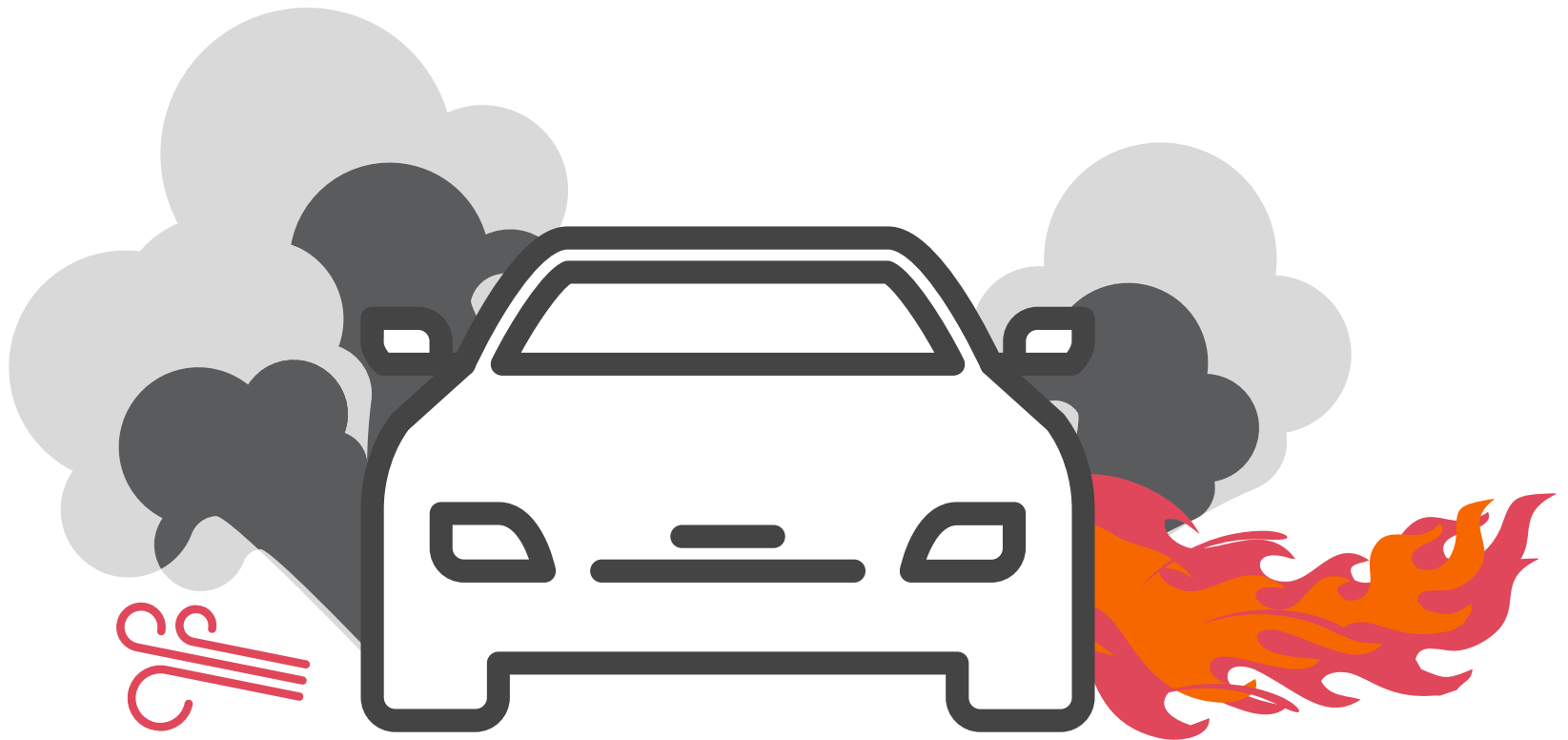
~10% of the time the
vapour cloud will explode
(often in enclosed spaces)



Stats from EV FireSafe research data



Once ignited:
Directional, jet like flames
Up to 2700°C





Thermal runaway & ignition

Go to [04.3 EV traction battery fire behaviour](#) at evfiresafe.com & watch the video; volume up





Thermal runaway - vapour cloud explosion

Go to [04.2 What is thermal runaway?](#) at evfiresafe.com & watch the video; volume up



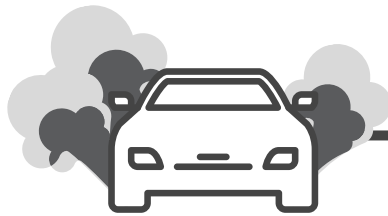
Recap: EV fire characteristics

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

Vapour cloud explosion
Violent deflagration



~90%



~10%



Electric vehicle fire suppression

- Recommended by Tesla & most fire agencies
 - **lots of water, established early**
- Cool battery & suppress flames
- Best practice examples used internationally
- Can it burn out?
- More resources may be required

Your agency SOPs should be followed!



Use lots of water

Establish water supply as soon as an EV fire is identified; more tankers, bulk tanker, hydrant connection

EV fire suppression





Use water to cool battery & suppress flames

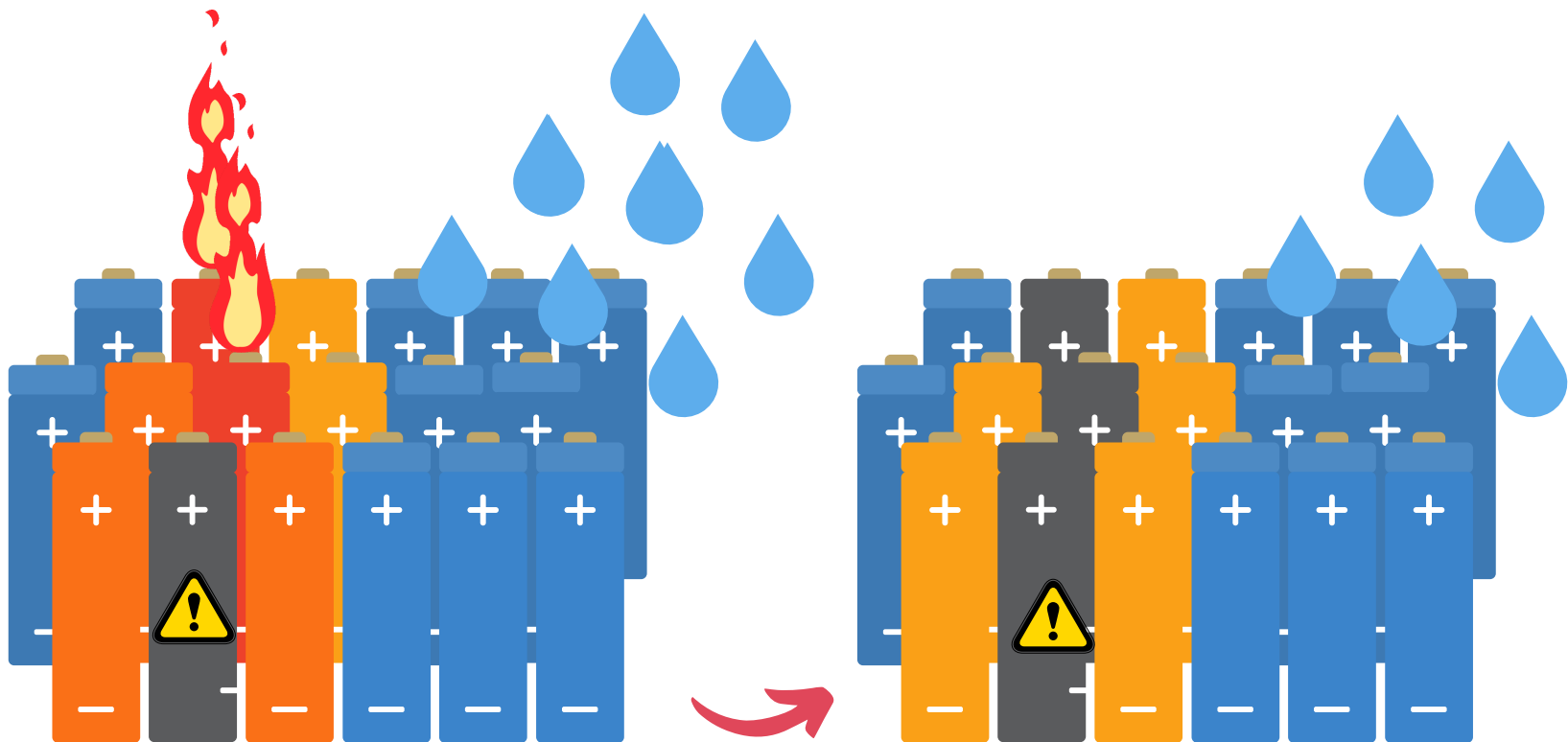
Establish a continuous stream of water onto the underside of the vehicle - where the traction battery is located - to absorb the heat being generated by the battery cells in thermal runaway



See 4.7 Suppression methods

Cool battery; slows thermal runaway

Cooling the battery with a continuous stream of water will slow & eventually stop the thermal runaway process - this may take several hours





International best practice

Many US fire agencies jack up one side of vehicle to get water directly onto the traction battery underside

EV fire suppression



Brock Archer, YouTube



International best practice

Put entire EV in water. Used by a number of fire agencies, but not recommended by Tesla due to reignition risk

EV fire suppression

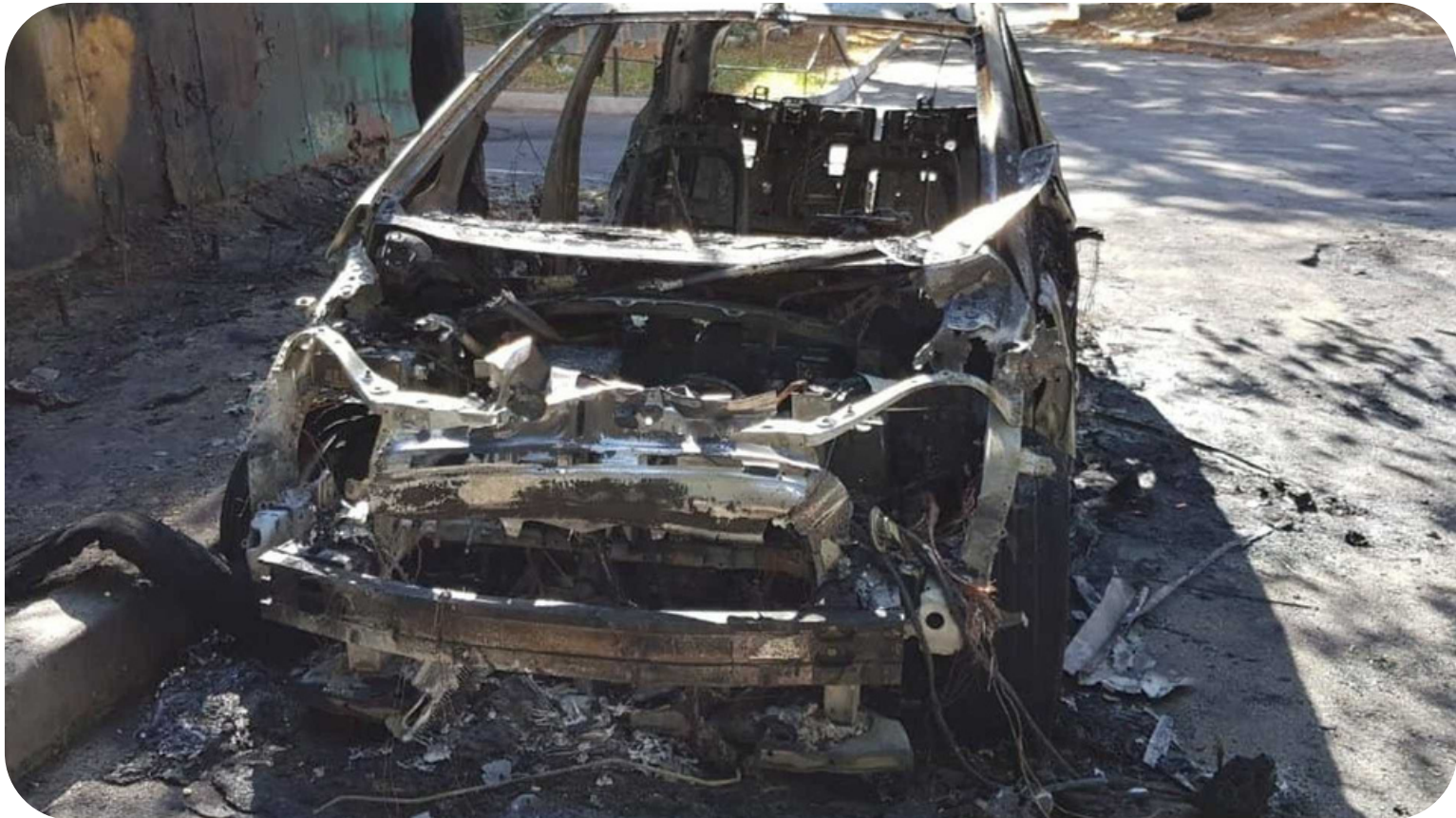




Can it burn out?

Is it possible to allow the traction battery to burn out completely?
This removes risk of stranded energy & reignition

EV fire suppression





EV fire suppression may require more resources

Best case

Worst case



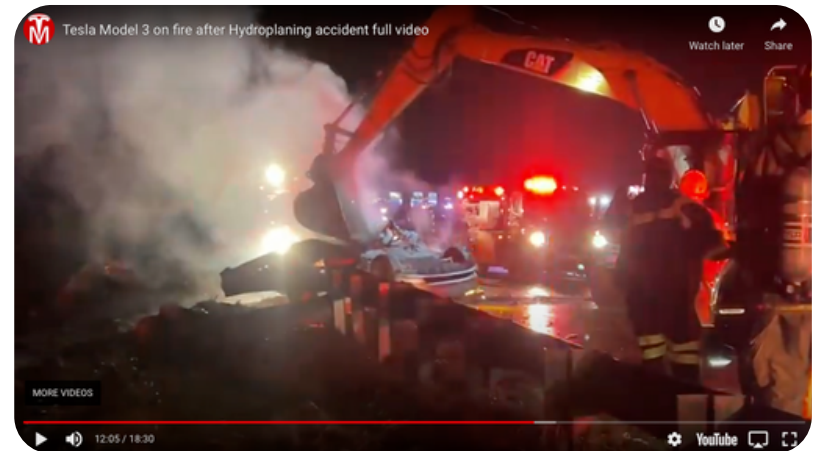
10min

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



1,000L

110,000L





Electric vehicle fire suppression with EV charging

What are the additional risks to emergency responders if a burning EV is connected to energised charging?

- A third of all EV fires occur when the vehicle is connected to energised charging
- Charging is not necessarily the fire cause
- What to do if a burning EV is connected to AC or DC charging
- Best practice - cut power at distribution board



33% of EV fires occurred while charging

Charging is not the cause of EV fires; by their very nature, EVs spend significant amounts of time plugged into charging

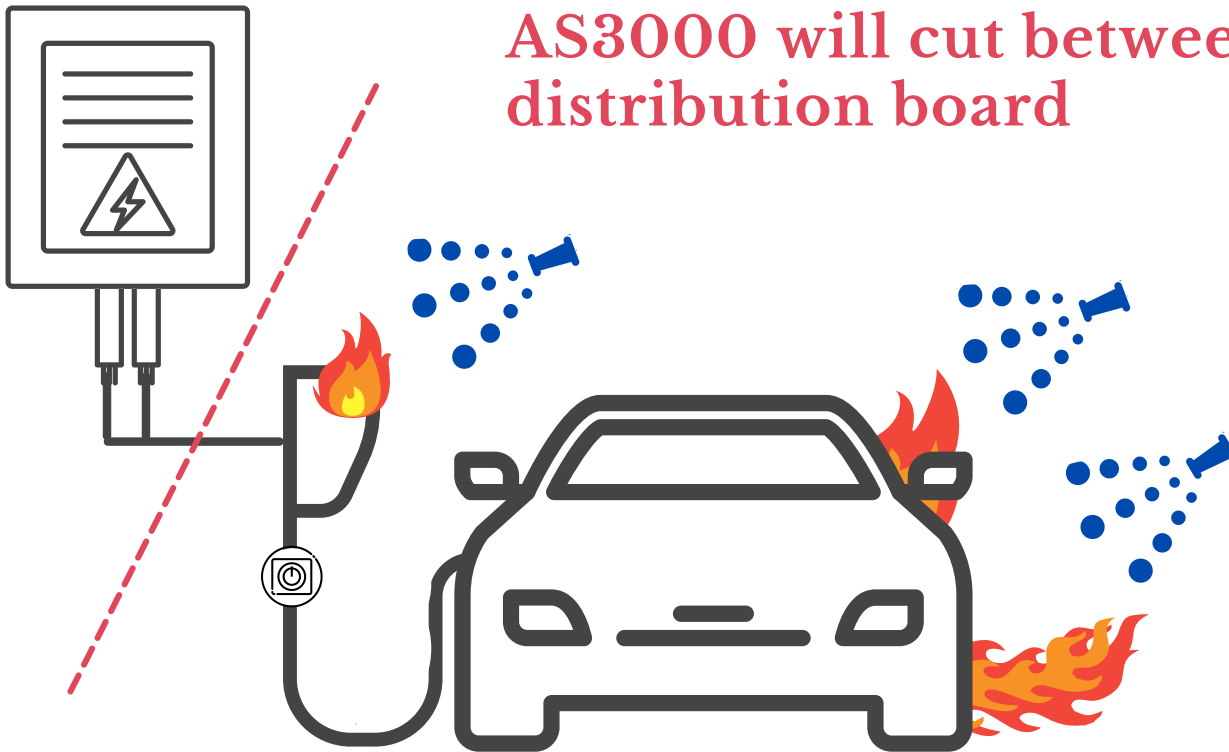
EV fire suppression





If connected to AC EV charging (7/22kW)

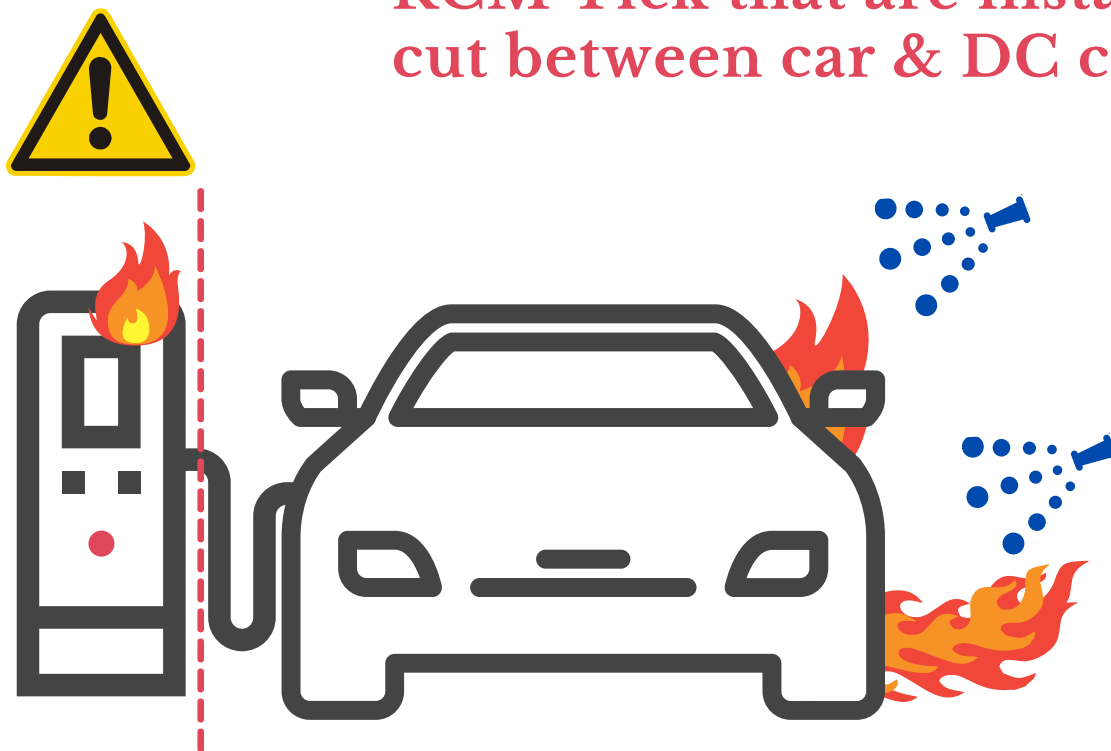
In theory, electrically compliant units with RCM Tick that are installed to AS3000 will cut between car & distribution board





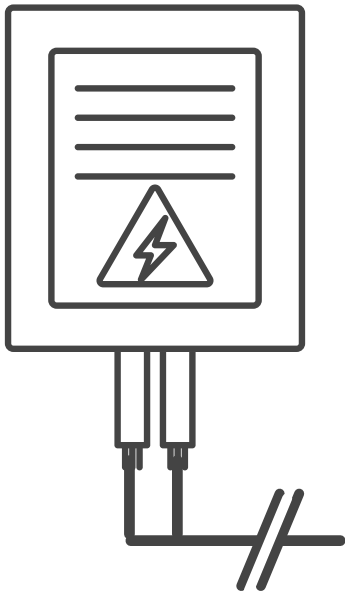
If connected to DC EV charging (50/350kW)

In theory, electrically compliant units with RCM Tick that are installed to AS3000 will cut between car & DC charging unit





Best practice



Treat as an energised electrical fire & follow your SOPs

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

See 4.6 Risks - EV fires while charging



Electric vehicle fire reignition

Fire reignition occurs when thermal runaway is not finished

- Reignition happens 10% of the time
- It poses a risk to tow trucks, drivers & storage yards
- Occurs when thermal runaway hasn't finished
- 2 reignition case studies
- Best practice internationally

10% likelihood of **EV** fire reignition



In 6 cases

Damage caused to
tow truck

In 2 cases

Injuries to drivers

See 4.9 Make safe & towing

Reignition occurs when thermal runaway is not finished

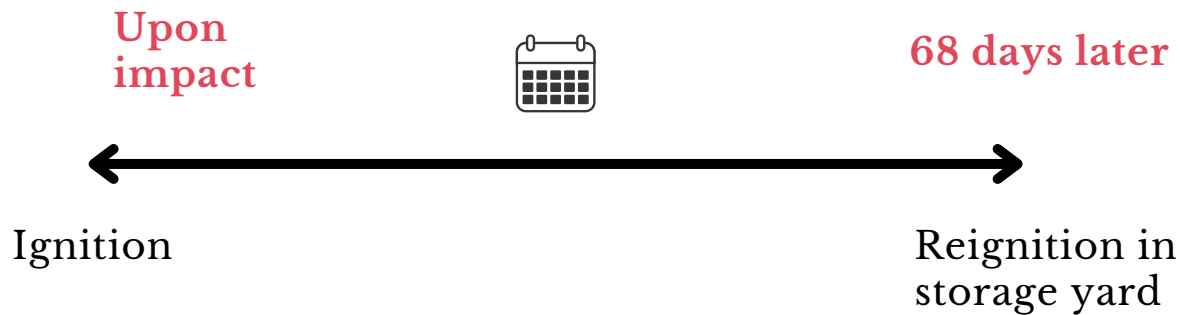
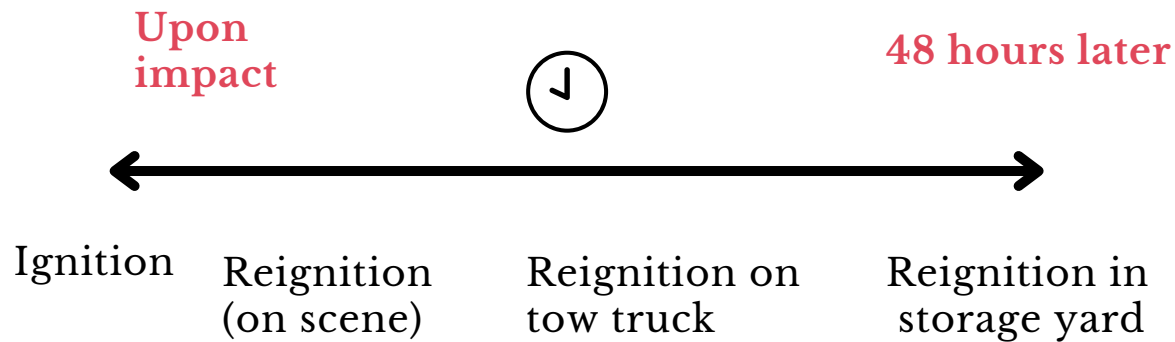
A battery cell within a module is abused, ignites & is extinguished

Another cell in a different module may have been abused in the original incident or by fire. When extinguished vehicle is moved, that cell may then go into thermal runaway.

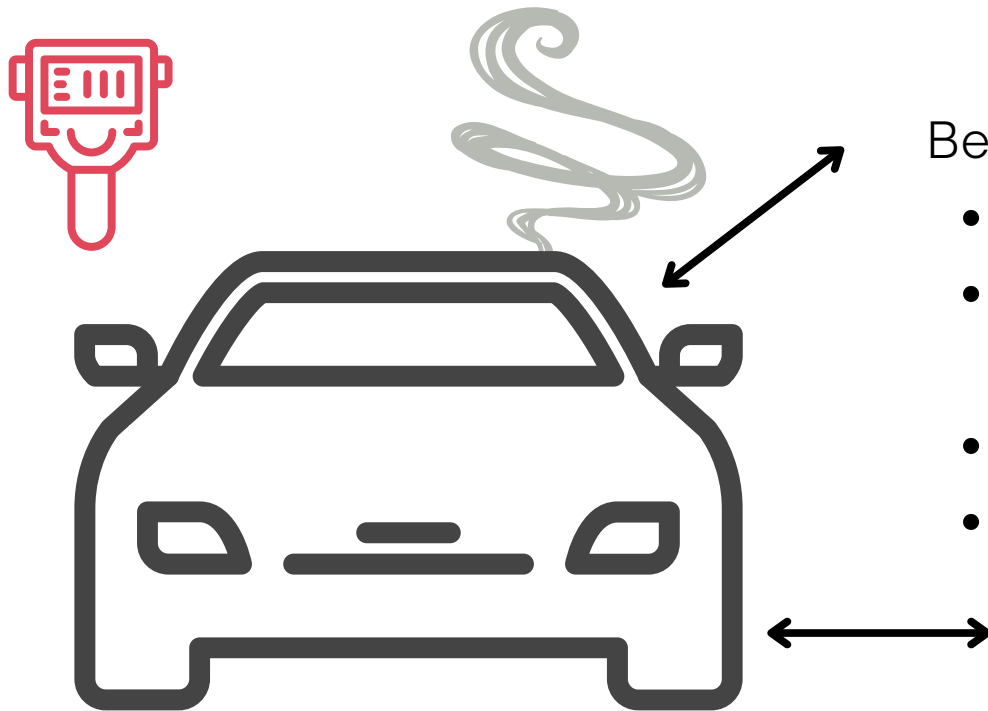




Reignition case studies



When can a burnt EV be made safe?



Best practice internationally is:

- Monitor with TIC
- Up to 30 minutes at ambient temperature
- No popping, hissing noises
- Store 15-30m from other vehicles



Electric vehicle FAQ

Electric vehicles are less likely to catch fire than internal combustion engine vehicles

But, when they do, there are new & different challenges for emergency responders



Go to evfiresafe.com
for more information



evfiresafe.com

Thanks!

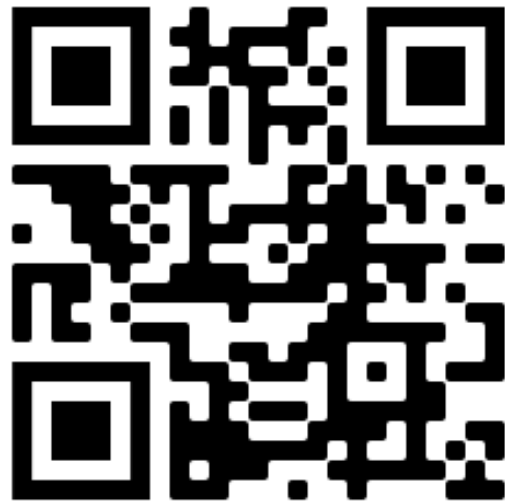
Have a question, noticed a problem or want to organise a free presentation? Contact:

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

