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From Papers to Practice: A Decision Gate Playbook for Managing EV Fires on Motorways

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Business as usual

- Fires on Internal Combustion Engines (ICE)
- Standard playbook: Detect → Protect life/traffic → Suppress → Clean/repair → Reopen

Escalations we already know:

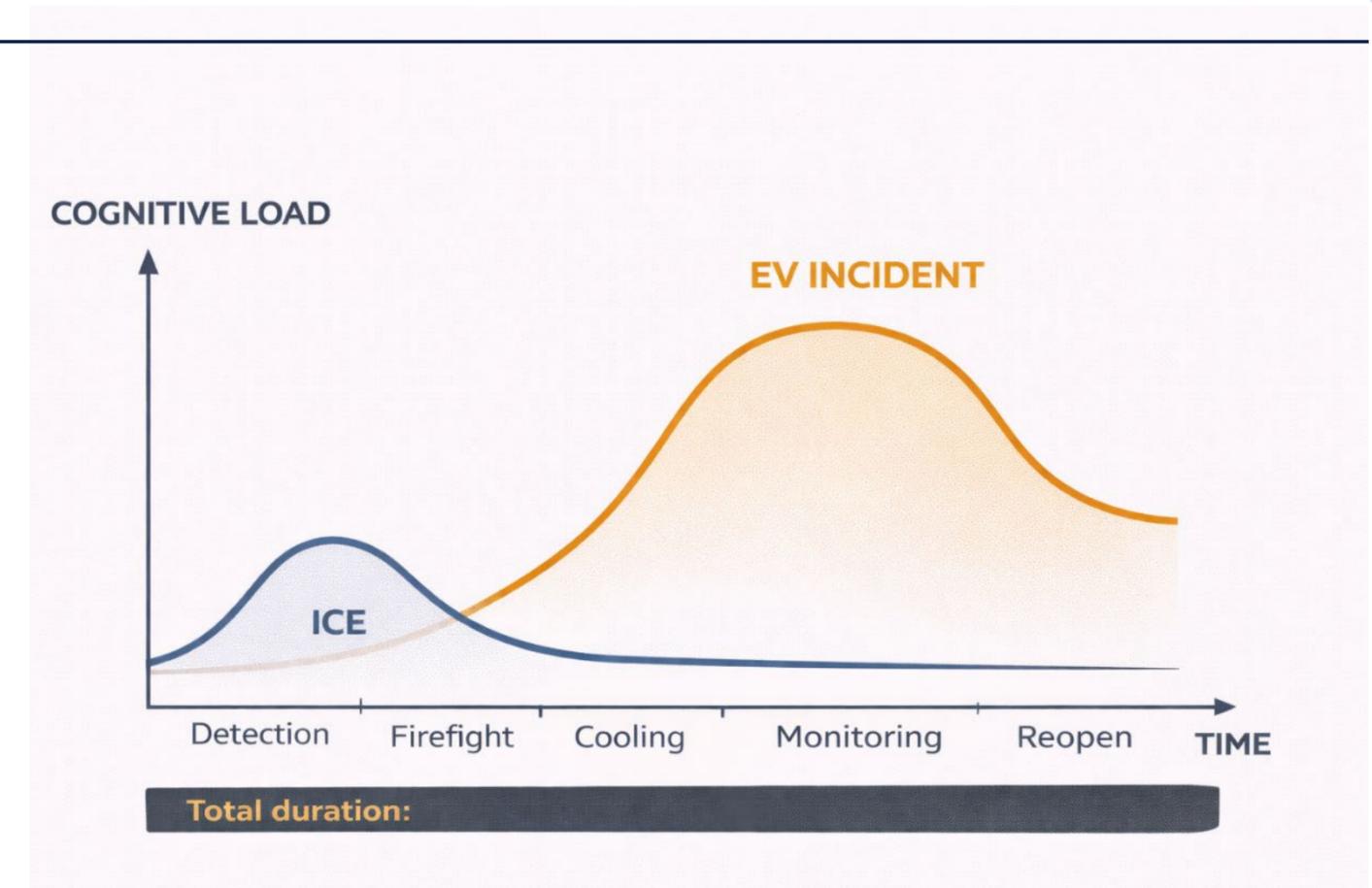
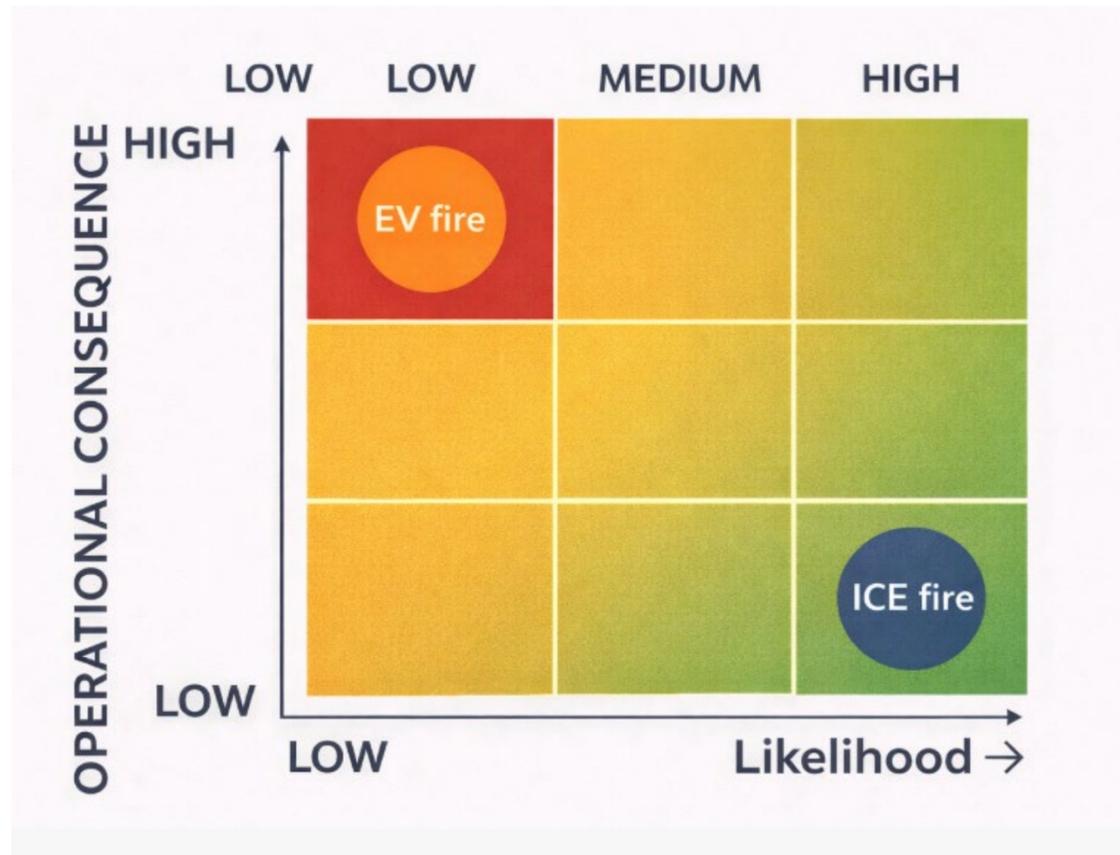
- HGVs / lorries (bigger fire load, longer suppression)
- Unpredictable cargo (unknown contents, hazard material protocols)
- Tunnels (tenability, ventilation, evacuation)



EV incidents are less about one peak moment and more about a chain of decisions.

- Non-linear behavior: delayed escalation, sudden flare-ups, re-ignition risk
- Different hazard package: high voltage + off-gas toxicity and corrosive residues
- Suppression changes: cooling can be longer, move water volume, creates runoff decisions
- Recovery is the trap: towing/transfer is not routine → quarantine + monitoring
- So we need: a Decision-Gate Playbook = the same calm procedure, adapted to EV reality

With EVs, the 'incident' doesn't always end when flames end — it ends when the risk tendency is stable.



EV fires may be less frequent, but when they happen, they consume more time, more coordination, and carry a longer tail of risk.

With EVs, the hardest part often starts after the flames — and that’s exactly why we use decision gates.

Hybrids are not half-EV — they’re EV plus fuel. Treat every hybrid as high-voltage, and the moment battery involvement shows, manage it like a full EV incident: cool, monitor, and move only with quarantine ready.

Key Differences – EV / ICE Fires

Key Difference	EV Fires (Electric Vehicles)	ICE Fires (Internal Combustion Engine)
Fire frequency	Generally lower reported rates (varies by country and data collection)	Higher overall incidence due to fleet size and fuel systems
Ignition source	Battery-related events (thermal runaway, damage, charging faults)	Fuel leaks, engine overheating, electrical faults
Peak temperature (typical ranges)	Approx. 800–1200°C possible depending on conditions	Approx. 800–1100°C possible
Duration	Can be prolonged; risk of reignition	Often shorter once fuel consumed (but varies)
Toxic emissions	HF, CO, possible flammable vent gas	CO, hydrocarbons, NOx
Suppression approach	Large water volumes, cooling battery focus, monitoring for reignition	Water, foam, dry chemical often effective
Operational risk	Jet flames, cell propagation, delayed escalation possible, towing delay	Rapid fuel-driven per cargo spread possible

What changes operationally

- Fire growth can be non-linear (delayed escalation; jetting/venting events).
- Smoke toxicity and corrosivity require faster isolation and PPE discipline.
- Re-ignition risk persists during towing, storage and post-extinction phases.
- Water demand and runoff management are critical, not an afterthought.

Why tunnels are different

- Limited access + constrained evacuation pathways.
- Ventilation decisions change tenability for users and responders.
- Fixed systems (detection, jet fans, deluge) must be integrated into the incident plan.
- Closure/reopening decisions require structured thresholds and documentation.

Playbook objective (what “good” looks like)

- Same triggers → same decisions, regardless of who is on duty.
- Early life-safety actions, followed by controlled suppression/cooling, then safe recovery & quarantine, transfer.
- Clear interface and procedures between Operator (TMC) ↔ Fire Service ↔ Tow/Recovery ↔ Environment/Authorities.

Gate 1
Recognize
Detect & Classify

Gate 2
Explore
Size up & Confirm

Gate 3
Stabilize
Control Scene

Gate 4
Fire Fight
Suppress & Cool

Gate 5
Aftercare
Monitor & Recover

How to use it (operator view)

- Start at Gate 1 as soon as an alert is received.
- Do not “skip” gates: each gate has exit criteria.
- Record decisions: includes clear thresholds for escalation, closures and recovery.
- Apply tunnel/open-road overlays at each gate.

Outputs (what you produce)

- A shared incident picture (vehicle type, location, exposure, smoke conditions).
- A coordinated plan: traffic control + responder access + suppression/cooling + water/runoff management.
- A recovery path: towing decision + quarantine/monitoring + Damage control + reopening checklist.

RECOGNIZE — Detect & Classify (first 2 – 5 min)

Inputs (operator & first crews)

- CCTV/incident report: fire/smoke? crash? location (lane/shoulder/tunnel section).
- Vehicle class: passenger EV/HEV, e-bus/van, HGV/ADR, unknown.
- Immediate exposures: other vehicles, tunnel equipment, structures, vegetation.
- Wind/ventilation state (open road/tunnel fans), traffic density.

Immediate actions

- Announce “EV suspected” only if indicators exist; keep working hypothesis updated.
- Start traffic controls: speed reduction, lane closures; prepare full closure if smoke/flash risk.
- Mobilize fire service + recovery/tow early (quarantine capability if available).
- Set initial safety perimeter and deny public access to smoke plume.

Exit criteria to Gate 2 (Explore)

- You have confirmed location, vehicle class, visible smoke/flame status, and immediate exposures.
- Traffic control is in progress and responder access route is defined.
- A single point of command/communication is established (TMC ↔ Incident Commander ad hoc).

EXPLORE — Size-up & confirm hazards (5 – 15 min)

Key questions (fast size-up)

- Is there active battery involvement (jetting, popping, white/grey vapor)?
- Is there life risk: occupants trapped? people in tunnel? secondary crashes?
- Can you safely access from upwind/upstream without entering smoke plume?
- What is the water/runoff plan (containment, drains, water protection zones)?

Tunnel overlay (if applicable)

- Confirm ventilation mode and tenability direction (keep evac side tenable).
- Decide closure direction(s) and initiate tunnel evacuation messaging.
- Activate/prepare fixed systems per tunnel plan (detection, deluge/sprinklers, jet fans).
- Establish access: closest cross-passage, portal strategy, staging outside portals.

Exit criteria to Gate 3 (Stabilize)

- Command intent defined: life safety → prevent spread → cool battery → recover safely.
- Safety perimeter and PPE baseline confirmed (HF/toxic smoke assumed if battery involved).
- A suppression/cooling strategy is selected (and resourced) with water/runoff controls.

STABILIZE — Control the scene (15 – 30 min)

Scene control (all locations)

- Hard perimeter: keep public away; keep crews out of line-of-fire from venting/jetting.
- Isolate ignition/exposures: protect adjacent vehicles, tunnel linings, cable trays, vegetation.
- De-energize where possible (charging points, tunnel equipment zones) per Standard Operating Procedure.
- Establish water supply + runoff retention (bunds, drain isolation, absorbents as per plan).

Communications & Roles

- Single incident commander; structured comms with TMC and recovery contractor.
- One log: decisions, times, ventilation settings (tunnel), water volumes/runoff measures.
- Early notify: environment authority if runoff to drainage/water bodies is possible.
- Plan the recovery path early (tow route, quarantine spot, monitoring responsibilities).

Exit criteria to Gate 4 (Fight)

- Access is safe, exposures protected, and a cooling/suppression plan is underway.
- Water/runoff measures are in place (or a decision is made to limit water with justification).
- Recovery/quarantine option is identified before the vehicle is moved.

FIRE FIGHT — Suppress & cool (Open road tactics)

Primary objectives

- Stop fire spread to exposures and keep the scene stable.
- Reduce battery temperature (cooling) to prevent further propagation. (surface/penetration)
- Maintain responder safety (toxic plume + venting events).

Tactical options (choose based on access)

- Defensive cooling with large water flows (where runoff can be controlled).
- Targeted battery pack cooling/penetration (e.g., UHP cutting/extinguishing where applicable).
- Vehicle isolation: increase separation distance; remove adjacent combustibles.
- If suppression is not achievable: contain + cool + plan controlled recovery/quarantine.

Key “don’ts” (common failure modes)

- Do not tow/move the vehicle without a defined quarantine/monitoring plan.
- Do not position crews directly in front of battery vent paths.
- Do not allow runoff to enter drains/water bodies without retention/notification.

FIRE FIGHT — Suppress & cool (Tunnel tactics)

Tunnel priorities

- Tenability drives everything: evacuation first, then suppression.
- Ventilation settings must be logged and coordinated with the IC.
- Protect tunnel systems (cables, signage, linings) and prevent domino failures.
- Runoff/water control: avoid uncontrolled contaminated water spread.

Tactical options (integrate fixed systems)

- Use fixed firefighting (deluge/monitors) where available to control Heat Release Rate and smoke.
- Portal strategy: stage resources outside portals; advance only with tenability control.
- Coordinate jet fan mode with evacuation direction and responder access.
- If cooling is prolonged: plan for extended closure and structured relief/rotation.

Tunnel “if/then” quick decisions

- If smoke threatens evac. routes → ventilation to protect evacuation, close portals, intensify messaging.
- If suppression cannot be achieved safely → defensive containment + cooling + protect infrastructure + plan recovery.
- If large water volumes required → implement runoff retention / environmental controls before sustained flows.

A bridge between Gate 4 and Gate 5 - Escalation & Closure Thresholds

Trigger / Condition

Action / Decision

Battery involvement indicators (jetting/venting, repeated flare-ups, rapid temperature rise)

Assume prolonged event: extend perimeter, rotate crews, prioritize cooling & exposure protection; plan quarantine/recovery early.

Smoke affects public area / tunnel tenability uncertain

Immediate full closure and evacuation actions; ventilation set to protect evac route; deny entry until tenability confirmed.

Water/runoff cannot be retained and drains connect to sensitive receptors

Limit flows to essential exposure protection; deploy containment; notify environment authority; document decision.

Vehicle must be moved (clear lane / prevent secondary incidents)

Move only with pre-staged quarantine location + thermal monitoring plan + tow brief; avoid enclosed spaces.

Commercial EV / e-bus / HGV in tunnel

Treat as high-consequence: early multi-agency escalation; anticipate longer closure and higher smoke load; protect infrastructure.

Aftercare — Monitor, quarantine & recover

After - extinction actions

- Thermal imaging: repeated scans; re-cool hotspots; continue monitoring for temperature rises.
- Manage residues and contaminated runoff (contain/collect; do not flush to drains).
- Document battery status, actions taken, and transport decision rationale.
- Handover: define who monitors the vehicle after the incident (tow yard, operator, fire service).

Quarantine principles

- Do not store damaged EVs in enclosed spaces; use designated outdoor quarantine areas.
- Maintain separation distances; protect against unauthorized access; secure against rolling.
- Provide monitoring (thermal camera / periodic checks) and an emergency plan.
- Consider immersion/quarantine container partnerships (towing contractors).

Exit criteria (incident closed)

- Vehicle is stable under monitoring plan AND custody is transferred with written instructions.
- Road/tunnel infrastructure inspected (heat/smoke damage, equipment status) and reopening checks completed.
- Lessons learned: timeline, decisions, water/runoff actions, and improvement items.

Reopen checklist

Open road — reopen when...

- Fire is out AND no rising temperatures on repeated thermal scans.
- Vehicle removed to quarantine location (or controlled shoulder position with monitoring).
- No contaminated runoff remains on carriageway; drains protected/cleared as per plan.
- Pavement/structures checked for damage and debris cleared; secondary crash risk removed.

Tunnel — reopen when...

- Atmosphere and visibility acceptable (tenability confirmed; ventilation normalized).
- Critical systems checked: lighting, signage, comms, ventilation, fire detection/suppression status.
- Fire residues removed; contaminated water managed; cable trays/linings inspected for heat damage.
- A post-incident report is recommended (times, ventilation mode, closures, decisions).

Minimum documentation

- Who decided what and when (closure/ventilation/water/towing); photos/CCTV snapshots; key measurements (temps/tenability) if available.

Preparedness Package – MoSCoW Method

Equipment & capabilities

- Thermal imaging (vehicle + pavement + tunnel equipment checks).
- Traffic management OPS (rapid closures, diversion plans, portal staging).
- Runoff control: drain covers, bunds, retention/containment materials.
- Access tools for battery cooling (as per local fire service capability; incl. UHP where used, fire blanket).

Agreements & interfaces

- Tow/recovery contract that includes quarantine/immersion capability.
- Defined quarantine locations and responsibilities (monitoring, security, reporting).
- Operator ↔ Fire service comms protocol (single channel, shared log, ventilation authority).
- Escalation roster: environment authority, infrastructure owner/maintainer, police.

Training focus (what to drill and exercise)

- Gate 1–2: correct recognition/classification and early traffic control.
- Tunnel: evacuation + ventilation decision sequence + portal staging.
- Aftercare: towing decision + quarantine handover + monitoring + reporting.
- Environmental: runoff containment decisions under time pressure.

MoSCow Method - Prioritization framework

MUST HAVE	SHOULD HAVE	GOOD TO HAVE
<ul style="list-style-type: none"> Communication plan Pre agreed closure authority + scenario triggers Tunnel evacuation triggers 	<ul style="list-style-type: none"> Enhanced CCTV procedures (presets, quick classification prompts) Gas/toxicity awareness protocol (PPE reminders, avoid plume) 	<ul style="list-style-type: none"> Automated smoke/thermal analytics (CCTV) Fixed nozzles-deluge optimization for vehicle fire scenarios
<ul style="list-style-type: none"> Rapid lane/tunnel closure procedures (VMS/ traffic plans , escalated diversions, message to motorway users) Ventilation protocol 	<ul style="list-style-type: none"> Tunnel equipment protection checklist (cabinets, cables, fans, dampers) + post incident inspection Pre defined portal staging layouts & access routes (incl. cross passages) 	<ul style="list-style-type: none"> UHP cutting/extinguishing capability integrated with local doctrine Dedicated EV quarantine yard with instrumentation/remote monitoring
<ul style="list-style-type: none"> Thermal imaging on scene (vehicle + surroundings) Defensive perimeter rules (no go zones, upstream approach) 	<ul style="list-style-type: none"> Standard incident timeline template (closure, ventilation changes, water use, handovers) 	<ul style="list-style-type: none"> Immersion container / water filled quarantine options
<ul style="list-style-type: none"> Runoff control basics (drain covers/isolations, bunds/booms, containment plan) Environmental notification chain (when runoff may reach receptors) 	<ul style="list-style-type: none"> Joint operator–fire–towing tabletop drill (annual) 	<ul style="list-style-type: none"> Digital incident review dashboard (lessons learned)
<ul style="list-style-type: none"> Quarantine plan (location, custody, separation, monitoring, emergency plan) “Move only if quarantine ready” rule + towing alignment Reopening checklist (road/tunnel) 	<ul style="list-style-type: none"> KPIs (time to closure, ventilation decision, runoff control, quarantine decision).EV fire blanket (fiberglass) + SOP/training 	<ul style="list-style-type: none"> Scenario library (open road, tunnel, lay by)

REFERENCES

- **Brzezinska, D. and Bryant, P. (2022)** 'Performance-Based Analysis in Evaluation of Safety in Car Parks under Electric Vehicle Fire Conditions'. *Energies*, 15(2), 649.
- **Castaing, P. (2025)** *Operational Guide: Emergency Response for Electric Vehicles—Present Situation, Recommendations, Perspectives* (Version 1, December 2025). Paris: CTIF (International Association of Fire and Rescue Services).
- **CFPA Europe (2025)** *Fire Safety Recommendations for Electric Vehicles: CFPA-E Guideline No 44:2025 F*. Brussels: Confederation of Fire Protection Associations Europe.
- **Chen, Y., Kang, Y., Zhao, Y., Wang, L., Liu, J., Li, Y., Liang, Z., He, X., Li, X., Tavajohi, N. and Li, B. (2021)** 'A review of lithium-ion battery safety concerns: The issues, strategies, and testing standards'. *Journal of Energy Chemistry*, 59, 83–99.
- **CTIF (2024)** *CTIF EXPO Magazine*, Issue 1-2024. Paris: CTIF (International Association of Fire and Rescue Services).
- **Dehghani, P., DiDomizio, M., Sauer, N. and Barowy, A. (2025)** 'Heat exposure from electric vehicle fires: Experimental results and analysis'. *Fire Safety Journal*, 158, 104535.
- **Dessi, R., Fruhwirt, D. and Papurello, D. (2025)** 'A Study on Large Electric Vehicle Fires in a Tunnel: Use of a Fire Dynamics Simulator (FDS)'. *Processes*, 13(8), 2435.
- **Dursun, Y. and Eleşkirtli, A. (2025)** 'Fire safety precautions and fire intervention techniques for electric and hybrid vehicles'. *International Journal of New Findings in Engineering, Science and Technology*, 3(1) (March).
- **European Commission, Directorate-General for Mobility and Transport (2025)** *Fire Safety – Electric Vehicles and Charging Infrastructure* (Sustainable Transport Forum guidance; MIO125004ENN). Brussels: European Commission.
- **Federal Highway Administration (FHWA) (2015)** *Tunnel Operations, Maintenance, Inspection, and Evaluation (TOMIE) Manual*. Publication No. FHWA-HIF-15-005. Washington, DC: U.S. Department of Transportation.
- **Federal Roads Office (FEDRO/ASTRA) (2020)** *Risk Minimisation of Electric Vehicle Fires in Underground Traffic Infrastructures: Research Project AGT 2018/006*. Bern: Federal Department of the Environment, Transport, Energy and Communications (DETEC).
- **Filzwieser, S. (2021)** 'Fire Tests Show that Austria's Tunnels are Fit for Electric Cars'. TU Graz News, 7 October.
- **Jang, J., Jeon, J. and Oh, C.B. (2025)** 'Risk assessment of toxic gas dispersion from electric vehicle fires in underground apartment parking garages using numerical analysis'. · **Javor, D., Krstić, D., Raičević, N., Petrović, N., Suljović, S. and Procopio, R. (n.d.)** 'Analysis of the causes and environmental consequences of electric vehicle fires'. [Conference/technical paper] (PDF provided by user).
- **Kutschenreuter, M., Klüh, S., Lakkonen, M., Rothe, R. and Leismann, F. (2020)** 'How electric vehicles change the fire safety design in underground structures'. In: *Ninth International Symposium on Tunnel Safety and Security*, Munich, Germany, 11–13 March.
- **Lecocq, A., Bertana, M., Truchot, B. and Marlair, G. (2012)** 'Comparison of the fire consequences of an electric vehicle and an internal combustion engine vehicle'. In: *International Conference on Fires In Vehicles (FIVE 2012)*, Chicago, USA, September, pp. 183–194.
- **Mohd Tohir, M.Z. and Martín-Gómez, C. (2025)** 'Evaluating fire severity in electric vehicles and internal combustion engine vehicles: A statistical approach to heat release rates'. *Fire Technology*, 61, 2957–2998.
- **Nederlands Instituut Publieke Veiligheid (NIPV) (2024)** *Recommendations for Framework for Action Deploying UHP Extinguishing System in Case of Fire in Battery Pack of Electric Vehicle* (26 November).
- **National Transportation Safety Board (NTSB) (2020)** *Safety Risks to Emergency Responders from Lithium-Ion Battery Fires in Electric Vehicles*. Safety Report NTSB/SR-20/01 (PB2020-101011). Washington, DC: NTSB.
- **Olona, A. and Castejon, L. (2025)** 'Full-Scale Experimental Analysis of the Behavior of Electric Vehicle Fires and the Effectiveness of Extinguishing Methods'. *Fire*, 8, 301.
- **PIARC (AIPCR) (1999)** *Fire and Smoke Control in Road Tunnels* (Report 05.05.B), Chapter 3: 'Comportement de la fumée'. Paris: World Road Association (PIARC).
- **PIARC (2017)** *Experience with Significant Incidents in Road Tunnels* (2017R35EN), Chapter 4.2: 'Characteristics of tunnel fires'. Paris: World Road Association (PIARC).
- **PIARC (2022)** *Impact of New Propulsion Technologies on Road Tunnel Operations and Safety: A PIARC Collection of Case Studies* (2022R05EN). Paris: World Road Association (PIARC).
- **PIARC (2025)** *Sustainability of Tunnel Operation: New Approaches—A PIARC Briefing Note and Collection of Case Studies* (2025R03EN). Paris: World Road Association (PIARC).
- **Pitana, T., Soewirjo, M.K.Y.H., Siswantoro, N. and Nurwahyudy, A. (2025)** 'Simulation of an electric vehicle fire on a ro-ro ferry'. *Journal of Applied Engineering Science*, 23(1), pp. 45–55. · **Sturma, P., Foßleitner, P., Fruhwirt, D., Galler, R., Wenighofer, R., Heindl, S.F., Krausbar, S. and Heger, O. (2022)** 'Fire tests with lithium-ion battery electric vehicles in road tunnels'. *Fire Safety Journal*, 134, 103695.
- **Vfdb (2022)** *Technical Quarantine Areas for Damaged Vehicles with Lithium-Ion Batteries* (Leaflet 06/10, October 2022). Münster: Association for the Promotion of German Fire Protection (vfdb).
- **Willstrand, O., Bisschop, R., Blomqvist, P., Temple, A. and Anderson, J. (2020)** *Toxic Gases from Fire in Electric Vehicles*. RISE Report 2020:90. Borås: RISE Research Institutes of Sweden.
- **Zhao, C., Hu, W., Meng, D., Mi, W., Wang, X. and Wang, J. (2024)** 'Full-scale experimental study of the characteristics of electric vehicle fires process and response measures'. *Case Studies in Thermal Engineering*, 53, 103889.



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