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ELECTRIC AND HYBRID VEHICLE BATTERIES

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Abbreviations

ABCB	Australian Building Codes Board
ACCC	Australian Competition and Consumer Commission
ADR	Australian Design Rules
AFAC	Australasian Fire and Emergency Service Authorities Council
ANCAP	Australasian New Car Assessment Program
BESS	Battery Energy Storage Systems
BMS	Battery Management System
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DCCEEW	Australian Department of Climate Change, Energy, the Environment and Water
EPA	NSW Environment Protection Authority
FRNSW	Fire and Rescue NSW
HEV	Hybrid electric vehicle
HFCV	Hydrogen-fuelled cell vehicles
ICE	Internal combustion engine
LEV	Light electric vehicle
LiB	Lithium-ion battery
MDT	Mobile Data Terminal
NCC	National Construction Code
OEM	Original equipment manufacturer
PPE	Personal Protective Equipment
SARET	Safety of Alternative and Renewable Energy Technologies
SoH	State of Health
TfNSW	Transport for NSW
WHS	Work Health and Safety
ZEB	Zero Emission Bus

Background

The NSW Government welcomes the opportunity to make a submission to the Joint Standing Committee on Road Safety inquiry into electric and hybrid vehicle batteries. The NSW Premier's Department has coordinated a consolidated NSW Government submission based on consultations with eight NSW agencies.[1]

Lithium-ion batteries (LiBs) are now a ubiquitous part of our lives, powering portable electronics, transportation solutions (vehicles, e-scooters, and e-bikes) and, more recently, energy storage systems. They are an essential part of the global renewable energy transition and NSW's commitment to achieving net zero emissions by 2050.

Electric vehicles (EVs) are critical to decarbonising transport in NSW where private road users are responsible for 90 per cent of transport-related emissions, including cars, light commercial vehicles, and heavy vehicles.

Sales of EVs in Australia have continued to increase, with the total volume of sales in the first half of 2023 so far exceeding the total for 2022. As of the end of June 2023, 46,624 EVs had been sold in Australia – almost 3 times higher than the same period in 2022 (a 269 per cent increase). EVs now represent 8.4 per cent of all new cars sold in Australia. This is a 120.5 per cent increase compared to all of 2022.[2]

In NSW, EVs comprised 3.7 per cent of new vehicle sales in 2022, an 84 per cent increase on the previous year. As at August 2023, there were approximately 40,000 battery electric vehicles (BEVs), 134,000 hybrid vehicles (HEVs), and a small number of hydrogen fuel cell electric vehicles (HFCV) registered in NSW.[3] NSW also has some 6,472 public charging locations, the highest number in Australia, which includes 85 fast charging, and 33 ultrafast charging sites.

Recently, the NSW Government has committed $260 million in the 2023–24 Budget to underpin the rollout of a new NSW EV Strategy being delivered in partnership with industry stakeholders which will prioritise investment in critical EV infrastructure.[4]

With the increasing prevalence of EVs, HEVs, and light electric vehicles (LEVs) such as e-scooters and e-bikes, authorities around the world are grappling with a surge in fires caused by batteries in these vehicles and devices. In response, there is a significant amount of work underway nationally and globally to ensure regulatory and operational settings are in place to address this, alongside increasing public awareness of these risks.

Recent media reports of EV fires have sparked wider concerns about EV safety risks in NSW. On 23 November 2023, Fire and Rescue NSW (FRNSW) issued an urgent warning about the dangers of LiBs following two further LiB fire incidents in Sydney's inner west and in Lismore – the first involving a home-made e-bike and battery pack, and the other involving two pallets of imported LiBs that exploded and destroyed a Lismore home.[5] While EV battery fires are rare, their consequences can be severe due to high temperatures, toxic emissions, and the challenge of extinguishing them. This risk is amplified in cases involving fuel sources or confined spaces.

Mitigating the risk of EV battery fires and other related hazards primarily relies on testing and design provisions within international and national standards, as well as the federally set Australian Design Rules (ADRs) which Transport for NSW (TfNSW) implements as part of its registration process. The Australian Government is currently leading the process of establishing national safety standards for EVs that will align with existing international standards.[6]To better understand the

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[1] Fire and Rescue NSW, Transport for NSW, NSW Rural Fire Service, NSW State Emergency Service, Department of Customer Service, NSW Environment Protection Agency, Department of Communities and Justice, NSW Ministry of Health.

[2] *Electric Vehicle Council,* State of Electric Vehicles, July 2023.

[3] Registration snapshot report | Transport for NSW (accessed 31 October 2023).

[4] $260 million to supercharge the shift to EVs in NSW | NSW Government (accessed 13 November 2023).

[5] FRNSW, Fire and Rescue NSW issues Lithium-ion battery warning after blazes break out in two homes - NSW - Fire and Rescue NSW (accessed 24 November 2023).

[6] National safety standards for electric and hydrogen-fuelled vehicles | Department of Infrastructure, Transport, Regional Development, Communications and the Arts (accessed 5 November 2023).

issues and risks related to LiB fires, and to assess the efficacy of mitigation and response measures, FRNSW is leading a collaborative research program into the Safety of Alternative and Renewable Energy Technologies (SARET). The outputs of this research will inform the development of evidence-based procedures, equipment, and training to assist emergency services workers to respond to high consequence incidents involving EVs.

NSW fire services are proactively training and equipping firefighters to understand and manage EV risks and hazards as the knowledge base on these continues to grow. For example, FRNSW in collaboration with TAFE NSW has developed an EV online training package for all emergency responders on EV hazards and risks and guidelines to work safely around EVs.

Since 2021, the NSW Rural Fire Service (RFS) has an operational protocol in place for incidents involving electric and hybrid vehicles.[7] Alongside leading the SARET program, FRNSW continues to work with other government agencies and industry stakeholders to ensure emergency responder training and responses are adapted to manage the risks and hazards associated with clean energy technologies.

Terms of Reference (a) the risk and management of fires and other issues caused by batteries in electric and hybrid vehicles, including light electric vehicles

The incidence rate of fires involving LiBs and EVs in NSW is currently low but rising. In 2022, 1 in every 100 fire or explosion incidents attended by FRNSW involved rechargeable batteries, with 16 fires involving LEVs and 5 involving EVs or hybrid EVs. Specifically, FRNSW attended 165 fire incidents involving rechargeable batteries, 52 per cent of which involved small portable devices, 13 per cent involved LEVs and 6 per cent involved EVs. From January to October 2023, FRNSW responded to 6 fires involving 8 EVs or HEVs.

Overall, EVs are much less likely to catch fire compared to internal combustion engine (ICE) vehicles – with available data indicating that the fire risk is 80 times greater for petrol and diesel vehicles.[8] The most common cause of fires involving a battery is collision and/or debris, followed by battery fault.[9]

National LiB incident data is limited

There is a lack of comprehensive national data on LiB incident rates. According to a May 2023 CSIRO report commissioned by the Australian Competition and Consumer Commission (ACCC), the limited data suggests that approximately 1 per cent of all fires attended by emergency services are battery-related, with this rate doubling every two years.[10] The number of incidents involving LiBs is likely underreported and there are differences in how the data is collected between jurisdictions and organisations, which makes data analysis challenging.

In response to the ACCC's recommendation for more uniform incident data collection across states and territories to assess public risks accurately, FRNSW is working with the ACCC and NSW Department of Fair Trading to collect incident data.

[7] NSW RFS, Memorandum - OP 1.2.21 Electric Vehicles v1.1 - revised 13 August 2021.PDF (nsw.gov.au)

[8] EV FireSafe, 'Global electric vehicle battery fires as of 11th July 2022', Report, evfiresafe.com, accessed 5 November 2023.

[9] Ibid.

[10] CSIRO, Report: Lithium-ion battery safety (productsafety.gov.au), p. 33.

LiB fire risks and hazards

The ACCC's October 2023 report on LiBs outlines consumer safety risks associated with LiB failure, especially where an uncontrolled failure can cause a serious and self-sustaining fire.[11] When LiBs (in any application) fail, they present risks that include:

- Thermal runaway – an exothermic chemical reaction involving intense, uncontrollable heating, often followed by the violent release of highly toxic, corrosive, flammable, and potentially explosive vapours, and intense, directional, jet-like flames.
  - Thermal runaway can occur due to electrical faults or abuse (e.g. overcharging or overdischarging, or short circuiting due to water ingress), mechanical abuse (e.g. impact, crushing or penetration during crashes or due to road debris), thermal abuse (e.g. exposure to heat from external fire), or cell-level defects (e.g. cell impurities or dendritic growth).
- Stranded electrical energy within large battery packs and installations that present significant fire and electric shock risks;
- Complex and protracted extinguishment and cooling;[12]
- Toxic fire emissions and effluents, including the containment of large amounts of contaminated fire water that may pollute soil, groundwater and nearby waterways; and
- Secondary ignitions, that may occur without warning some time after the initial event, potentially during recovery, transport, storage, and disposal.

In September 2023, the high voltage battery from an EV caught alight and destroyed five vehicles at a rental car yard at Sydney Airport. The subsequent investigation by FRNSW identified that the battery pack was faulty, showing signs of short circuiting from water ingress and was removed from the vehicle by an auto-electrician in April 2023. It was then stored within the workshop for over four months before both the vehicle and battery pack were returned to the owner two weeks before the fire occurred. The EV battery pack had been stored uncovered on the ground underneath the vehicle in close proximity to other vehicles in the car yard.

In July 2023, 14 fire trucks were called to an Eastgardens home to extinguish a fire when an e-bike with a faulty LiB caused a fire that tore through the ground floor of a home and destroyed a vehicle. FRNSW reported that a faulty LiB on the e-bike exploded, causing the fire. Firefighters remained overnight to prevent the battery from reigniting and removed several other LiBs from the scene.[13]

FRNSW is also seeing a number of incidents involving LiB-powered utility vehicles such as golf carts and forklifts, LiB truck batteries, and a rising number of incidents involving aftermarket LiB products, including portable chargers and jump starters, and energy storage systems for (especially) off-road vehicles and campervans.

[11] ACCC, Lithium-ion batteries and consumer product safety. Report (accc.gov.au).

[12] Tesla advises that it can take between 3000-8000 gallons (11,356-30,283 L) of water applied directly to the battery to fully extinguish and cool down a EV battery fire: https://www.tesla.com/sites/default/files/downloads/Model_3_Emergency_Response_Guide_en.pdf.

[13] ACCC, Lithium-ion batteries and consumer product safety. Report (accc.gov.au) p. 19.

Factors contributing to battery-related risks and hazards

Lack of national regulatory coverage for LiBs

Consumer product safety regulation in Australia is a joint responsibility between the ACCC and state and territory consumer protection agencies. The ACCC and state and territory consumer protection agencies regulate the safety of general consumer products.[14]

There is currently no single mandatory safety standard for LiBs or products containing LiBs.[15] There are also no nationally consistent requirements for testing, certification, or labelling for LiB products.[16] In October 2023, the ACCC released a report on LiB safety that was informed by public consultations on its Issues Paper. FRNSW and the NSW Environment Protection Authority (EPA) made submissions to this consultation.[17]

The ACCC made a series of recommendations aimed at improving LiB safety outcomes for consumers, including the establishment of a national framework for electrical safety regulation that provides a consistent approach across states and territories.[18]

Risks are higher in LEVs than in EVs

Several authorities globally have been reporting elevated numbers of fires in e-bikes and e-scooters. In the first half of 2023, they accounted for more than 500 battery fires, 138 injuries, and 36 deaths worldwide.[19] Over the same six months, 35 EV battery fires resulted in eight injuries and four deaths.[20] There has been extensive media coverage of LEV fires, for example, it was reported that in 2022, the New York Fire Department responded to 216 fires that resulted in 6 fatalities and 147 injuries,[21] while the London Fire Brigade attended over 116 fires. The Netherlands Institute for Public Safety reported 327 incidents between 2020 and 2022.[22] In China, the National Fire and Rescue Administration reported over 3000 e-bike fires in the first quarter of 2022.[23]

The ACCC report noted that LiBs within e-scooters are a significant and growing safety hazard.[24] FRNSW reported 149 battery-related incidents from 1 January to 15 September 2023, a 16 per cent increase on the same time last year.[25] Of these incidents, 22 per cent involved LEVs (a 94 per cent increase from 2022) and 1 per cent involved EVs. The higher risk for LEVs can be attributed to a lack of regulatory coverage of these products upon importation, which are not subject to manufacturing standards requirements within the automotive sectors, while EVs are required to meet the Australian Design Standards under the Commonwealth *Road Vehicle Standards Act 2018*.[26]

Electric cars and trucks use the same battery technology but have more sophisticated designs.[27] Advanced cooling systems keep their batteries at optimal temperatures during everyday driving and recharging. This makes them much safer than batteries in e-scooters and e-bikes.[28]

Road vehicles are also required to comply with the ADRs in accordance with the *Commonwealth Road Vehicle Standards Act 2018*.

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[14] ACCC, Lithium-ion batteries and consumer product safety. Report (accc.gov.au), p. 50.

[15] ACCC, Lithium-ion batteries and consumer product safety. Report (accc.gov.au), p. 4.

[16] Ibid.

[17] ACCC, Published responses for Lithium-ion Batteries - Issues Paper - Australian Competition and Consumer Commission - Citizen Space (accc.gov.au) (accessed 10 November 2023).

[18] ACCC, Lithium-ion batteries and *consumer* product safety. Report (accc.gov.au), p. 56.

[19] JUNE 23 EVFS Quarterly Stats (evfiresafe.com)

[20] Ibid.

[21] https://www.nytimes.com/2023/03/06/realestate/e-bikes-fires-danger.html

[22] https://nipv.nl/wp-content/uploads/2023/03/20230315-NIPV-Analyse-mediaberichten-branden-met-LEVs.pdf

[23] https://www.119.gov.cn/gk/sjtj/2022/28761.shtml

[24] ACCC, Lithium-ion batteries and consumer product safety. Report (accc.gov.au), p. 23.

[25] ACCC, Lithium-ion batteries and consumer product safety. Report (accc.gov.au), p. 27.

[26] ACCC, Lithium-ion batteries and consumer product safety. Report (accc.gov.au), p. 23.

[27] ACCC, Lithium-ion batteries and consumer product safety. Report (accc.gov.au), p. 27.

[28] Ibid.

As the uptake of LEVs increases, incidents are expected to rise. The likelihood of an incident involving LiBs in LEVs is increased by improper usage by consumers, such as using incompatible chargers/batteries, damaged batteries, or poor charging methods. Investigations by FRNSW of the 23 November 2023 LiB fire incident revealed that the battery was cheaply produced and had been charged using an incompatible charging device, while it was understood that the LiB fire that destroyed a Lismore home the previous day had ignited because the battery in the shipment was damaged.[29]

International case study: London

- In 2023, London Fire Brigade reported a record number of e-bike and e-scooter fires, with one occurring approximately every two days.[30]
- Of the e-bike fires in the first half of 2023, 40 per cent involved converted e-bikes.[31]
- 77 per cent of e-bike fires were linked to suspected faulty batteries.[32]
- In 2021, Transport for London banned e-scooters on their transport services, including buses and the Tube.[33]
- To address safety concerns, the London Fire Brigade launched the #ChargeSafe campaign, offering tips to LEV owners and users that emphasise the importance of proper usage and safe charging practices.

International case study: New York City

- As reported in the New York Times, in New York City in 2023, there were 154 fires involving LiBs, resulting in 14 fatalities and 93 injuries (as at August).[34]
- In September 2023, a new law came into effect prohibiting the sale, lease, or rental of e-bikes and e-scooters (or their batteries) that do not meet industry standards.[35] This law targets retailers and online sellers, mandating adherence to safety standards for e-bikes and e-scooters.
- New York City also plans to establish a trade-in program for e-bikes and LiBs, allowing owners to exchange faulty ones for compliant units.

Existing building codes do not address battery fire risks

The National Construction Code (NCC) sets building standards for all new buildings and building work. NCC 2022 came into effect on 1 May 2023, introducing new requirements to facilitate the future installation of EV charging equipment in carparks. In NSW, they apply to:

- a new residential apartment building that is subject to a Building Sustainability Index (BASIX) certificate issued on or after 1 October 2023
- all other classes of buildings that are subject to a construction certificate or complying development certificate application lodged on or after 1 October 2023.

[29] FRNSW, Fire and Rescue NSW issues Lithium-ion battery warning after blazes break out in two homes - NSW - Fire and Rescue NSW (accessed 24 November 2023).

[30] https://www.london-fire.gov.uk/news/2023/august/new-record-high-of-e-bike-and-e-scooter-fires-in-london/ (accessed 10 November 2023).

[31] Ibid.

[32] Ibid.

[33] https://tfl.gov.uk/info-for/media/press-releases/2021/december/tfl-announces-safety-ban-of-e-scooters-on-transport-network (accessed 10 November 2023).

[34] https://www.nytimes.com/article/ebike-laws-nyc.html (accessed 10 November 2023).

[35] https://legistar.council.nyc.gov/LegislationDetail.aspx?ID=5839354&GUID=D0854615-5297-460B-BCBC-646D24A75B2E (accessed 10 November 2023).

However, current design requirements for buildings do not include specific considerations or provisions for EV battery failures and fires. Yet, there are significant challenges for firefighter capability in managing EV and other LiB fires in these environments. This scenario is complicated by the likely need to contain and remove potentially contaminated fire water runoff from these incidents, and the need to promptly remove EVs from these environments due to the risk of secondary ignition.

A recent incident attended by FRNSW in September 2023 in a ground level car park of a commercial building demonstrated the potential for structural damage to buildings caused by LiB fires. A LiB-powered golf cart caught fire while charging, resulting in severe concrete spalling to the 3.6-metre-high ceiling above the battery compartment housing a 5kWh system. Following this incident, FRNSW released an Operational Hazard Alert warning firefighters of the injury risk due to large and heavy falling debris, and potential structural failure in LiB fires.

In December 2022, the Australasian Fire and Emergency Service Authorities Council (AFAC) (with FRNSW and RFS support) moved to advise government and industry that underground EV parking should be classified as a special type of hazard that requires builders to consider specific fire protection measures.[36]

At the national level, the Australian Building Codes Board (ABCB) is currently undertaking a project to determine whether the NCC fire safety provisions applicable to carparks are appropriate and if not, whether any amendments should be made to these provisions for future editions of the NCC. The ABCB also released an Advisory Note in June 2023, which identified measures that could be implemented in a building to assist in the safe installation and use of EV chargers.[37]

End of life battery issues, including second life, disposal, and recycling

Dangerous goods transport regulations

Lithium and Lithium-ion are classified as dangerous goods under the Australian Code for the Transport of Dangerous Goods by Road and Rail. Dangerous goods transport regulations are already well harmonised across Australia, meaning that when LiBs are transported, they are subjected to the same regulations. In NSW, this is reflected in *the Dangerous Goods (Road and Rail Transport) Act 2008* and the *Dangerous Goods (Road and Rail) Transport Regulation 2022*.

Second life batteries and second hand EVs

Second life batteries are aimed at the battery energy storage systems (BESS) market using EV batteries that still have 80 per cent of the initial usable capacity.[38] A second life battery pack consists of modules and/or full packs taken from an EV and then 're-manufactured' into a new battery pack.[39] They are considered to be a cheaper and potentially more available alternative to a brand-new battery pack especially when considering the current cost and demand for new batteries.[40] However, this activity has serious safety implications for not only the persons undertaking the work but also to the general public. The CSIRO has noted that, given the market for second life batteries is relatively new, there are no second life battery standards and intervention by regulators may be necessary.[41]

FRNSW and other government agencies agree there is a need to ensure best practices in the safe recovery, assessment, storage, acquisition, and use of second-hand EV batteries in different applications. Often detailed information on the operating history, usage, environmental conditions, and state of health (and degradation) of the batteries is fragmented or unknown.

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[36] AFAC, Electric Vehicles (EV) and EV charging equipment in the built environment (accessed 9 November 2023).

[37] ABCB, ABCB EV Guidance Document June 2023.pdf

[38] CSIRO, Report: Lithium-ion battery safety (productsafety.gov.au), p. 27.

[39] Ibid.

[40] Ibid.

[41] Ibid.

The ACCC stated in its recent report that it will lead a targeted safety and education campaign on LiB safety, with assistance from government, fire agencies, and industry stakeholders, to enhance consumer awareness of the safety risks of LiBs.[42] The education campaign will focus on increasing consumer awareness about:

- how to select, use, store, and dispose of LiBs safely
- how to identify when batteries are at risk of being unsafe
- and practical steps and risk mitigation strategies consumers can take to help stay safe.[43]

Risks in the disposal process

LiBs are more hazardous than standard batteries when incorrectly discarded into household rubbish and recycling bins. Their chemical makeup means they are likely to ignite when exposed to conditions common during household waste disposal, such as compaction or exposure to heat or moisture. LiBs create intense and persistent fires that are difficult and dangerous for firefighters to extinguish.[44]

This is the most concerning issue after community safety, and FRNSW is seeing a 30 per cent year on year increase in fires involving waste trucks and waste facilities due to the incorrect disposal of LiBs. Batteries, which are thrown into rubbish bins instead of being disposed of safely, also contribute to an increase in recyclable materials winding up in landfill.[45]

How batteries are collected, stored, and recycled should be accounted for to mitigate fire and environmental risk. The ACCC has recently recommended that the Australian Government (led by the Department of Climate Change, Energy, the Environment and Water) and industry develop infrastructure, policies, and regulations to enable the safe and efficient collection and recycling of LiBs.[46]

The ACCC has authorised the Battery Stewardship Scheme to establish and operate a national stewardship scheme for managing many types of end-of-life batteries.[47] This scheme is currently operated by the Battery Stewardship Council (a not-for-profit industry organisation that has designed and managed battery stewardship in Australia) via B-cycle. Regular household and standard size handheld rechargeable batteries of all chemistry types up to 5kg can generally be recycled through B-cycle.[48] The EPA provided support to the B-Cycle scheme and has given feedback in the development of its training materials.[49]

[42] ACCC, Lithium-ion batteries and consumer product safety. Report (accc.gov.au), p. 7.

[43] Ibid.

[44] ACCC, Lithium-ion batteries and consumer product safety. Report (accc.gov.au), p. 20.

[45] EPA, Battery safety to prevent fires (nsw.gov.au) (accessed 10 November 2023).

[46] ACCC, Lithium-ion batteries and consumer product safety. Report (accc.gov.au), p. 8.

[47] ACCC, Lithium-ion batteries and consumer product safety. Report (accc.gov.au), p. 45.

[48] Ibid.

[49] EPA Submission to the ACCC Lithium-ion Batteries Issues Paper, p. 17.

As NSW's lead environmental regulator, the transport, handling, and disposal of LiBs is a significant issue for the EPA. The EPA currently funds the following recycling and circular economy initiatives aimed at LiBs:

Collection and disposal	Community Recycling Centre EPA funds a network of Community Recycling Centres (CRC) that take hazardous waste, free of charge. CRCs are operated in partnership with Local Councils and other organisations. Some larger batteries, for example, batteries from e-bikes and e-scooters, and EV batteries, can be dropped off at a CRC or Household Chemical CleanOut event. Embedded batteries, solar panels, and large energy storage batteries are not accepted. EPA is preparing guidance on best practice for the safe collection and storage of batteries that can be used to update CRC operations guidance and to communicate updated requirements to CRC operators. The Guidance will also be able to be used by Household Chemical Cleanout contractor/s and waste transfer stations to better understand the requirements for handling and storage of batteries.
Disposal	Circular solar grants program EPA funds the circular solar grants program to develop NSW capability for processing and recycling solar panel LiBs. PV Industries Pty Ltd has been funded $2,371,581 to support the establishment of a viable circular economy for solar panels, their lithium-ion batteries, and inverters in NSW. The project is closely aligned with circular economy principles, promoting solar panel and inverter reuse, repair and refurbishment, and diversion from landfill through end-of-life processing. PV Industries will scale-up their processing technology, establishing a high-capacity solar panel and LiB recycling facility in NSW, capable of processing up to 8,000 tonnes per annum, and expand their metro and regional collection and logistics network. This will lead to increased access to services and diversion from landfill in the Bankstown area. The project will also improve collection and logistics for LiBs. A process for onshore warranty support, reuse, repair, and refurbishment of solar inverters will be implemented. TES-AMM Australia Pty Ltd has been funded $1,913,517 to develop NSW local capability in circular LiB re-use and recycling. This new plant will address lithium-ion waste from solar panel batteries. Through collaboration, the project will complement rather than duplicate already emerging infrastructure that is being established in solar panel recycling and the collection network being built around these products and the B-cycle scheme. This facility will be the first of its kind in NSW and Australia, processing up to 800 tonnes per annum of LiBs from solar panel systems. Beyond the establishment of the lifecycle facility infrastructure in the Fairfield area of Western Sydney, the project will deliver an additional 20 green jobs, knowledge sharing around systems, processes and standards, access to international markets for battery materials, and encourage the circular economy through reuse.

The EPA's website provides guidance to consumers about proper disposal of batteries, and notes that CRCs accept e-bike and e-scooter batteries.[50] The EPA is also rolling out social media content that warns of the risks of batteries and advises consumers how to properly dispose of old, unused or dead batteries.[51] A letter was sent to Councils, seeking their support to encourage residents to never discard dead batteries in household waste or recycling bins.[52]

Damaged or defective LiBs

Australia does not have national regulations for the collection, management, inspection, or disposal/recycling of damaged or defective LiBs of any size. Post incident management and handling of damaged or defective LiBs can expose workers from all industries involved in inspections and assessments, investigations, recovery, recycling, and waste disposal to associated risks and hazards. Following any incident where an EV battery has sustained damage or is indicating a fault, there is a risk of ignition hours, days or even weeks following the initial incident.

FRNSW is working with the EPA and industry to help identify suitable disposal processes for damaged or defective household LiBs to mitigate the risks of waste fires due to improper disposal.

EV chargers

Damage to installed EV chargers also presents a challenge. For example, of the 15 EV slow chargers installed in total as part of the Commuter Car Park Program in each of the Leppington, Edmondson Park and Rooty Hill Commuter Car Parks, some are showing signs of damage and/or vandalism to an extent where they are no longer operational.

TfNSW is working with Sydney Trains and a maintenance provider to repair chargers that are currently non-operational. A new maintenance program will be in place for existing stations and new installations from 2024. The location of the chargers within a car park and use of CCTV will be considered to deter vandalism.

In new proof-of-concept EV charger programs developed in partnership with industry, TfNSW requires providers to manage all maintenance to a high standard. Providers are monitored through key performance indicators for compliance. Measures to mitigate vandalism currently include the provision of barriers to prevent vehicle collision, and the adoption of BYO cables so that these do not need to be maintained. Due to the vandalism experienced at Rooty Hill, where some units were "rocked" back and forth creating a gap at their base, TfNSW's specifications are being updated to increase the level of robustness of future chargers.

Hydrogen fuel cell electric vehicles (HFCVs)

While adoption rates are currently low, there is highly likely to be future demand for HFCVs. Various manufacturers have models available in market, or are developing hydrogen passenger, light commercial and heavy vehicle platforms, including buses. While their fundamentals are similar to EVs (they operate using high voltage batteries and motors), the addition of the pressurised vessel, storage of hydrogen and the fuel cell itself presents unique challenges which will need to be addressed. Many of the actions taken to support the safe introduction of EVs on to NSW roads will need to be extended to incorporate hydrogen in the future.

TfNSW has supported the Commonwealth in considering and introducing new ADRs (ADR 110 – still in draft) which would introduce minimum safety requirements for HFCVs. TfNSW is currently undertaking a Hydrogen Fuel Cell Standards study as a review to identify and address any opportunities for improvement in Transport Standards.

[50] Safe battery recycling (nsw.gov.au) (accessed 10 November 2023).

[51] EPA, Battery safety to prevent fires (nsw.gov.au) (accessed 10 November 2023).

[52] Ibid.

Terms of Reference (b) the risk to workers in the automotive industry and emergency services personnel caused by batteries in electric and hybrid vehicles

The risks associated with EV batteries affect various groups of workers, including those in the automotive industry and emergency services personnel. FRNSW observes that the hazards and associated risks posed by LiBs in electric and hybrid vehicles are not well understood by workers in these sectors. The nature and level of risk depends on factors such as their roles, work environments, and the opportunities for failure across the battery lifecycle.

Emergency services personnel

Electric and hybrid vehicles incorporate a range of safety features designed to ensure the safety of occupants and responders. Unfortunately, emergency services personnel will often encounter electric and hybrid vehicles in situations which are beyond what was designed for the vehicle to safely operate.

The risks to these workers include:

- Electric shock or electrocution from high voltage electricity stored within the vehicle's high voltage battery, electrical components, cabling, connected charging equipment, and associated energy storage infrastructure.
- Electric shock or electrocution from stranded electrical energy trapped within high voltage battery packs and capacitive high voltage vehicle components.
- Physical injury from unexpected vehicle movement – EVs are silent at idle and emergency responders have been seriously injured during rescue activities when the accelerator has been inadvertently pressed and the vehicle is still switched on.
- Exposure to hazardous materials from leaked coolant or electrolytes associated with LiBs.

If the EV battery experiences thermal runaway, workers may be exposed to physical injury from:

- Extreme fire behaviour including high intensity, jet-like flames.
- Violent venting of toxic, corrosive, and flammable gases, including high energy projectiles.
- Vapour cloud ignition and explosion particularly in enclosed or covered areas such as in garages or carparks.
- Unexpected secondary failures and ignitions after the initial event.

Additional complexities in the management of EV fires include:

- Managing toxic and flammable vapours particularly in compartments such as garages and carparks, which are positioned under or adjacent to occupied areas, especially in domestic dwellings or residential buildings.
- Containment and recovery of large volumes of contaminated fire water runoff.

Automotive and other workers

Workers carrying out work on EVs including maintenance, repair, modification, and disposal and accident recovery, face risks such as electrical hazards, battery fires, chemical exposure, and manual handling. These workers include:

- underbody technicians
- panel beaters
- spray painters
- auto dismantlers
- Installers of aftermarket equipment (e.g. towbars, bullbars, suspension)
- tow truck operators
- waste and recycling facilities.[53]

SafeWork NSW has a webpage advising of hazards and associated risks for people undertaking work on EVs, as follows:[54]

Hazard	Potential harm
Stored or generated electrical energy	• Workers and others may receive an electric shock if they come into contact with components of the electrical system. Even when working on other parts of the vehicle (not involving the electrical system) there may be a risk of shock if the isolation between the electrical system and the vehicle chassis has been compromised. • Some EVs also generate electricity when the wheels are rotated. If the EV is moved by pushing the vehicle (such as in a workshop or after an accident), sufficient electrical energy may be produced to cause electric shock or arcing. • Arc flash may cause burns directly to the worker or through ignition of other materials.
Battery Electrolyte	Battery electrolyte can cause injury through skin or eye contact, ingestion, or inhalation of vapours. This is particularly relevant following collisions or when dismantling vehicles.
Powerful magnets contained within EV components	Some EVs contain powerful magnets. If a person who is wearing a pacemaker or other medical device is close to these parts, the medical device may be affected by the magnets. Such persons should not perform work on the vehicle.

Risk mitigation for automotive workers involves providing personal protective equipment, operational procedures for ensuring safety, creating controlled work environments, and adherence to regulatory requirements.

Risk mitigation measures

EV labelling

The Australian Light Vehicle Standard Rules 2015 s114A and s114B and the Heavy Vehicle (Vehicle Standards) National Regulation (NSW) s108A and s108B sets out the labelling requirements for vehicles powered by alternate fuel systems. All electric, hybrid and hydrogen heavy vehicles manufactured or modified after 1 January 2019 and all electric and hydrogen (regardless of date of manufacture) must have a blue EV warning sticker on their registration plates.[55] These stickers are designed to warn emergency responders of the presence of a high voltage battery.[56]

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[53] Electric vehicles | SafeWork NSW

[54] Electric vehicles | SafeWork NSW

[55] *Heavy Vehicle (Vehicle Standards) National Regulation (NSW), s. 108A&B.* The Australian Light Vehicle Standard Rules 2015 are incorporated into NSW through Schedule 2 of the Road Transport (Vehicle Registration) Regulation 2017.

[56] Electric vehicles - Fire and Rescue NSW

Australasian New Car Assessment Program (ANCAP) safety ratings

ANCAP performs crash tests of cars sold in Australia and rates vehicles on a 5-star scale. Most EVs achieve a 4 or 5 star ANCAP safety ratings. Out of 51 vehicle models tested, five have been rated 4-star all of which are models from 2021 onwards. The remaining 46 models are rated 5-star.

EVs, inclusive of battery EVs, fuel cell EVs, and hybrid EVs are subject to the same ANCAP crash protection and crash avoidance tests as other vehicles. Additional elements are monitored as part of the testing process specific to battery monitoring post-crash, including:

- Monitoring the output of the high-voltage battery. High voltage batteries are fitted with a 'safety cut-out' that will rapidly disconnect the battery in the event of a crash. The battery output is monitored to record if and when this cut-out operates.
- Checking the vehicle body safely for any high voltage immediately after the crash. If the safety cut-out were to fail and a damaged high-voltage wire was to be in contact with the vehicle body, then a person touching the vehicle could be injured. Test technicians use insulated gloves and stand on a rubber mat to ensure that the vehicle has no high voltages and is safe to touch.
- The battery is examined for any sign of damage, such as intrusion into the battery unit, leakage of fluids, fire, or abnormal heat. Only the exterior of the battery pack can be examined in this manner, as such this process may not be sufficient.

ANCAP requires Rescue Cards from vehicle manufacturers each time a vehicle is rated. Rescue Cards are designed to assist emergency services personnel in quickly identifying in-vehicle hazards (e.g. high-voltage batteries) to minimise risk to first responders, and safely free occupants from the vehicle following a crash. The ANCAP Rescue application provides this information for many makes and models accessible in one place for first responders.

Development of new specifications for TfNSW buses

TfNSW is consulting with the education and training sector, emergency services and the bus industry to better understand requirements and current options available to manage risks around battery electric and hydrogen buses.

Case study: Zero Emission Buses (ZEB)

TfNSW has commenced development of technical standards to support electrification of the fleet and major programs such as the ZEB Program, in support of the NSW Government's broader commitment to achieving net zero emissions by 2050.

To date, $3 billion has been allocated to the Program to support the introduction of 1,200 electric buses on Sydney's roads.[57] The transition to ZEBs has seen over 100 battery electric buses introduced as at September 2023, with around 1,700 electric buses expected to be operating across Sydney by 2028.

Throughout program development, TfNSW conducted extensive consultations to identify fire safety risks and constraints for battery electric buses, and opportunities and mitigations that can be applied to reduce risk and improve safety. Minimum requirements established during the program development stage focused on safety and vehicle interoperability. These minimum requirements were used to inform the fire safety specifications of ZEBs for Bus Panel 4[58] and a new panel of TfNSW approved buses is currently in the process of tender review. An online introductory training package on operating a ZEB, developed in collaboration with TAFE NSW, is now available.[59]

As the first stage of the program rolls out, TfNSW will maintain its focus on fire risk management for buses, while on the road and at depots. The program will work closely with operators, the wider

[57] Zero Emission Buses | Transport for NSW (accessed 6 November 2023).

[58] eTendering - Archived Tender Detail View - WS3421949176 (nsw.gov.au) (accessed 6 November 2023). Bus Panel 4 is a selection of buses that meet a required standard and have been preapproved by experts at TfNSW. This allows bus operators to select from a preapproved panel when replacing buses at the end of life or adding growth services.

[59] Package: Electric Vehicle Baseline training – store.training.tafensw.edu.au (accessed 8 November 2023).

industry, independent fire safety experts including FRNSW and the Office of Transport Safety Investigations (OTSI) at a local and strategic level. TfNSW will continue to explore opportunities to optimise the use of ZEB batteries and depot designs to mitigate risks and improve performance, including looking into sustainable options for second life batteries and battery recycling.

Terms of Reference (c) the adequacy of training and equipment for workers in the automotive industry and emergency services personnel regarding potential hazards of batteries in electric and hybrid vehicles

FRNSW is leading important research to build a knowledge base about the nature of LiBs, which will inform the development of appropriate training, equipment, and training for emergency services workers.

Automotive repair workers

Repair work qualification for working on EVs being considered

Under WHS legislation, a person conducting a business or undertaking must ensure workers are trained in the work procedures and can demonstrate they are competent to perform the task according to the procedure.[60] .However, currently there is no specific licence class or mandatory training for workers undertaking repair work on EVs. As the number of EVs in NSW increases, so will the demand for suitably qualified repair workers. Currently, the *Motor Dealers and Repairers Act 2013* requires that repair work can only be performed by a person holding a tradesperson certificate, which is awarded based on successfully completing the prescribed qualification set out in the *Motor Dealer and Repairer Regulation 2014*. To obtain a certificate for a class or classes of repair work, the tradesperson must have the prescribed Certificate II or Certificate III qualification.

The introduction of a new repair class for working on EVs is being considered as part of the remake of this Regulation. Consultation has commenced on recognising appropriate qualifications for tradespeople to perform work on EVs. Issues under consideration include the upskilling or bridging requirements to allow ICE trained mechanics to work on EVs.

Emergency services personnel

Training

Training emergency responders is a significant challenge as EV incidents may be encountered by police, volunteer rescue agencies, fire services and tow truck operators. It is important that all responders understand the hazards and risks that may be present when dealing with EVs.

To address the knowledge gaps amongst emergency responders and some parts of the automotive industry, FRNSW and TfNSW, in collaboration with TAFE NSW developed an online training package for emergency responders to raise awareness of EV hazards and risks, and guidelines to work safely around EVs. The work includes a project to develop a specialised trailer capable of moving EVs experiencing thermal runaway.

More recently, TAFE NSW has taken the lead on EV response training and has developed a course under the Vocational Education Training framework. TfNSW has provided its first responders (Transport Commanders, Traffic Emergency Patrollers and Tow Truck operators) with training through TAFE NSW to manage the risks related to EVs. TfNSW's first responders, including Transport Commanders and Tow Operators, have been issued specialised personal protective equipment to protect them when handling a damaged EV.

[60] SafeWork NSW, Electric vehicles | SafeWork NSW (accessed 9 November 2023).

Equipment

The table below outlines some existing trials of safety equipment and tools to protect firefighters when dealing with EV related risks and hazards.

Safety measure equipment	Trials underway and further work
DC voltage detection High voltage DC electricity is a serious hazard that may cause injury or death to workers. EVs incorporate several features that are designed to contain the hazardous electrical energy to the vehicle battery, however hazardous electricity may still present if these features fail or workers are exposed to the energy within the battery which cannot be removed	**FRNSW is undertaking a trial of a non-contact DC voltage detector which, if effective, would allow workers to identify the presence of hazardous DC electricity in and around an EV.** FRNSW currently carries alternating current (AC) voltage detectors which do not detect direct current (DC) electricity. Further research is required to investigate the safety of current FRNSW protective equipment due to the higher voltage of electric vehicles, sometimes >1000V DC. Current FRNSW electrical safety equipment is only rated for up to 650V AC.
EV immobilisation Unexpected vehicle movement is a serious hazard that has led to responders being injured. It occurs due to the silent operation of EVs and responders not recognising that the vehicle is running/powered on due to the absence of engine noise.	**FRNSW is currently investigating options to minimise this risk including an emergency plug, designed to immobilise plug-in EVs only.**
Access to EV Rescue Cards and Emergency Response Guides	**FRNSW has now made Rescue Cards available on fire appliance Mobile Data Terminals (MDTs) to enable crews to look up vehicle rescue cards quickly and efficiently at incidents to minimise intervention delays.** Further regulation will be required to ensure that all road-registered EV models have up-to-date Rescue Cards and Emergency Response Guides available for use by emergency responders.
EV fire containment system	**FRNSW and TfNSW are collaborating to develop an EV fire containment system and response capability.** This will be an interim measure until a comprehensive system can be obtained that is fit for purpose. The system under development includes a large trailer that has been modified to allow an EV to be loaded into it and immersed in water. It is designed to minimise roadside cooling operations of an EV battery pack that could exceed four hours and result in large volumes of fire water runoff. This has the potential for serious impacts on traffic along major transport routes.
Personal Protective Equipment and Clothing (PPE/PPC) Due to the nature of firefighting, firefighters often rely heavily on structural firefighting uniform and	Further work is required to assess the effectiveness of current firefighting PPE against the products and hazards of LiB thermal runaway.

breathing apparatus to minimise health and safety risks.	
Hazmat detection equipment	FRNSW is reviewing its current equipment for effectiveness when monitoring EV and LiB fires including air quality monitoring, water runoff testing, and testing for human exposure to LiB thermal runaway products.

In the built environment space, FRNSW and other fire services are strongly advocating for fire protection measures that will assist firefighting operations in the event of EV-related fires. These may be readily achievable in new structures, however their implementation in existing buildings is understandably more challenging. Some desired measures include:

- Early smoke detection in areas where EVs are parked
- Automatic ventilation in parking areas to remove toxic and flammable vapours, gases and smoke
- Automatic notification to the fire service
- Automatic shutdown of EV charging facilities upon activation of alarm and facility for fire services to isolate EV charging
- Adequate structural stability and compartmentation
- Availability of firefighting water on site
- Automatic fire sprinkler systems in all parking areas to minimise fire spread and protect structural building elements
- CCTV including thermal imaging in areas where EVs are parked to assist with situational awareness, firefighting intervention, and subsequent investigations
- Onsite facility to capture and recover contaminated water runoff
- Onsite emergency services information package.

Any training or associated new equipment for dealing with these significant hazards must be well researched and assessed for effectiveness and safety. Methodologically rigorous testing is required to assess the suitability of such products and FRNSW is cognisant that some may create additional hazards at an EV incident.

Fire services' activities

FRNSW and the RFS are working proactively to develop knowledge, processes, equipment, and training to keep pace with renewable and alternative technology developments.

SARET Research Program

FRNSW is leading a collaborative research program into the Safety of Alternative and Renewable Energy Technologies (SARET).[61] The research and testing program includes four main projects:

1. Fire service response to LiB fires
2. End-of-life LiB hazard management
3. Electric vehicle fires in structures
4. Fire propagation in battery energy storage systems

The SARET program aims to inform the development of operational procedures, new equipment and training for firefighters and fire safety requirements for buildings and infrastructure housing these

[61] SARET Research - Fire and Rescue NSW (accessed 6 November 2023).

technologies. It has some financial support from the ABCB, the NSW Government's Natural Hazards Research and Technology Program and other sources. It also has a number of industry sponsors providing products for inclusion in the testing program, and other key stakeholders offering in-kind support.

Education, training, and advocacy activities

Alongside this important research, FRNSW continues to work closely with other NSW government agencies and industry stakeholders, including the RFS and other AFAC members to ensure its training and responses adapt to changes in alternative and renewable energy technology hazards. This includes:

- Representation on the AFAC Alternative and Renewable Energy Technologies (ARET) working group. This group comprises representatives of all Australian firefighting agencies, and frequently involves collaboration with industry and other groups closely involved in battery incident issues.
- Contribution to the ARET working group's development of two key guidance documents:
  - Incidents Involving Electric Vehicles[62]
  - Electric Vehicles (EV) and EV charging equipment in the built environment[63]
- The publication of interim operational advice for dealing with LiB failure to maximise work health and safety for operational firefighters.
- Collaborating with NSW electricity network service providers as LiB energy storage systems, including EV charging infrastructure, are integrated into the NSW electrical network
- Working with the ACCC and NSW Department of Fair Trading to provide advice on community education on fires involving LiB-powered devices and equipment.
- Working with the EPA, Local Councils, and service providers to develop policy and solutions to dispose of damaged LiBs safely and effectively.
- Providing community education through a range of media to reduce the incidence and consequence of LiB-related fires.
- Advocating for and contributing to improved regulation, codes, and standards to support a safer clean energy transition.

FRNSW's ongoing SARET research will assist it and partner fire and emergency service organisations across Australia in actively supporting the safe integration of EVs into the vehicle and transport fleet. It seeks to avoid duplication of effort and maximise research output and return.

Similarly, the RFS has undertaken the following actions:

- Developing and disseminating the RFS operational doctrine dealing specifically with EV incidents, and domestic solar incidents where BESS is involved.
- Providing education sessions to RFS Districts to discuss the Operational Protocols and their implementation.
- Amending RFS internal processes to ensure that all EV or other LiB fires are notifiable to State Operations. The notification will enable data on fire occurrence and behaviour to be collected including firefighting crews' observations of the effectiveness of suppression techniques. This will then be incorporated into the RFS Lessons Management Framework for the benefit of RFS members.
- Working with the RFS Learning Design and Assurance team to incorporate the Operational Protocols into mainstream training packages for all RFS members.

[62] AFAC, https://www.afac.com.au/auxiliary/article/incidents-involving-electric-vehicles

[63] AFAC, https://www.afac.com.au/auxiliary/article/electric-vehicles-(ev)-and-ev-charging-equipment-in-the-built-environment

— Collaborating with FRNSW in the development of a multi-agency online learning and video package, which informs firefighter members of hazards, risks, and incident management processes for EV and similar fires. This product is understood to be due for release in November 2023

— Including RFS business units such as Engineering and Safety in discussions on emerging issues related to EV fires. This is to ensure that equipment, PPE, and processes take EV and BESS fires into account.

— In conjunction with FRNSW, undertaking an ongoing trial of an Emergency Plug.

— Provision of and training on thermal imaging cameras at brigades, given their importance in determining whether a LiB is or is not likely to enter thermal runaway.

— Discussion with other Australian emergency service agencies regarding the viability of commercial products that purport to suppress or reduce the impact of EV battery fires.

— Inclusion of EV, LEV, and BESS fire characteristics in RFS fire investigation development programs such as the RFS' Fire Investigators forum.

— In conjunction with FRNSW, the RFS Operational Improvement team ran a series of information sessions for TfNSW traffic commanders across the State to increase awareness of the potential for EV incidents, as well as their impacts in terms of road closures.

Terms of Reference (d) other related matters

Australian Government-led initiatives

In March 2022, Australia became a signatory to the United Nations Global Technical Regulation (GTR) on In-Vehicle Battery Durability. This helps to ensure that minimum requirements are met for batteries fitted in EVs, mitigating the use of low-quality batteries, and increasing the environmental performance of EVs.[64]

The Australian Government's National Electric Vehicle Strategy acknowledged the risks to emergency services workers when facing EV-related incidents, and stated that:

> *The Government will support emergency service workers and first responders by funding the development of world-leading guidance, EV road rescue demonstrations, and fire safety training to address safety and risk knowledge gaps around EVs, chargers and battery technology.*[65]

Presently, concurrent initiatives seeking to introduce regulatory frameworks that govern the production, use and management of LiBs and EVs are being progressed across the Commonwealth Government. Notably, NSW government agencies are contributing to the following Commonwealth-led initiatives:

— development of a National Battery Strategy to grow a sustainable and thriving battery industry in Australia, which will also consider recycling and safe disposal of batteries, including LiBs.[66]

— a regulatory product stewardship scheme for small electrical and electronic equipment and solar photovoltaic systems.[67]

— proposed new ADRs prescribing national safety standards for EVs and HFCVs.[68]

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[64] Department of Industry, Science and Resources, national-battery-strategy-issues-paper.pdf (storage.googleapis.com), p. 17.

[65] DCCEEW, National Electric Vehicle Strategy (dcceew.gov.au), p. 29.

[66] Department of Industry, Science and Resources, National Battery Strategy Issues Paper (accessed 6 November 2023).

[67] DCCEEW, Wired for change: Regulation for small electrical products and solar photovoltaic systems, DCCEEW website, published 20 June 2023.

[68] Australian Department of Infrastructure, Transport, Regional Development, Communications and the Arts, National safety standards for electric and hydrogen-fuelled vehicles (accessed 6 November 2023).

The latter concerns two draft ADRs proposing to deal with management strategies that will cover cars, trucks and buses:

- Draft ADR109/00 includes performance requirements for battery design and is based on the international UN R100 rev2. All light EV suppliers are already compliant with the international safety standard. The performance standards are based on testing a sample battery to ensure the design has considered known risks. This standard will include testing for vibration, heat cycling, crash protection, thermal loading, overcharging and venting for overpressure. This provides some assurance that the design has considered the risks but will not require real time battery monitoring should an issue occur on the road.
- Draft ADR109/01 builds upon ADR109/00 and is based on UN R100 rev3. It adds real time monitoring of the battery including temperature monitoring and safety system monitoring to warn the driver of a system failure or elevated temperature prior to a thermal event to allow passengers increased evacuation time.

A similar ADR has been drafted related to the safety of HFCVs.

These ADRs do not address all existing EVs already released into the Australian market, nor do they address how vehicles with EV systems may be modified. It should also be noted that in-service regulation of EVs is a national issue. Having a consistent approach to in-service maintenance of EVs can be best achieved by the Australian Government.

Potential future considerations for the Australian Government include:

- Fast tracking of EV safety in retrofitting of/or modifying EVs into the National Codes of Practice for modified vehicles (VSB14 - Light Vehicles) and VSB6 (Heavy Vehicles).
- Conducting national research into inspection and maintenance (in service) and certification of modified vehicles which would provide valuable insights into how to address this issue nationally. Any study conducted should also include understanding the existing vehicle fleet of EVs and how current battery technology in Australia conforms to international standards in providing a minimum level of safety to the fleet.

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