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# Carpark fire safety

## Are electric vehicles a red herring?

**Adam Glew**

Fire Australia 2025, Sydney, 14 May 2025

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# Agenda

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# Introduction


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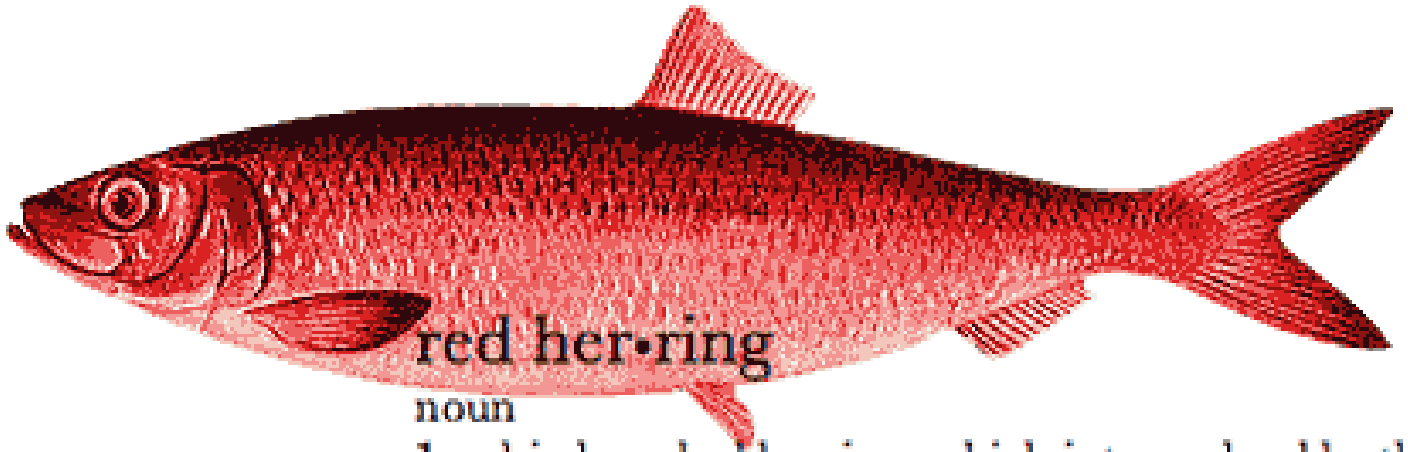
CERIB
Fire Testing Centre
YTONG
YTONG


RIVERSIDE
THEATRE

# Introduction

**What is a ‘red herring’?**



**red her•ring**

noun

**1** a dried smoked herring, which is turned red by the smoke.

**2** something, esp. a clue, that is or is intended to be misleading or distracting : *the book is fast-paced, exciting, and full of red herrings.* [ORIGIN: so named from the practice of using the scent of red herring in training hounds.]

Red Herrings… indeed – RLS's Blog

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# Contemporary design of carparks

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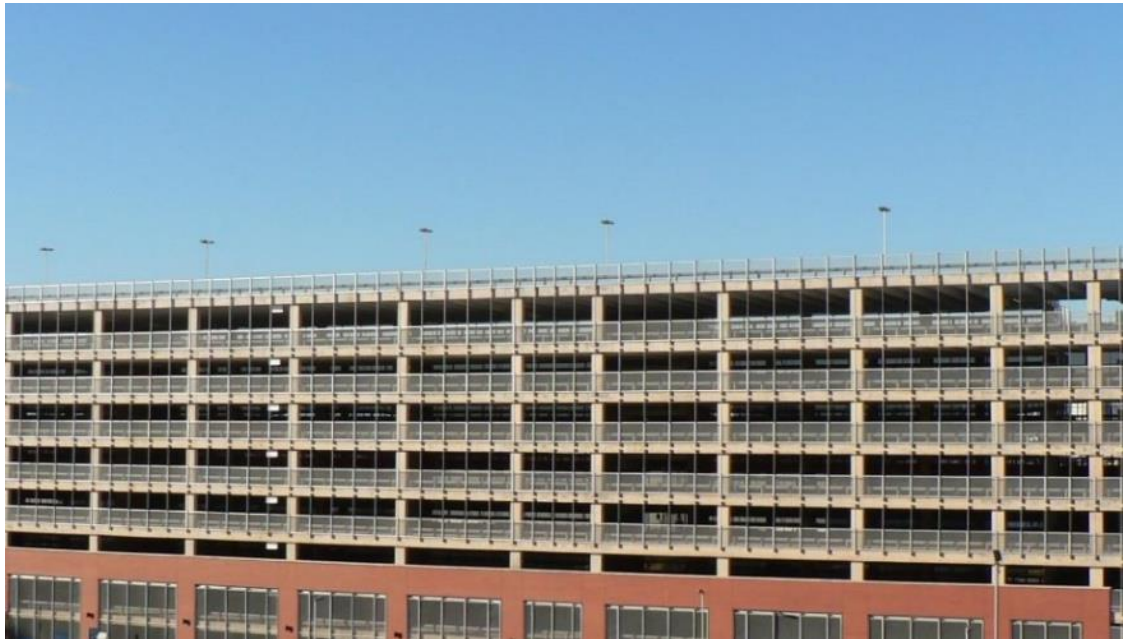
# Carpark fire safety

## Open-deck and enclosed Class 7a carparks




## Open-deck

**Open-deck carpark**: A carpark in which all parts of the parking storeys are cross-ventilated by permanent unobstructed openings in not fewer than 2 opposite or approximately opposite sides, and –

a) each side that provides ventilation is not less than ⅙ of the area of any other side; and

b) the openings are not less than ½ of the wall area of the side concerned.

## Enclosed

Typically basements.

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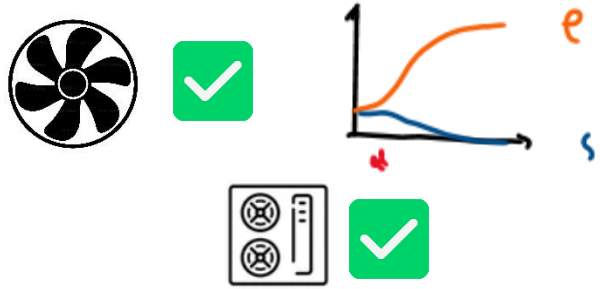
# Setting the DtS scene

## Case study: typical DtS fire safety provisions in a Class 7a carpark designed to NCC 2022

- Day-to-day **mech ventilation** in enclosed carparks – operable in a fire event, **ramps up to max exhaust rate**, but <u>not</u> a smoke control system. Supply air system shuts down on fire trip.
- Fans (other than stair press) do not need fire-resistant cabling.
- **Control switches provided at the building/carpark entry** such that the brigade can control / shut down the fans as required.
- Smoke detectors are needed:
  - To operate a zone/stair press system. Note: this is not required for open-deck.
  - Carparks with; (i) day-to-day mech ventilation <u>and</u> (ii) pressurised fire-isolated exit paths need smoke detection in circulation spaces and at each required exit and lift landing door. Note: **the BCA requires every stairway or ramp serving as a required exit in Class 7 buildings to be fire-isolated ∴ most carparks have smoke detectors.**
  - Watch-it: a two-storey enclosed basement carpark technical doesn't need fire-isolated stairs thus may not have detection.



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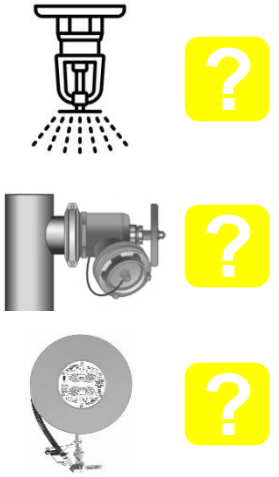
# Setting the DtS scene

## Case study: typical DtS fire safety provisions in a Class 7a carpark designed to NCC 2022

- **Sprinklers** required **if; (i) the building has an effective height > 25 m**, except for open-deck carparks if they are a separate building, **or** (ii) **for enclosed carparks accommodating > 40 cars**.
- **Fire hydrants required if the carpark's total floor area > 500 m².**
  *AS 2419.1:2005 required concurrent supply to both hydrants and sprinklers – this was often subject to a Performance Solution and is no longer required by AS 2419.1:2021.*
- **Fire hose reels required if**; internal fire hydrant(s) are installed, or, if **the carpark's total floor area > 500 m²**.
- **Fire-isolated exits serving the rest of the building are allowed to discharge into carparks** if the carpark is open for at least ⅔ of its perimeter and the travel distance to outside is ≤ 20 m.



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# Watch-it: carpark concessions

## Carpark-specific concessions permitted under NCC 2022

- Compartment size limits do <u>not</u> apply to; (i) sprinkler-protected enclosed carparks, and (ii) open-deck carparks.
  I.e., **compartment size limits only apply to unsprinklered enclosed carparks**.
- **Significant reductions in structural fire resistance levels (FRLs) are permitted** within; (i) open-deck carparks, and (ii) sprinklered enclosed carparks.
- Generally speaking; Type A and B open-deck and sprinklered enclosed carparks can have **60-minute FRLs for non-steel elements** and **nominal (unclassified) FRLs for exposed steel meeting the stated ESA/M ratio**.
- *ESA/M = exposed surface area to mass per unit length. Describes how much surface area of a structural element is exposed to fire per unit of mass per unit length. A proxy for how quickly a structural element will heat up in a fire.*
- Carparks accommodating < 40 cars do not require sprinklers. Note: this may be overridden by other requirements to provide a sprinkler system throughout a building, e.g., if the effective height > 25 m.

Most conservative

Least conservative

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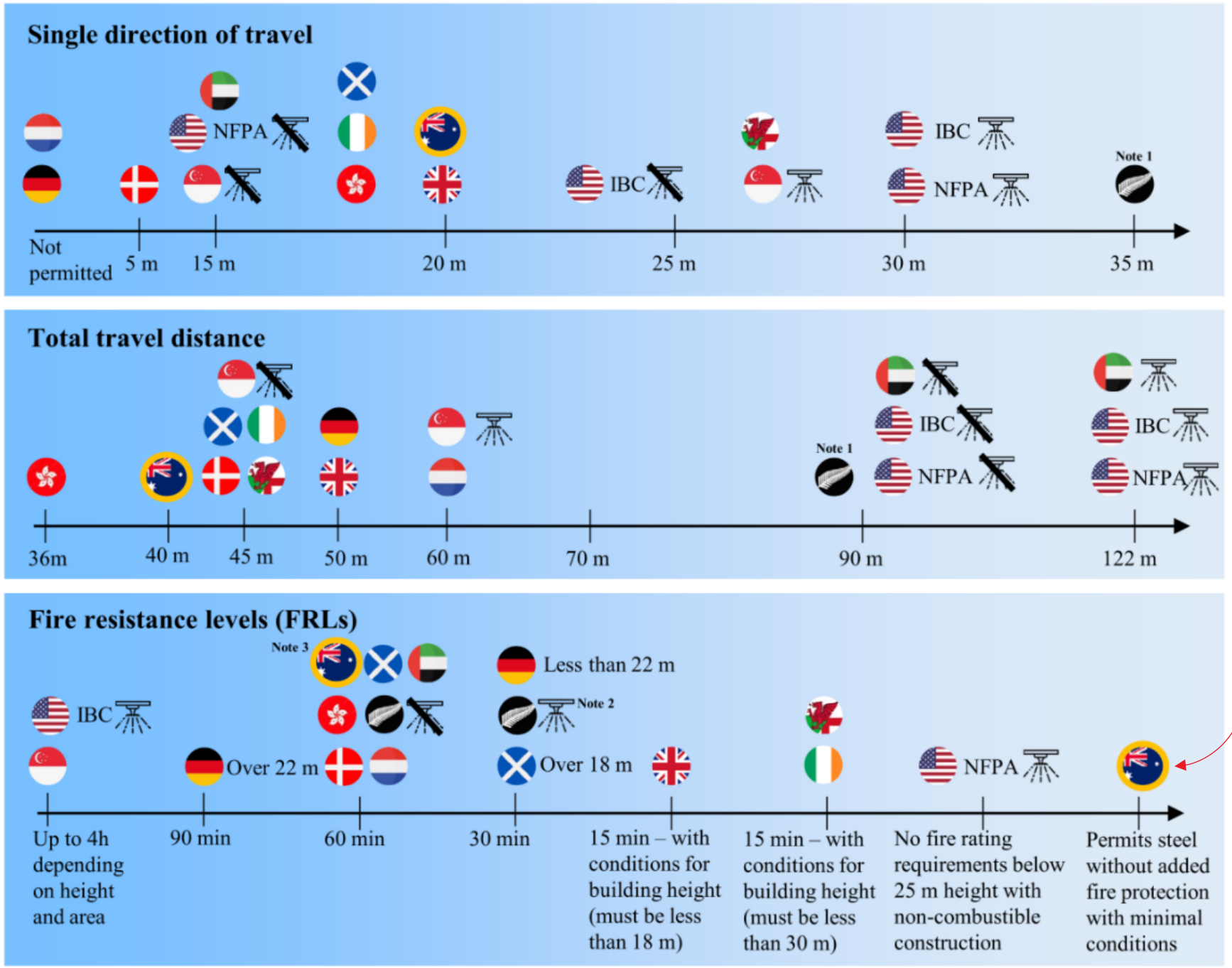


*Quite a significant outlier. Note some other countries do get to this point through PBD also.*

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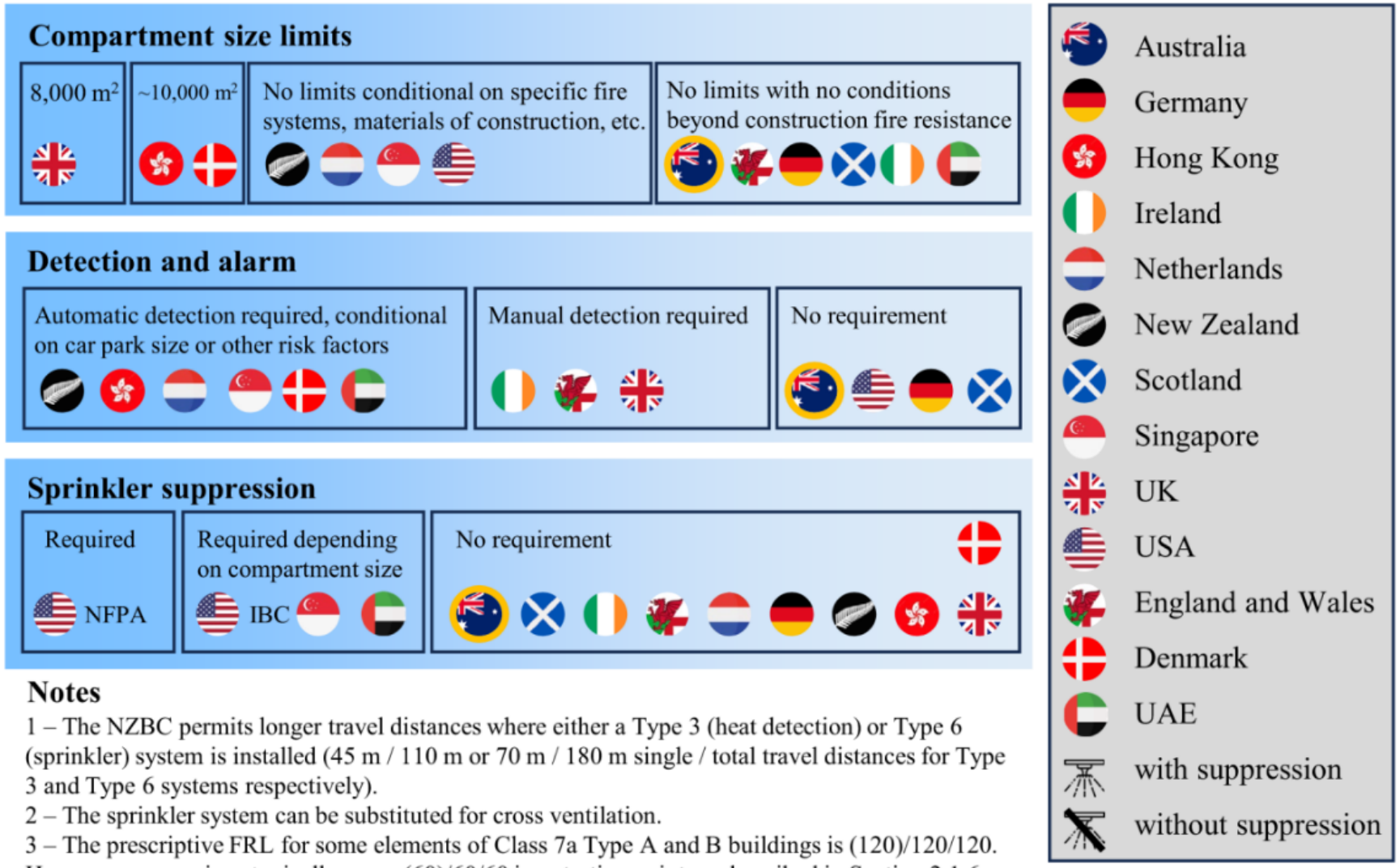
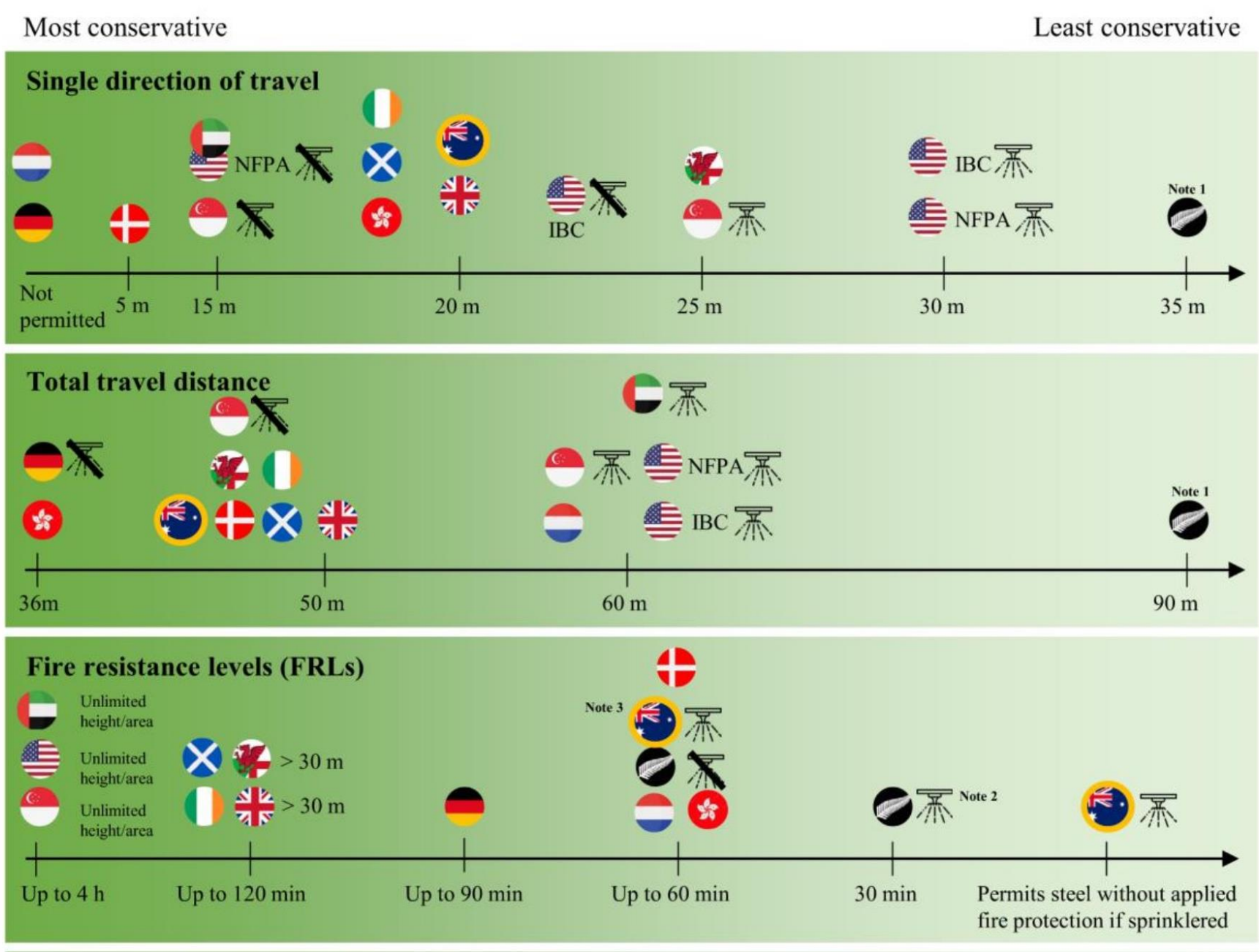



**Notes**

1 – The NZBC permits longer travel distances where either a Type 3 (heat detection) or Type 6 (sprinkler) system is installed (45 m / 110 m or 70 m / 180 m single / total travel distances for Type 3 and Type 6 systems respectively).

2 – The sprinkler system can be substituted for cross ventilation.

3 – The prescriptive FRL for some elements of Class 7a Type A and B buildings is (120)/120/120. However, concessions typically mean (60)/60/60 is a starting point, as described in Section 2.1.6.


Most conservative
Least conservative
Single direction of travel
NFPA
IBC
IBC
NFPA
Note 1
Not permitted
5 m
15 m
20 m
25 m
30 m
35 m
Total travel distance
NFPA
IBC
Note 1
36m
50 m
60 m
90 m
Fire resistance levels (FRLs)
Unlimited height/area
Unlimited height/area
Unlimited height/area
> 30 m
> 30 m
Note 3
Note 2
Up to 4 h
Up to 120 min
Up to 90 min
Up to 60 min
30 min
Permits steel without applied fire protection if sprinklered

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## Compartment size limits

| 5,000 m² | 8,000 m² | 10,000/10,500 m² | No limits conditional on specific fire systems, materials of construction etc. |
|---|---|---|---|
| (FRL of 120) | | (FRL of 120 and suppression) | |

## Detection and alarm

| Automatic detection required, conditional on car park size or other risk factors | Manual detection required | No requirement |
|---|---|---|

## Sprinkler suppression

| Required | Required depending on car numbers / compartment size | No requirement |
|---|---|---|
| | 40 cars; >230 m²; 10 cars; if more than 1 basement, 2000 m² in basement or 4000 m² above ground | |

## Smoke exhaust

| 10 ac/hr, or naturally vented (or jet fans (BS 7346-7)) | Mechanical purging systems (special rules for jet fans) | Performance -based | Fire brigade controls on daily mech. | No req. |
|---|---|---|---|---|

- Australia
- Germany
- Hong Kong
- Ireland
- Netherlands
- New Zealand
- Scotland
- Singapore
- UK
- USA
- England and Wales
- Denmark
- UAE
- with suppression
- without suppression

## Notes

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2 – The sprinkler system can be substituted for cross ventilation.

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# Seminal experimental carpark fire research

# JFRO, UK (1967)

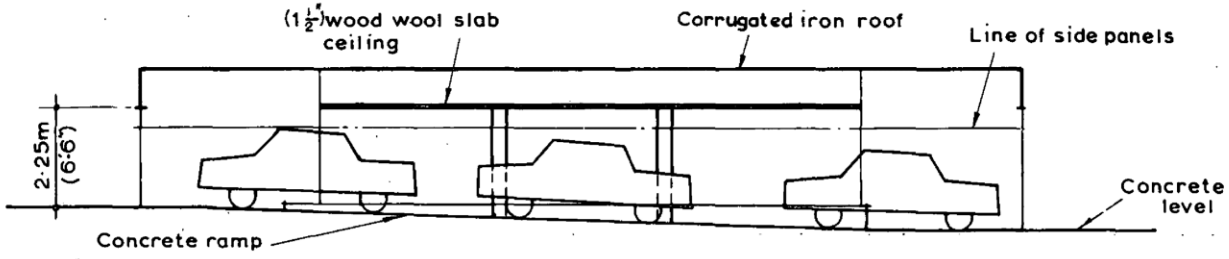
## Cars in position before first test



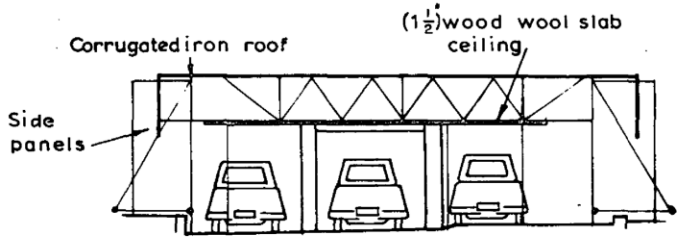
# JFRO, UK (1967)

**Earliest experimental study on fires in carparks**

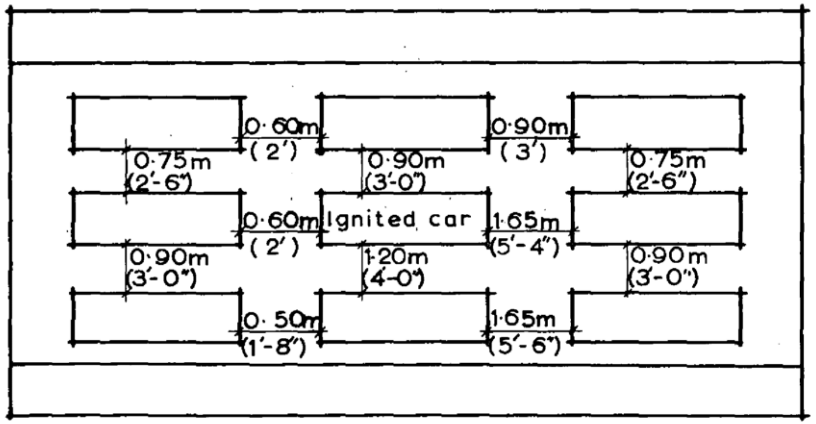
- Three full-scale burns within a single storey test building
- 167 $m^2$ with a floor-to-ceiling height of approximately 2.25 m
- Longer façades; 50% ventilation
- Short façade; open (2), closed (1)
- No fire spread to neighbouring vehicles in any of the experiments
- BRE (2010): “It is likely that the fuel load of these cars [is] certainly different from modern cars”




SECTION A




SECTION B




TEST 2

# AISI, USA (1972-73)

## Largest floor area available

### Carpark building

- Existing open-deck carpark
- Unprotected steel frame with concrete deck
- Previously operational building
- 69 m x 55 m = floor area of 3,800 $m^2$

### Test at 5 mins

- Only three cars in the experiment
- Flames under the steel beam
- One car involved

### Test at 37 mins

- Fuel tank engulfed
- Fire spread to rear of second vehicle
- No significant structural damage

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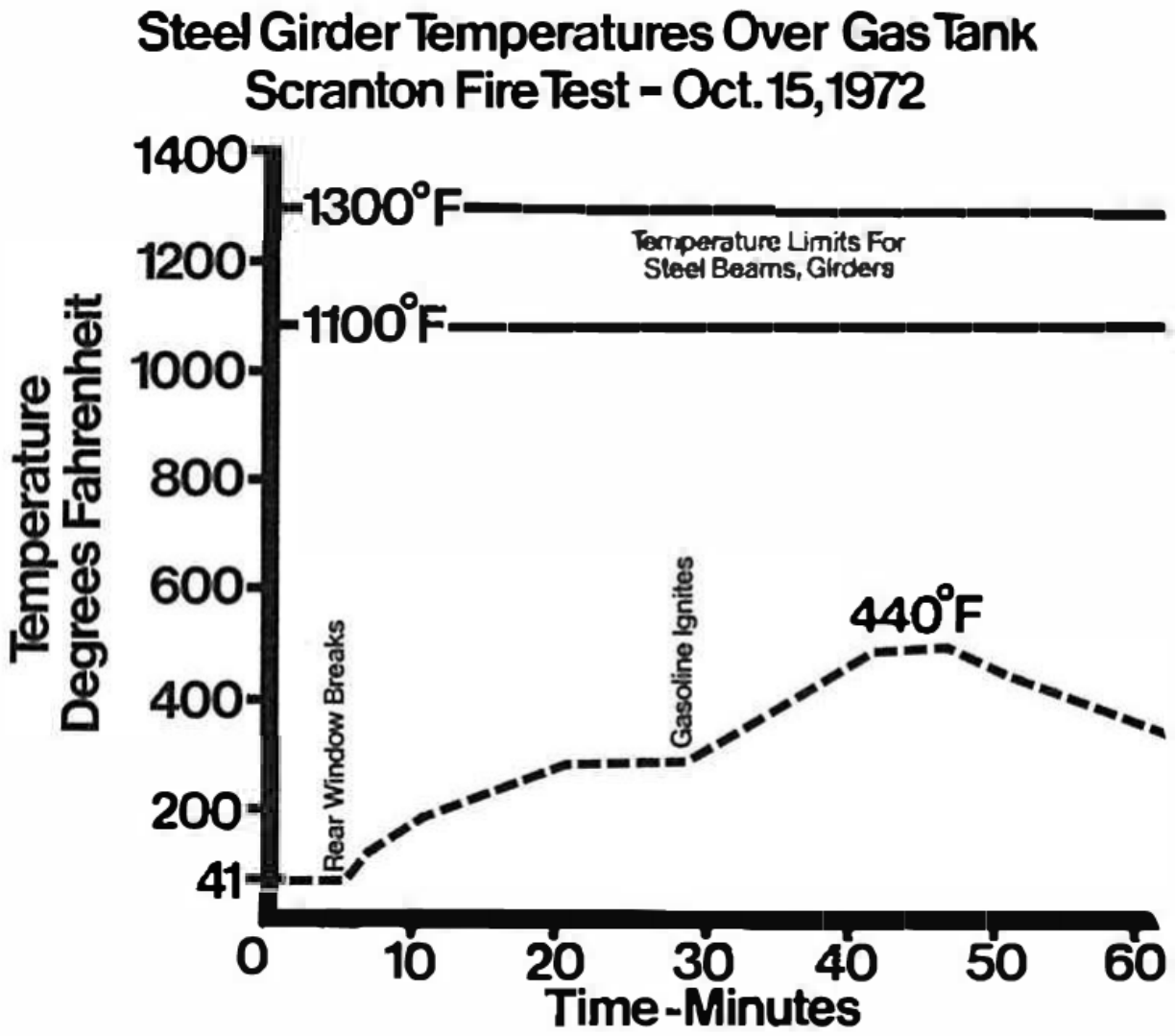



*704 C*

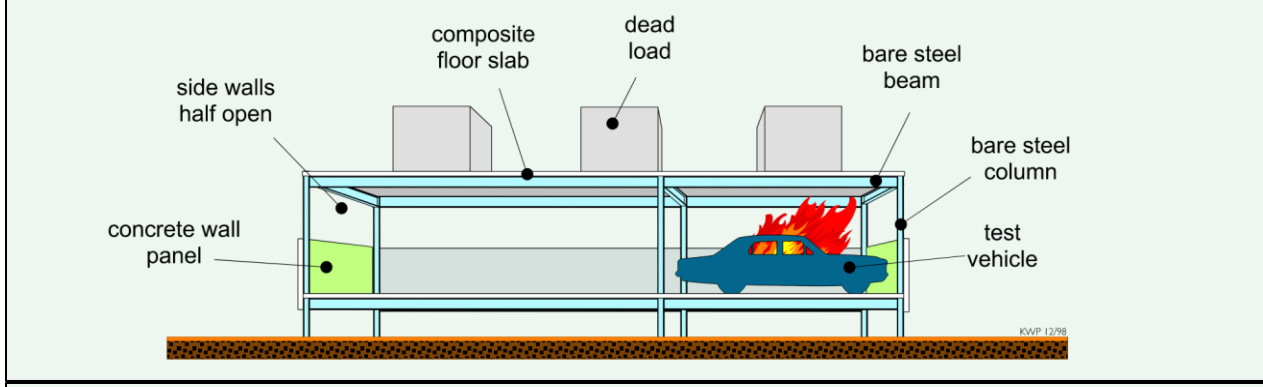
*593 C*

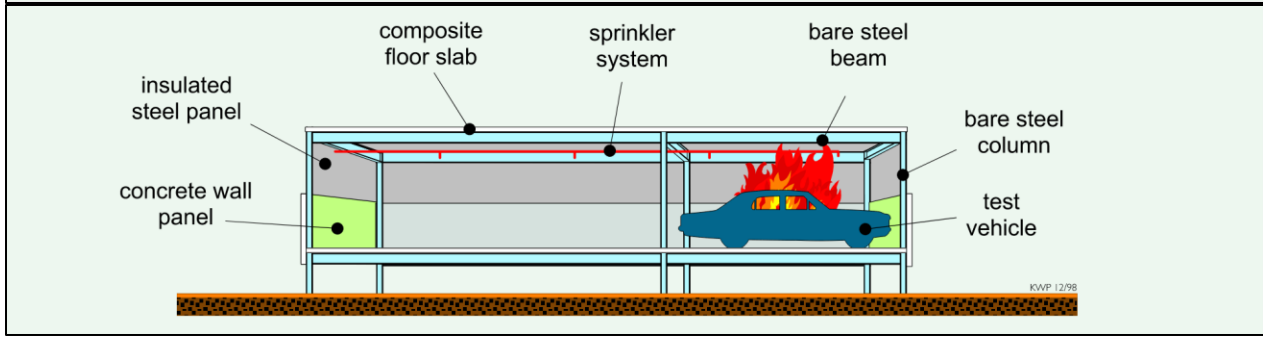
*227 C*

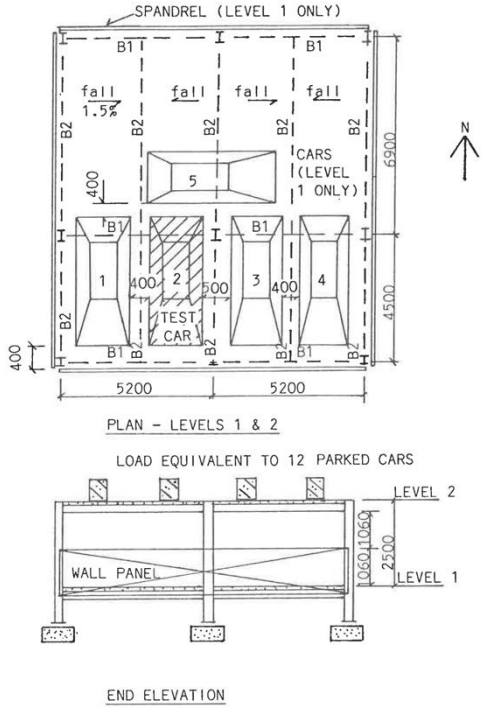
# BHP Steel, AU (1985-89)

**Comprehensive experimental series**

- 10-15 year gap – increase in the use of plastics in cars and cars got bigger
- Plastic for petrol tanks
- Increasing use of light steel structures
- 25 experiments in total – some with cars as the fuel load, others with liquid pool
- 120 $m^2$ with a floor-to-ceiling height of approximately 2.4 m
- 50% ventilation in open-deck
- Led to the NCC concessions on steel FRLs in open-deck carparks




# CTICM, France (1995)

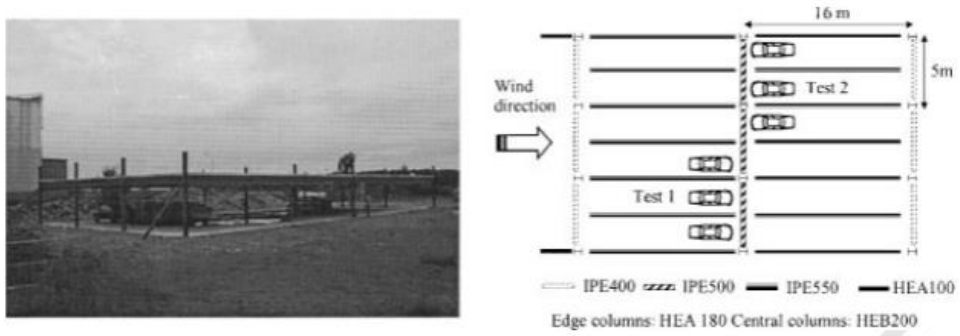



Figure 3. Tested open car park.

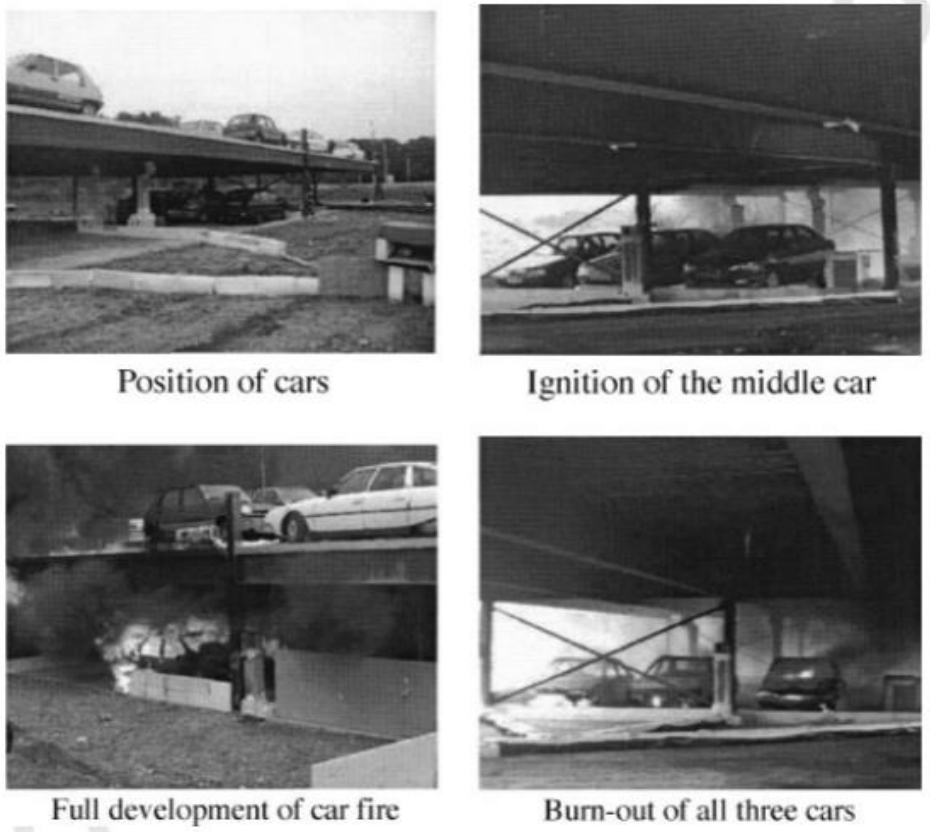



Figure 4. Summary of a fire test involving three cars.

# Japan (1999)

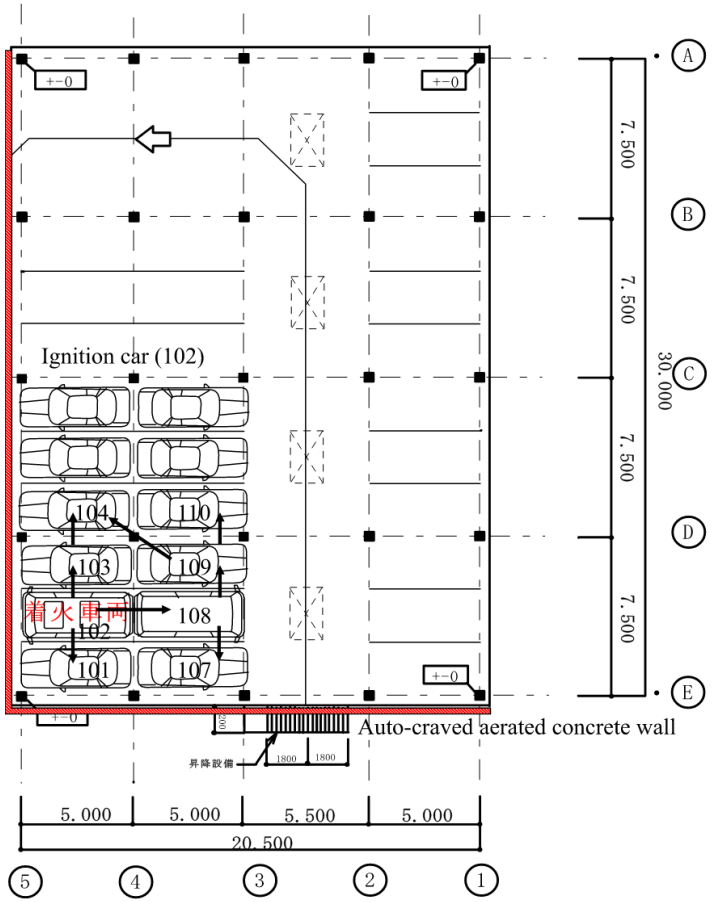



**FIGURE 1.** The external view of the experimental structure and the view of the spreading car fire during the experiment

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# Carpark fire experiments

## Maximum steel temperatures recorded

| Experiment(s) | Year(s) | Maximum steel temperature recorded (° C) | |
|---|---|---|---|
| | | Beam | Column |
| JFRO, UK | 1967 | 275 | 360 |
| Nippon Steel, Japan | 1970 | 245 | 242 |
| US | 1972-1973 | 226 | - |
| BHP Steel, Australia | 1985-1989 | 340 | 320 |
| CTICM, France | 1995 | 700 | 640 |
| Japan | 1999 | 700 | - |

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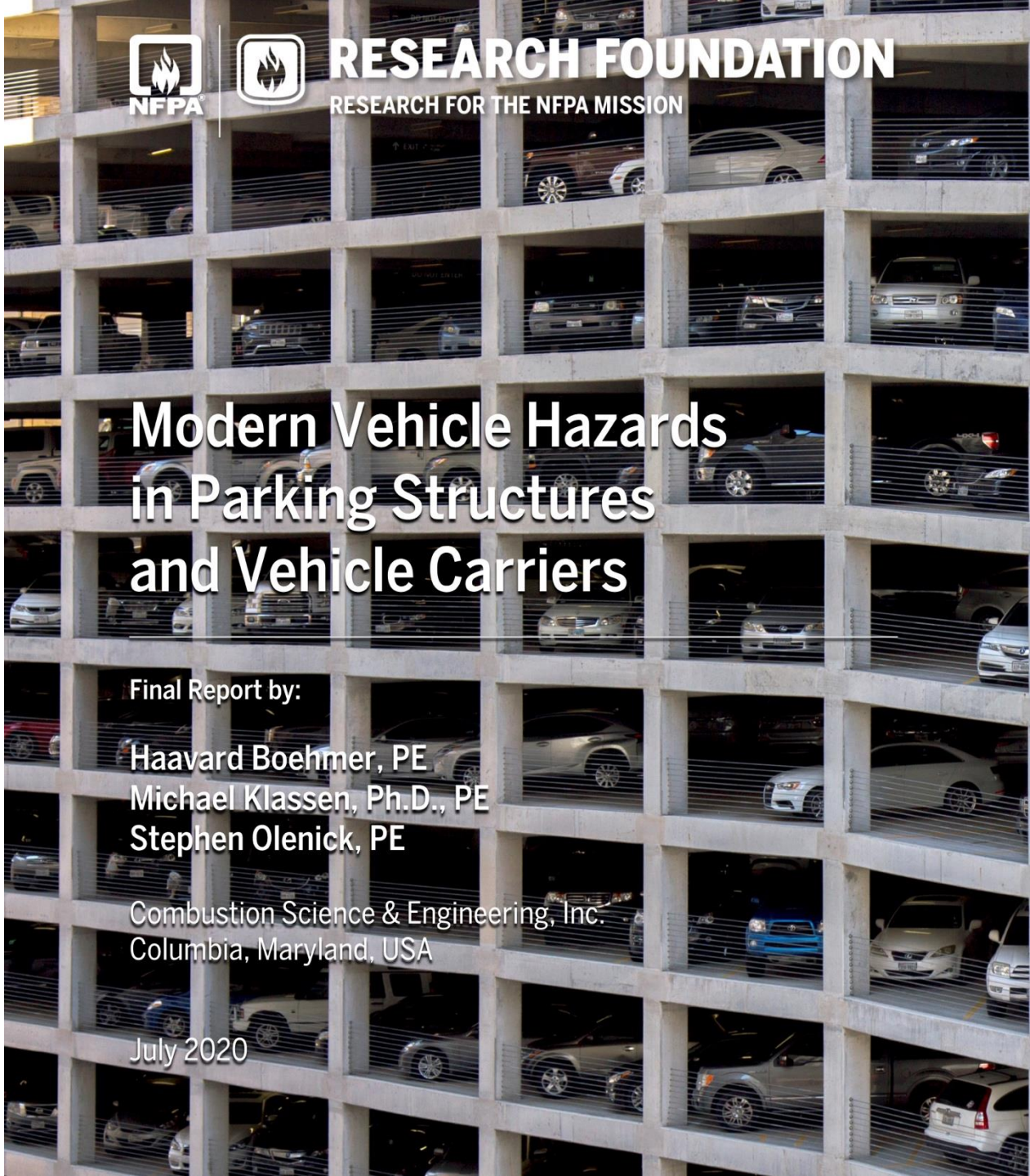
# Fire hazards in the modern-day carpark

# Modern carpark hazards

**Credit: NFPA**

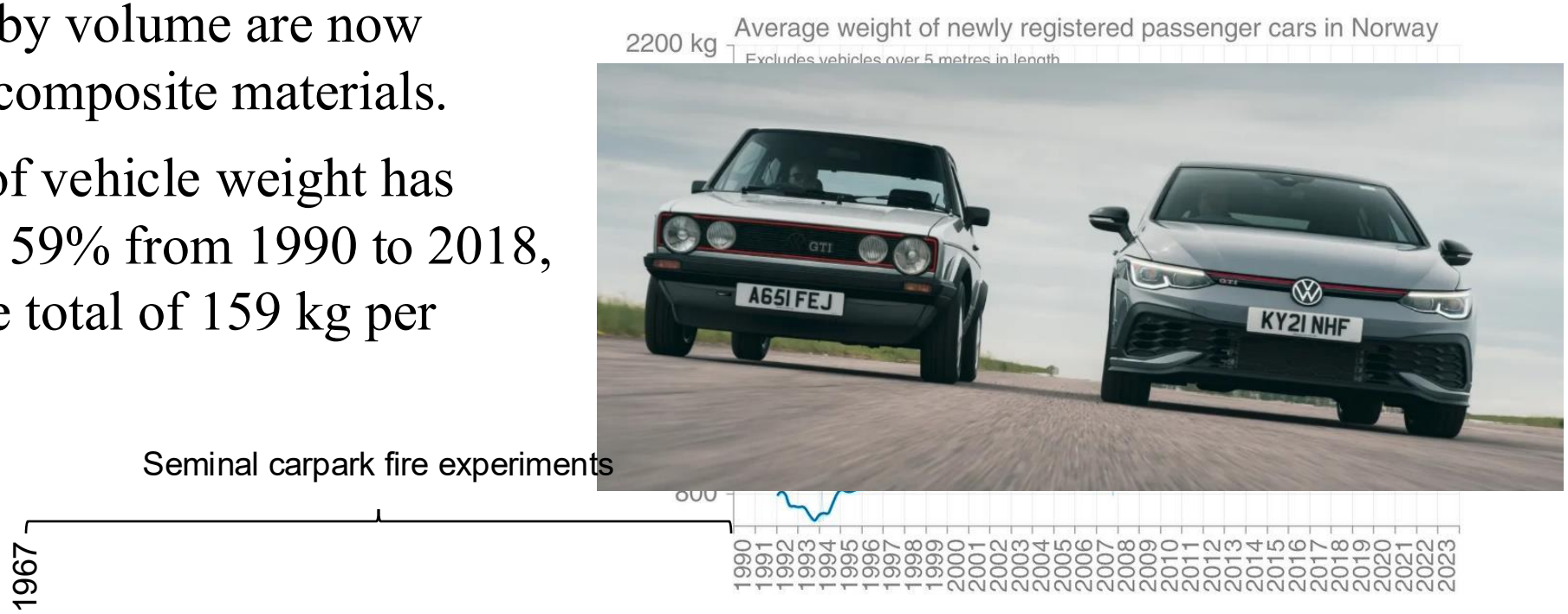
1. Modern vehicles which are larger, heavier and have increased quantities of combustible materials (e.g., fuel, plastics, synthetic materials).
2. Rapid, widespread market growth of alternative fuel vehicles (AFVs).
3. Car stackers.



# Cars are getting bigger and heavier

**Credit: NFPA**

- NFPA found:
  - 50% of cars by volume are now plastics and composite materials.
  - Their share of vehicle weight has increased by 59% from 1990 to 2018, to an average total of 159 kg per vehicle.

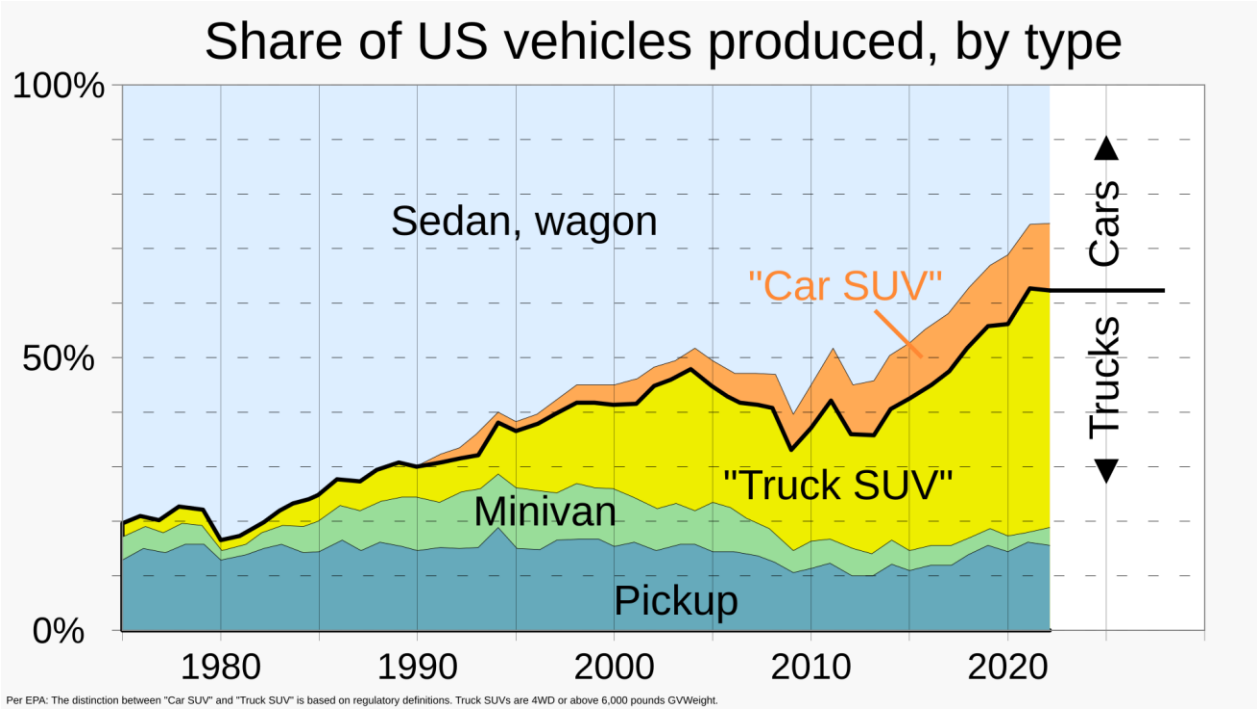


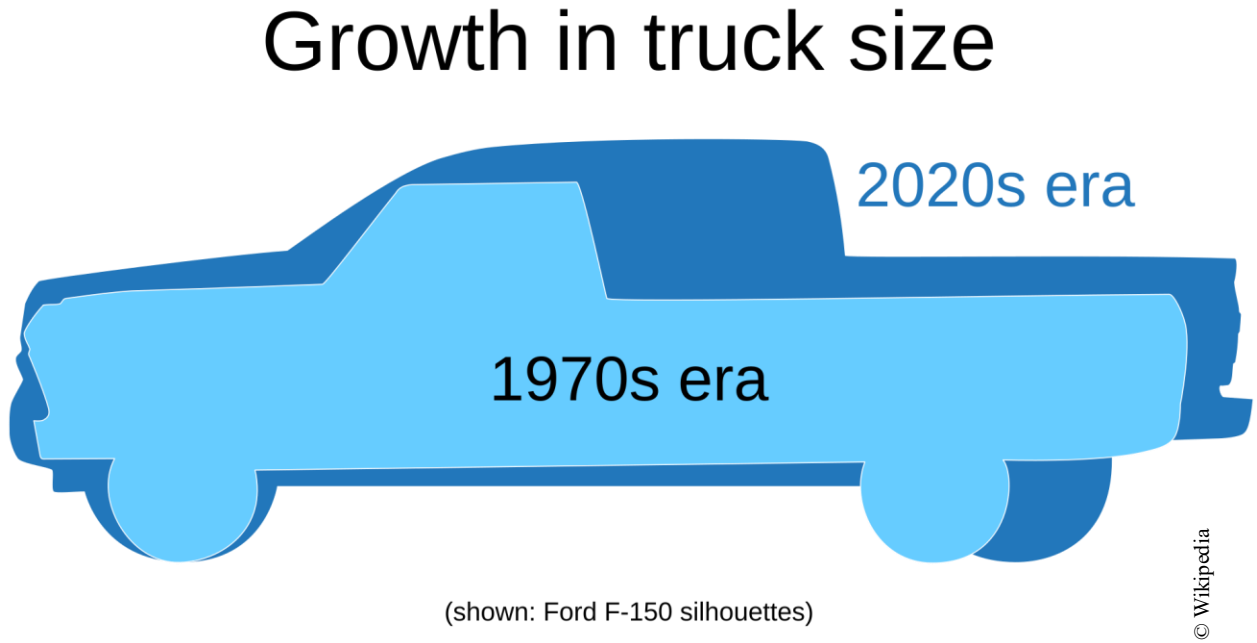

The weighty issue of electric cars [Part 1] (sustainabilitybynumbers.com)

# “Autobesity”

**Credit: Wikipedia**

- “In the United States, SUVs and pickup trucks comprised more than 75% of new sales in 2024 compared to 38% in 2009.”

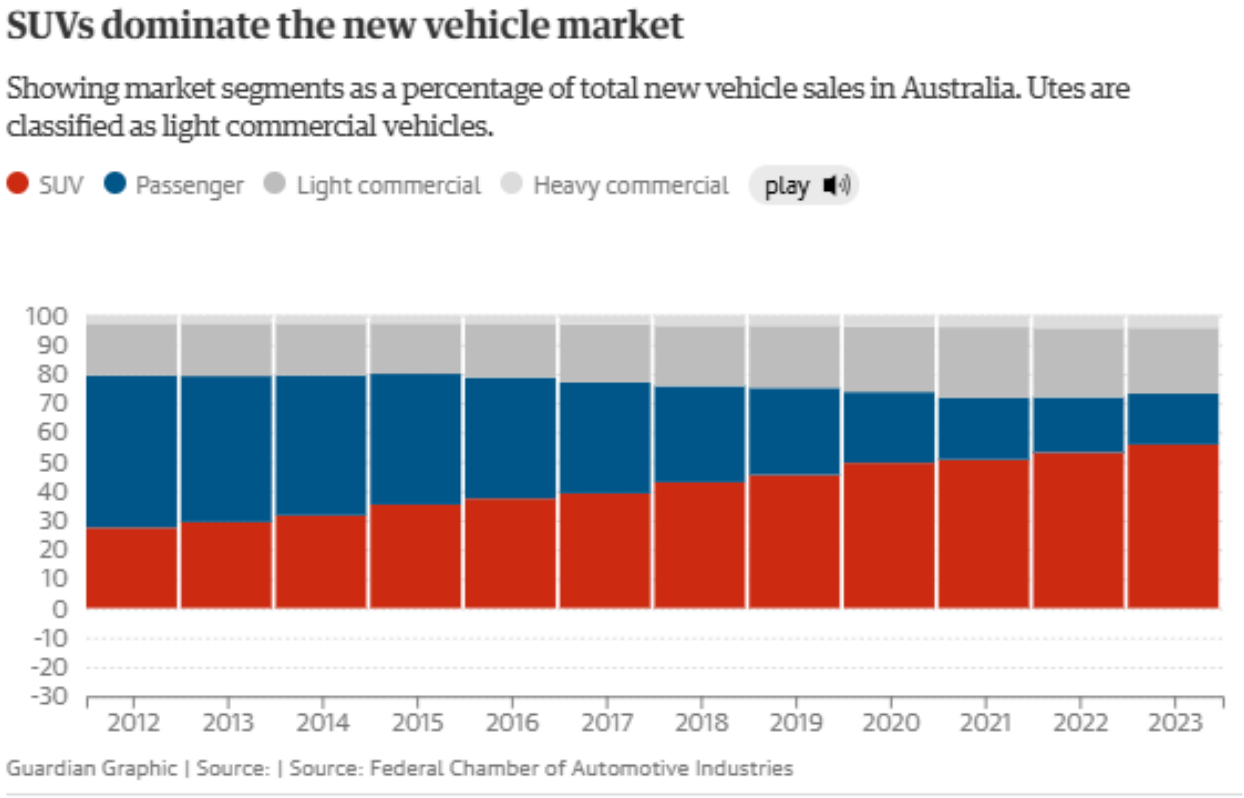


# Australian context

**Credit: UTS (2024) and The Guardian (2024)**

- "Australian cars are typically larger, heavier and less efficient, producing 43% more emissions than their EU counterparts."
- "The real-world $CO_2$ emissions of registered vehicles in 2021 were 143 g/km for the EU and 204g/km for Australia. This means the average Australian car on the road is producing 43% more GHG emissions than the average EU car."



# Increased use of plastics

**Credit: NFPA FPRF**

- Approximate doubling in plastic weight in US light vehicles (excluding trucks) between 1980 and 2020.

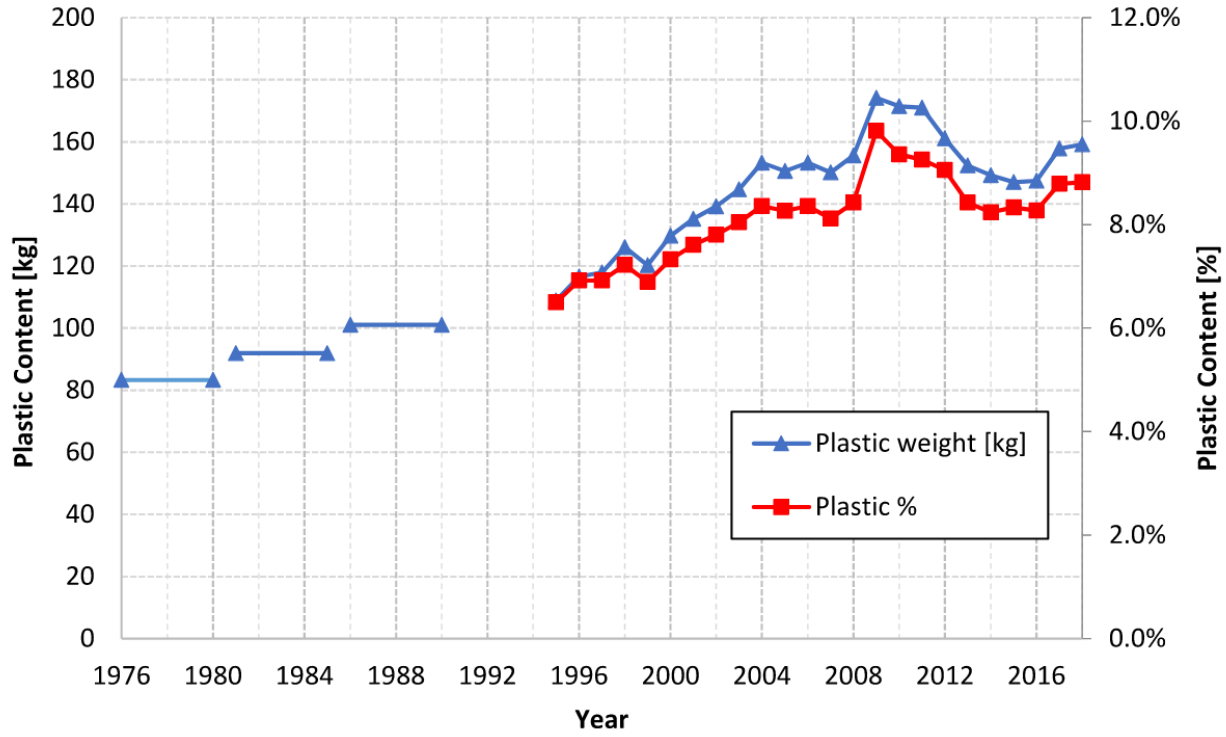



**Figure 2 – Amount of plastic in average US light vehicles in weight (kg), and as percentage of vehicle curb weight.**

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# Unique hazards associated with electric vehicles

**Credit: EV FireSafe**

## Thermal runaway + vapour clouds

- Batteries can off-gas toxic flammable gases if they go into thermal runaway.
- Can pose respiratory and explosion risks.

## Jet flames

- If thermal runaway occurs, a fire is likely.
- Jet flames can occur if the gaseous volatiles are released with momentum in a particular direction.

## Difficult to suppress + reignition risk

- Battery fires can be difficult to suppress, requiring lots of water.
- Even once suppressed, there is a risk of reignition.

## Lack of understanding

- Discomfort from some emergency agencies as BEVs are seen as a rapidly emerging technology.

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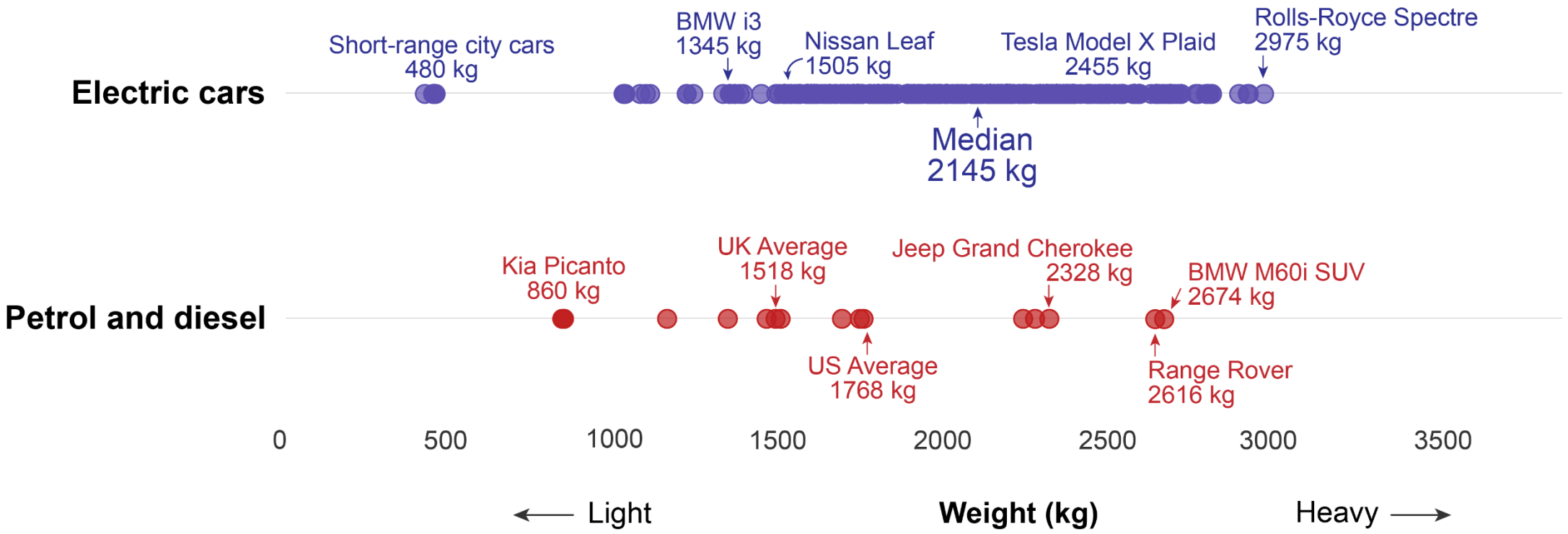
# Are EVs heavier than ICEVs?




The weighty issue of electric cars [Part 1] (sustainabilitybynumbers.com)

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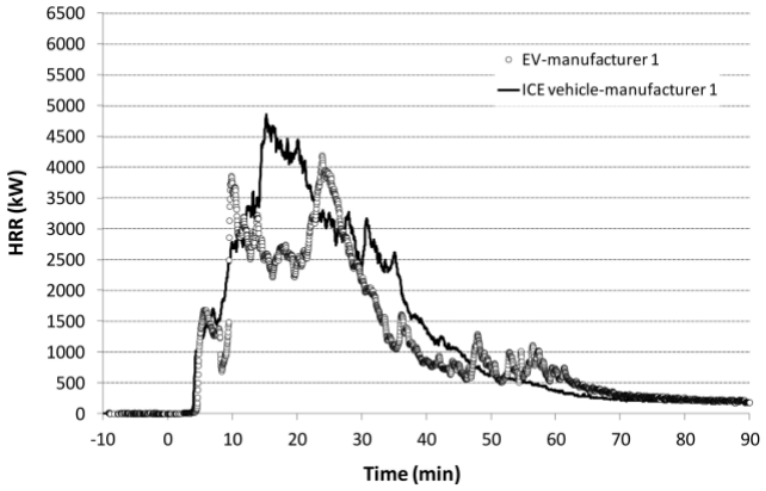
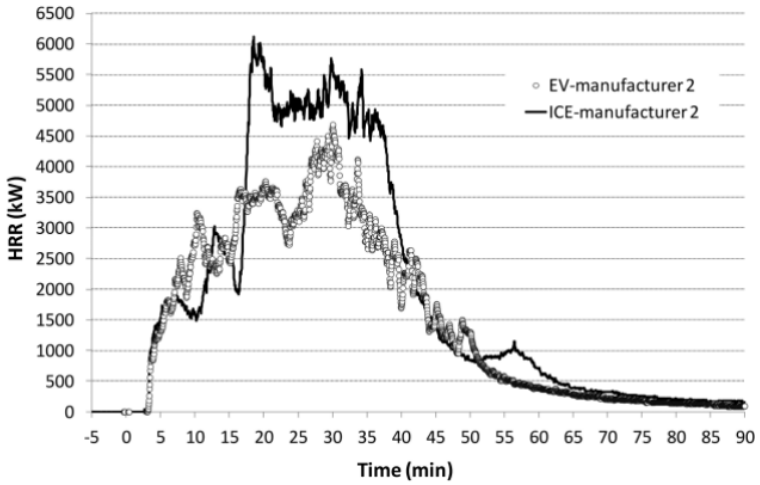
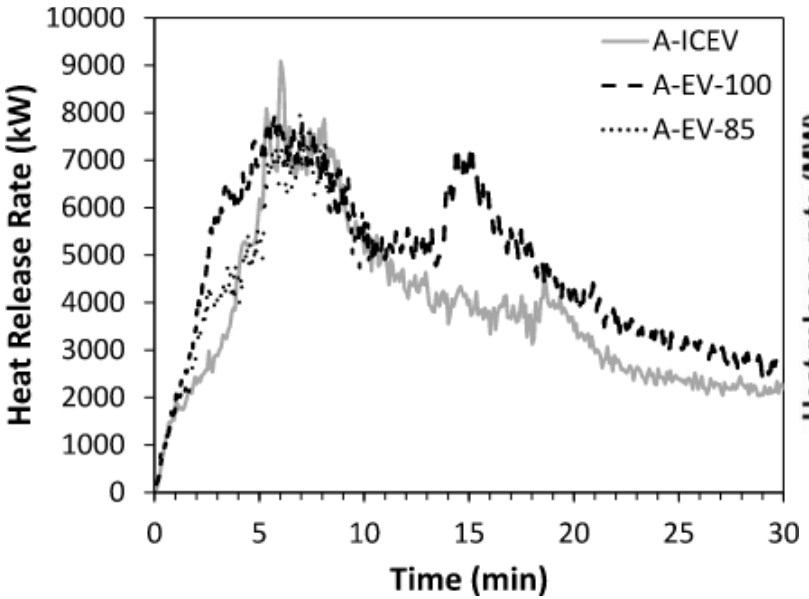
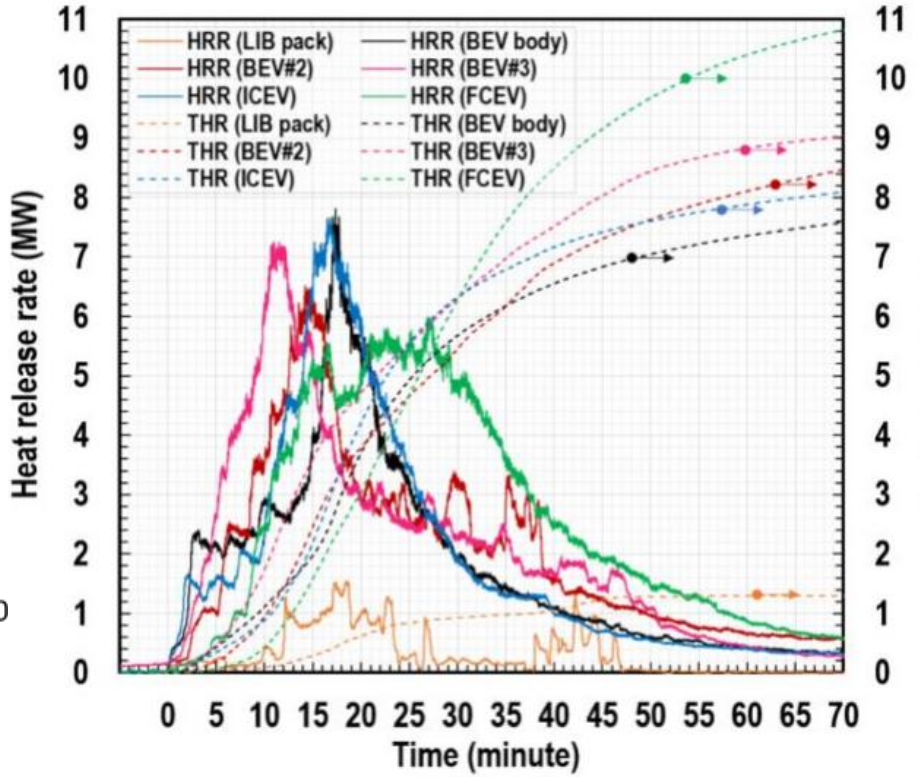
# Do alternative fuel vehicles (AFVs) have a different fire curve from ICEVs?



# ABCB, June 2023

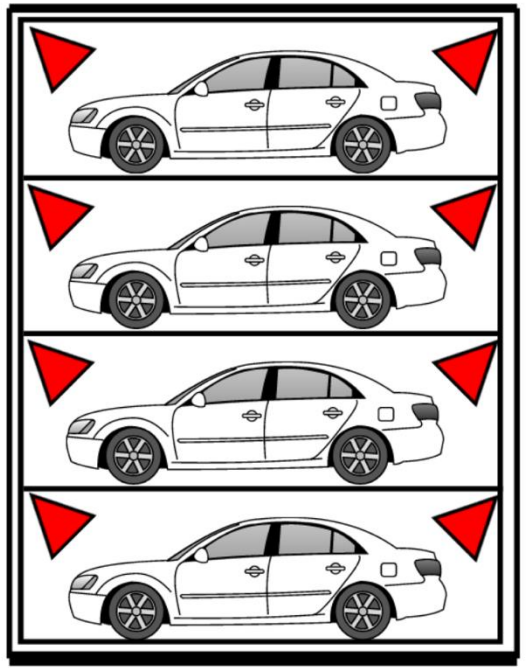
## Are EVs a “special hazard”?

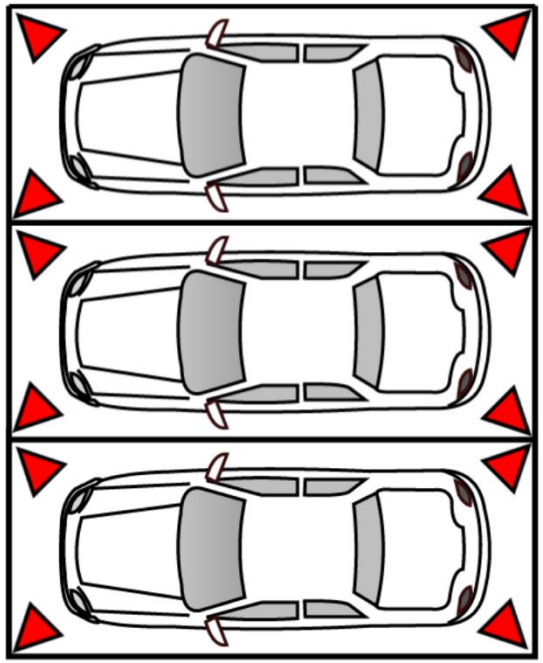
- ABCB CEO Gary Rake says **the “special hazard” provision in the NCC was designed for unexpected hazards and should not apply to cars**.
- **“The presence of electric vehicles in a car park is now common enough to be reasonably ‘expected’ and ‘usual’ and therefore not the original intent of the special hazards provisions when they were written”**…
- …the conditions should only apply if there is an unusual combination of electric cars and specific building features, and while the board is reviewing car park safety, it is investigating “a global trend of vehicles being larger and containing more plastic”.

Vehicle or hazard: New rules treat EV chargers like firework factories (May 2024)

# Car stackers

- Whilst Automated Vehicle Parking Systems (AVPS) have existed for over 100 years, there is still very little codified guidance on their design.
- No guidance exists within the NCC.
- BRE carried out experimental research in 2009 – found an unsprinklered fire can spread upwards rapidly, and “these fires [are] a particular problem for firefighters”.





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Australian Building Codes Board

# Fire safety in carparks

## Literature review

Reference: 296877-ABCB-ARUP-Fire safety in carparks

Rev A | 28 February 2024





Job number 296877-00

Arup Australia Pty Ltd | ABN 76 625 912 665

**Arup Australia Pty Ltd**
Level 5
151 Clarence Street
Sydney
NSW, 2000
Australia
arup.com

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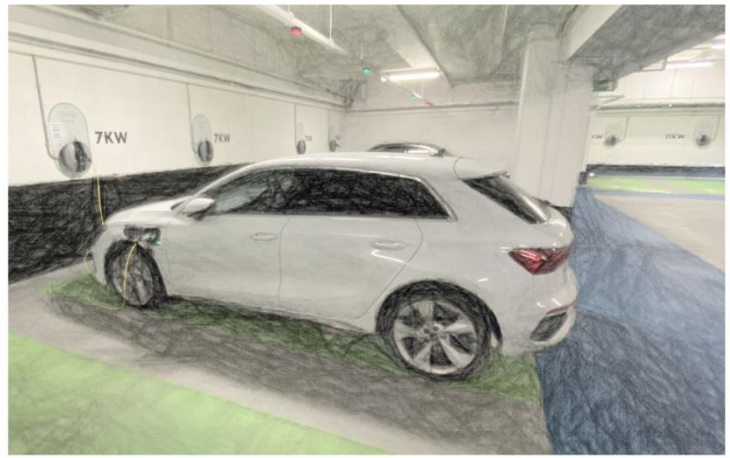
Office for Zero Emission Vehicles (OZEV)

# T0194 – Covered car parks - fire safety guidance for electric vehicles

Interim guidance to support parking and/or charging of electric vehicles and the installation of electric vehicle chargepoints in covered car parks

Issue | July 2023



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EUROPEAN PARKING ASSOCIATION

*Positively promoting parking solutions for sustainable mobility*

# EPA Fire Safety

## *Toolbox*

Advisory notice

# Electric vehicles in buildings

ABCB

To support Australians making the switch to electric vehicles (EV
the National Construction Code (NCC) is requiring more building
for EV charging.

The global experience of EVs to date indicates they have a lower likel
involved in a fire than internal combustion engines, but the characteri
fires are different to liquid fuel fires.

To ensure we understand and respond proportionately to any update
charging risks, the ABCB has reviewed the approaches taken by inter
including those countries with greater uptake of EVs. We have also er
research team EV FireSafe to help develop a set of recommendations
the safer installation and use of EV chargers without being an unreas
adoption. The full report from EV FireSafe, on which these provisions
read here.

We believe the recommendations set out in this advisory note are low
visual impact, are easily implementable and reflect the better practic
adopted by many reputable suppliers. These recommendations will h
of substandard equipment or installation practices emerging as the E
grows.

The ABCB will continue to work with other government bodies and er
agencies to review the latest evidence on EV charging trends from ar
will review and update our guidance and/or regulatory response as ne



afac

# Electric Vehicles (EV) and EV charging equipment in the built environment

PROCEDURAL

**POSITION**
Version 1.5
2 October 2023
Doctrine ID: 3098

FIRE + RESCUE

## Electric vehicles (EV) and EV charging equipment in the built environment

FIRE SAFETY POSITION PAPER

Report No.: D25/20316
Issued: 3 March 2025

ARUP

# Case studies: real fire events

ARUP

# Recent carpark fire events

## Stavanger Airport

| | |
|---|---|
| **Date:** | 07/01/2020 |
| **Location:** | Stavanger, Norway |
| **Vehicles involved:** | 200 |
| **Carpark type:** | Open-deck |
| **Storey area:** | 18,500 $m^2$ |
| **Sprinklered?** | No |
| **Smoke exhaust?** | No |
| **Injuries:** | 0 |
| **Fatalities:** | 0 |

## Echo Arena, King's Dock

| | |
|---|---|
| **Date:** | 31/12/2017 |
| **Location:** | Liverpool, UK |
| **Vehicles involved:** | 1,150 |
| **Carpark type:** | Open-deck |
| **Storey area:** | 5,000 $m^2$ |
| **Sprinklered?** | No |
| **Smoke exhaust?** | No |
| **Injuries:** | 0 |
| **Fatalities:** | 0 |

## Ravensburg

| | |
|---|---|
| **Date:** | 24/11/2021 |
| **Location:** | Ravensburg, Germany |
| **Vehicles involved:** | 4 |
| **Carpark type:** | Enclosed |
| **Storey area:** | Unknown |
| **Sprinklered?** | Yes |
| **Smoke exhaust?** | Unknown |
| **Injuries:** | 0 |
| **Fatalities:** | 0 |

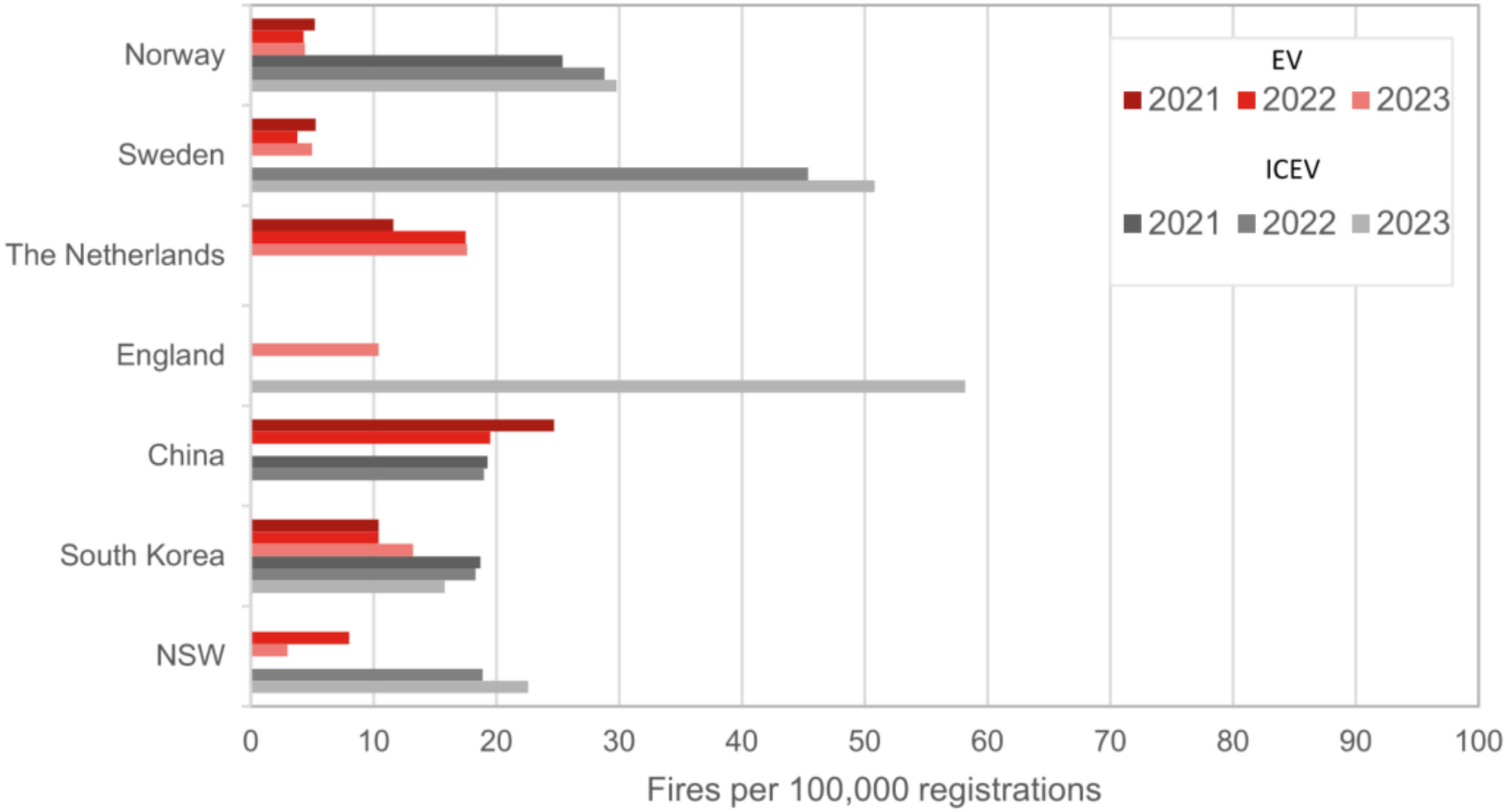
<u>Arup report for the ABCB, issued 22 Sep 2023:</u>

*Recently, a number of large-scale fires have occurred in carparking structures around the world. A sample is documented in Section 5. Some have involved multiple hundred or even over a thousand vehicles and led to large economic losses,* ***many occurring at airports where cars are kept for significant periods of time in large carparks with narrow spacings****.*

ARUP

# Car fire frequencies

**Credit: Fire and Rescue New South Wales**



ARUP

# Light electric vehicles

## Road Registered Electric Vehicles

**44**
Battery fires

**15**
Injuries

**4**
Fatalities

**3**
Battery fires

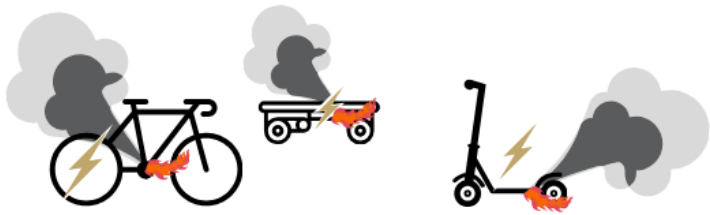
**0**
Injuries

**0**
Fatalities

**2**
Battery fires

- Very high quality LiB cells
- Sophisticated BMS
- Rigorous testing & certifications
- Excellent occupant safety
- Low wear & tear in daily use
- Typically outside / open space

## Personal Mobility Devices



**500+**
Battery fires

**138**
Injuries

**36**
Fatalities

- Often poorly constructed LiB cells & BMS
- No standards or regulations on privately owned PMDs
- Few safety considerations
- High wear & tear
- Stored & charged indoors

EV FireSafe: Categorising fire risk with lithium-ion batterie

# TfL announces safety ban of non-folded e-bikes on its transport network

26 March 2025

## Non-folded e-bikes will not be permitted on most TfL services

- Ban will come into effect on 31 March 2025
- TfL is the first transport operator in the UK to enforce a ban on its services

> "The safety of Londoners is my top priority and, while most e-bikes are safe, there have been a small number of incidents where non-foldable e-bikes have caught fire on the transport system, which have caused me great concern"
>
> **Sadiq Khan**
> Mayor of London

Transport for London (TfL) has announced that all non-folded e-bikes will be banned on parts of London's transport network from 31 March to ensure the safety of customers and staff.

TfL has been working closely with the London Fire Brigade and other partners to carry out a comprehensive review of the safety of e-bikes and their suitability for carriage on the TfL transport network.

While the majority of e-bikes are safe, there have been a small number of incidents where non-foldable e-bikes have caught fire on the transport system in London. To ensure the safety of the network for customers and staff, customers in possession of non-foldable e-bikes will not be permitted to travel on most TfL services, including on the Tube, Overground, Elizabeth line and DLR. The ban includes all non-folding e-bikes, including standard cycles that have been converted to e-bikes using conversion kits.

Media

Press releases

2025

January
February
March
April
May

2024
2023
2022
2021
2020

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# Revisiting the rhetorical

# Red herrings?

**Where should our focus be?**

- In carpark design; should such a focus be placed on electric cars/buses/trucks, or ‘the modern car’?
- In the built environment, should the focus be on cars, or so-called ‘light electric vehicles’ (e-bikes, scooters)?
- What will other alternative fuel vehicles, e.g. hydrogen fuel cell electric vehicles, mean in the future?

*Fig 1. Red Herring*

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## Contact

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