LEGISLATIVE ASSEMBLY
FOR THE AUSTRALIAN CAPITAL TERRITORY

STANDING COMMITTEE ON PLANNING, TRANSPORT, AND CITY SERVICES
Ms Jo Clay MLA (Chair), Ms Suzanne Orr MLA (Deputy Chair),
Mr Mark Parton MLA

Submission Cover Sheet

Inquiry into electric vehicle (EV) Adoption in the ACT

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STANDING COMMITTEE ON PLANNING, TRANSPORT AND CITY SERVICES: INQUIRY INTO ELECTRIC VEHICLE ADOPTION IN THE ACT

August 2022

UFU ACT Branch Submission

Greg McConville,
Secretary ACT Branch

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INTRODUCTION

The UFU ACT Branch represents the industrial, professional, health, safety and wellbeing interests of career firefighters and communications officers employed by ACT Fire and Rescue

The primary focus of this submission is the areas where the Terms of Reference are relevant to the work performed by UFU members.

Terms of Reference

Our submission is most relevant to the following Terms of Reference:

a. Skills development needs to support an expanding EV uptake

b. Industry development opportunities

c. Planning laws and regulations and education and promotions in relation to charging infrastructure requirements in a variety of residential, public and commercial configurations and precincts

and

Any other matter relevant to this issue.

The UFU has a significant record in advocating for measures aimed at addressing climate change, and the challenges posed to firefighters by extreme weather events. Included in this has been support for reducing the reliance on fossil fuels, and support for shifting to greater reliance on renewable energy sources. It follows that we are generally supportive of a greater uptake of electric vehicles.

In this submission we advance a framework for risk management associated with increasing use of electric vehicles, including the vehicles themselves, charging infrastructure and energy storage.

TYPES OF ELECTRIC VEHICLES

It is often assumed that the greatest fire and rescue risks are associated with cars and trucks, however this ignores the significant variety of vehicles which use batteries, mostly of the Lithium Ion type:

- Bicycles;
- Scooters;
- Hoverboards;
- Motor scooters;
- Electric motorcycles;
- Cars;
- Trucks;

Each of the above are subject to differing levels of regulation, including that pertaining to the design, construction and use of the vehicles themselves but also their charging infrastructure. The latter ranges from adapters simply plugged in to power boards to large scale industrial installations of battery arrays.

Standards pertaining to charging infrastructure in Australia are of general application and have not been developed with the specifics of charging infrastructure in mind. For example:

- AS/NZS 3820 - Essential Safety Requirements for Electrical Equipment pertains to all electrical equipment imported and sold in Australia;
- AS/NZS 4417.2 - Regulatory Compliance Mark for Electrical Equipment applies to all equipment for domestic use or sold over the internet;
- AS/NZS 3000:2018 – "Wiring Rules" requirements sets some minimum requirements in relation to charging infrastructure.

The National Fire Protection Association in the United States (NFPA) has published NFPA 855, "Standard for the Installation of Stationary Energy Storage Systems". As the first step in addressing the rollout of electric vehicles, the ACT Government should support the development of more comprehensive standards such as this to regulate the infrastructure on which such vehicles rely.

Recommendation 1

That the ACT Government support the development of Australian Standards based on NFPA 855 to regulate the installation of charging and storage infrastructure.

Light Rail

It is important to mention stage 2 of Canberra Light Rail. The lithium batteries proposed to be fitted toCanberra's light rail vehicles are reported to be in the vicinity of 1 - 2 tonnes. This places them in the weight range of large Battery Energy Storage Systems (BESS)[i]. In the event of a fault, like many BESS the BMS (battery management system) shuts down but doesn't affect thermal runaway or off gassing. The Light Rail Depot at Mitchell is fully sprinklered except workshop: the exception to the usual requirement for sprinklers to be installed is allowed because it is a high voltage area. The installation of batteries hasn't changed this exception because high voltage and water simply don't mix. Stage 2 of light rail will present the same challenges as other electric vehicles but placed on the scale of an industrial BESS.

ELECTRIC VEHICLE RISKS

"These vehicles are no more likely to be involved in fires than conventional vehicles. But when they are involved with fires, the fire management risks are high"

(Prof David Hayward, A Better Fire and Rescue Service for the ACT: Context, pressures and organisational challenges, August 2019)

The reported experience of London is that electric vehicle fires account for 50:2000 or 1 in 40 of all car fires.

> *"Some 7,248 electric vehicles (EV) were sold in Australia between January and June, according to the latest Electric Vehicle Council market report, in addition to 1,440 plug-in hybrids (PHEV).*
>
> *These combined 8,688 sales equaled 1.57% market share, up from 0.78% share in 2020. Strip out light commercials and it's 2.0%. More EVs were sold in the first half of 2021 than all of 2020." (*https://apfmag.mdmpublishing.com/safely-tackling-electric-vehicle-and-internal-combustion-engine-fires/)

To date there have been two notable incidents involving electric vehicle fires in Canberra in Canberra: both at battery storage facilities. Any analysis of EV adoption must have at least some regard to charging facilities and Battery Energy Storage Systems (BESS), based on the dependency of vehicles on charging and energy storage, and also because of the similar challenges posed for firefighters. Planning for fire prevention and response in respect of vehicles assists those endeavors in respect of charging and storage, and vice versa.

The risks associated with Electric Vehicles are best illustrated through some examples.

EXAMPLE 1 TESLA MODEL S

> "After an out-of-control Tesla Model S ploughed into a stand of palm trees on a highway median outside Fort Lauderdale last month, police rushed to put out the ensuing blaze using a department-issued fire extinguisher. It was a wasted effort. The car kept on burning after the crash, which killed the driver. The police may not have known lithium-ion batteries inside electric vehicles, once ignited, can't be put out with chemicals from a conventional extinguisher. The battery fires are susceptible to a self-destructive chain reaction known as thermal runaway, causing a feedback loop of rising temperatures. The Tesla fire stumped a series of first responders in Florida. Firefighters eventually doused the flames with water, which seemed to work, but the wrecked car reignited twice more after being towed away." Bloomberg 2019

Comment: the example illustrates a number of key issues for Fire and Rescue: the volume of water required, methods of vehicle identification and appropriate suppression, the risk of re-ignition.

EXAMPLE 2 Canberra Scooter battery recharging station (Fyshwick)

- Initial Fire 30 May when batteries were on charge
- Fire "extinguished" by early afternoon
- Ongoing monitoring for 2 days
- Street re-opened 1 June
- Fire investigator was on site on 1 June and noticed it re-ignited when batteries not on charge
- Re-ignited again 14 July
- Company statement: "as per instructions from WorkSafe ACT, we have not accessed the facility since the fire in late May, and the warehouse has not been utilised for operations"
- Emergency Services Agency: "not being further investigated, investigation from WorkSafe ACT already underway."
- WorkSafe ACT: "unable to comment - active investigation"

The example illustrates the risk of re-ignition even when not charging, as well as the challenges of inter-agency cooperation. It also illustrates the disruption that can be caused to neighbouring businesses.

EXAMPLE 3: VICTORIAN BIG BATTERY SITE

- Tesla megapack near Geelong (Victoria)
- 13-tonne lithium battery engulfed, spread to adjacent battery
- More than 150 firefighters

- A toxic smoke warning
- Residents to close windows, close fireplace flues, bring pets inside
- Decision made to allow the battery to burn and use water to cool adjacent units (environmental impact?)
- Over 2 km of hose was used to connect to hydrants and cool adjacent batteries
- Fire burned for 4 days

Comment: Significant firefighting resources, significant public safety risk, huge quantity of water used.

EXAMPLE 4: LITHIUM ION BATTERY SYSTEMS MORRIS ILLINOIS (29 June 2011)

40 known fires in large-scale, lithium-ion battery systems, (Newcastle University's Paul Christensen) Morris, Illinois (29 June 2021)

- Building believed by firefighters to have been unoccupied since the Federal Paper Board facility closed almost 35 years ago, was housing approximately 100 tons of lithium ion batteries which were not connected. Owner believes water dripping onto the batteries could have sparked the explosions and fire
- Thousands of residents evacuated for three days;
- "The lithium fire laughed at the 1000 pounds of Purple-K (dry chemical) - didn't put a dent in it."
- 300 emergency personnel smothered fire with 28 tonnes of cement
- On July 11, Morris Fire Chief announced fire extinguished

EXAMPLE 5: BEIJING JIMEI DAHONGMEN SHOPPING MALL (APRIL 2021)

- Lithium-iron phosphate (LFP) battery fire claimed the lives of two firefighters
- 235 firefighters, 47 fire trucks from 15 fire stations
- it is hard to determine if the fire accident was initiated by the poor quality of the batteries or the overloading input to the batteries which exceeds the limitation of the batteries (although facility was on 3 years old)

EXAMPLE 6: MCMICKEN BATTERY ENERGY STORAGE SYSTEM APRIL 19, 2019[ii]

A minor drop in voltage (of 0.24 V in rack 15, module 2, battery 7 (4.06 to 3.82 V)) led to temperature increase (10 seconds later) to activation of smoke alarms (50 seconds) to activation of fire suppression system (80 seconds). 911 was called after 1 hour 50 minutes and responded within 4 minutes. Within 2 minutes opening the door of the container which housed the batteries an explosion occurred causing significant damage.

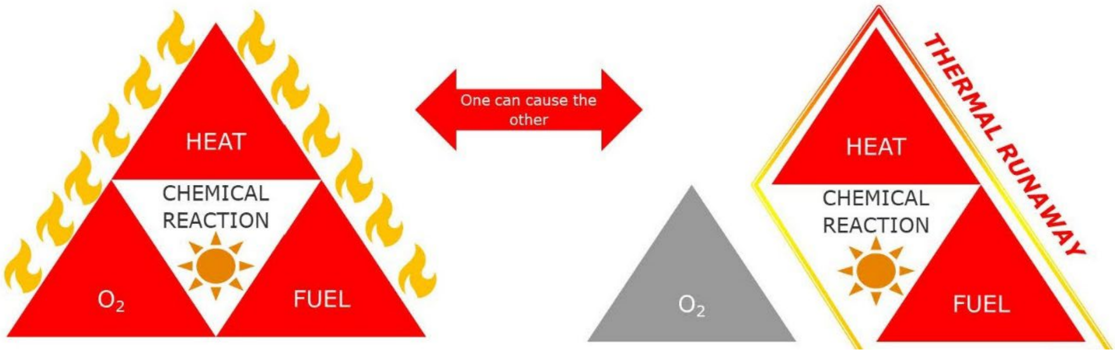
While the incident was not catastrophic, the forensic analysis of the incident identified significant systemic failures. The findings represent a useful guide of what to avoid in installation and management of BESS.

THERMAL RUNAWAY

As can be seen from the examples, not all of the incidents have been characterised as fires per se. Lithium ion batteries when damaged cause an escape of energy. Just as a mobile phone become warm when being charged, escaping energy from a damaged cell causes heat build-up faster than it can be dissipated. This in turn accelerates further heat build up. The process, known as "thermal runaway": can lead to either fire or explosion. Fire can reach temperatures of 1600C, and a jet of flame can be intense and concentrated.

The figure below is reproduced from "McMicken Battery Energy Storage System Event -Technical Analysis and Recommendations, Arizona Public Service, July 18, 2020". That report describes the difference between thermal runaway and fire as follows:

> *"thermal runaway in a Li-ion battery differs from the conventional fire triangle, as shown in the right triangle in Figure 11. As a Li-ion battery is consumed in thermal runaway, it is fueled by an internal chemical reaction that releases heat and can continue without oxygen or a visible flame. Accordingly, management of thermal runaway differs from that of a conventional fire, specifically because starving a thermal runaway event of oxygen may have little effect, at least until the exothermic reaction is complete. Instead, heat must be removed (by cooling with water), or the fuel must dispersed in order to stop a thermal runaway event."* [iii]



An EU project from 2015: "Li-IonFire (An Automated HEV and EV Vehicle Fire Early Warning and Suppression System) project" noted:

> "*Current fire suppressing systems have failed to effectively deal with li-ion fires and Dafo Brand has come up with an innovative HEV/EVLi-ionFire project aimed at fire management and suppression for heavy commercial HEV and EV such as buses and trucks*." [iv]

Results of the project remain unavailable.

THERMAL RUNAWAY AND FIRE SUPPRESSION

Traditional Firefighting foams do not work in suppressing thermal runaway. In general terms, the efficacy of firefighting foam is that it greatly reduces the amount of water required to extinguish a fire in two main ways: A class foams lower the surface tension of water, allowing it to penetrate the material (e.g. wood, paper, fabric) which is burning. B class foams (e.g. for flammable liquids or flammable gases) play a role in seeking to smother the fire and hence reduce the oxygen available to it. Neither approach is effective for thermal runaway.

Cooling the battery to suppress the thermal runaway can be effective, however there are reports of water causing explosion. Fully electric vehicles may require lifting to gain access to the floor pan battery for cooling purposes.

Sprinkler systems (including misting systems) can assist to control ambient temperature and suppress collateral fire, but are not adequate for suppression of thermal runaway.

Suppression requirements:

Typically, thermal runaway suppression requires 1125 litres per minute to a total between 2000 litres and 60000 litres required. [v] One particular controlled training exercise in USA required over 15,000 litres.

For perspective, it is worth noting that the average Canberra home uses 200,000 litres per year, while average conventional car fire uses less than 1400 litres.

ACTF&R pumpers can pump up to 3800 – 5700 litres per minute, but only have about 1400 litres on board. Where access to hydrants is available, quantity of water is more than sufficient, however if thermal runaway events become more common this will place a significant drain on water supplies.

Once battery is cool, wait 45 minutes and test for heat

Once removed, risk of re-ignition requires vehicle to be stored at least 15 meters from other objects.

Noting the requirements for thermal runaway suppression, it is not difficult to imagine a scenario which typifies some of the challenges in the context of Canberra's environment.

Watch the second video shown in the link at 19 seconds (https://www.youtube.com/watch?v=UsuYxFBHsiQ), and consider the following:

Scenario 1

An electric vehicle collides with a safety barrier on Parkes Way, at the foot of Black Mountain and adjacent to Lake Burley Griffin. The battery is damaged leading to a jet of flame from the battery. The questions to be considered include:

- to suppress the fire or not, given the proximity to Black Mountain;
- how to access sufficient water to suppress if that is the decision, given that there are no hydrants adjacent to Parkes way;
- if 60,0000 litres of water are required, how can it safely be transported in a timely manner?
- If 60,000 litres is used, can it be captured without environmental damage?
- How long would traffic be disrupted?

The above points to a need for detailed procedures to be developed and documented in a training package for firefighters. This is of direct relevance to the skills development needs that are subject to this inquiry.

> *"It is not just that the fires are difficult to extinguish. First responders must first work out if the vehicle is still running — a challenging task because they are so quiet. Then they need to know how to turn them off — again, a challenge as car manufacturers are using different techniques. They also must understand how to avoid being effectively electrocuted while*

> *trying to manage the fire. All of these issues require first responders to be well-trained on this issue and kept up to date with latest developments."*
>
> (Prof David Hayward, A Better Fire and Rescue Service for the ACT: Context, pressures and organisational challenges, August 2019)

Any such training will need to fit into a packed training schedule. The ACT Public Sector ACT Fire and Rescue Enterprise Agreement 2020 - 2024 ("The Agreement") increased the list of "mandatory skills refreshers" from 3 to 25 (15 core and 10 specialist) skills / qualifications. Most of these refreshers are 3 yearly.

Importantly, awareness programs will also need to be developed for Police, Ambulance, road users and public. There is a significant risk that well meaning (and untrained) bystanders could be placed in danger. At 4 minutes and 30 seconds of the video link posted above, the risks to bystanders and non-fire first responders is apparent.

PLANNING FOR FUTURE SUPPRESSION

Matters to be considered in planning for future emergency response include:

- Toxicity to firefighters and members of the public
- Co-location of batteries and means of suppression
- Purpose built vehicle suppression and disposal trucks
- Capture of contaminated water

While by-products of all car fires are highly toxic, lithium Ion battery fires produce two particularly dangerous battery fire chemicals: Carbon Monoxide; and Hydrogen Cyanide. (Hazardous materials specialists refer to these as "The Terrible Twins"). Both of these prevent the body using oxygen, and Cyanide affects organs that rely on a lot of oxygen: (heart and brain).

In addition, Hydrogen Fluoride gas is highly toxic: it causes damage to lung tissue and swelling and fluid accumulation in the lungs (pulmonary oedema). Skin contact with hydrogen fluoride may cause severe burns that develop after several hours and form skin ulcers. [vi]

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5577247/

While Personal Protective Clothing and Breathing Apparatus seem adequate for these risks, firefighter cancer continues to increase. Most recently the World Health Organisation International Agency for Research on Cancer (IARC) declared firefighting a cancer-causing occupation. A significant factor in firefighter cancer is that personal protective clothing (PPC) does not prevent dermal absorption:

> *"Dermal absorption of chemicals can occur even in firefighters wearing PPE due to limitations of its design, fit, maintenance, or decontamination. Furthermore, exposures can occur when firefighters are not actively fighting fires and are not wearing PPE."*
>
> (www.thelancet.com/oncology Published online June 30, 2022 https://doi.org/10.1016/S1470-2045(22)00390-4)

Aside from dermal absorption occurring in the circumstances described above, the requirement of PPC to prevent metabolic heat build-up requires a degree of breathability which also leads to dermal absorption. A recent study observed that firefighter protective clothing did not appear to affect the level of benzene and toluene contamination, as levels inside and outside firefighter protective clothing were similar. The same study observed that dermal absorption was evident through analysing levels of the same chemicals on a firefighter's breath pre- and post fire, event though they were wearing breathing apparatus[vii]. "Characterizing exposure to benzene, toluene, and naphthalene in firefighters wearing different types of new or laundered PPE"

As mentioned previously, risk to the public through vehicle fires are arguably greater as they do not have the same protective clothing as firefighters. Risks to public and bystanders, Police and paramedics.

Recommendation 2

That with regard to BESS installations associated with electric vehicles in the ACT, the approach recommended in the case of the McMicken[viii] incident be applied by ACT authorities, specifically:

- A heavy emphasis on cell quality in installations.
- Design and installation to prevent cell-to-cell cascading, for example barriers to limit the or prevent cascading
- Addressing proximity of modules to prevent module-to-module cascading and propagation of gases;
- Adequate Ventilation and cooling and dissipation of gases;
- Proper extinguishing using a combined approach of fire suppression followed by ventilation and cooling strategies;
- Response plans and entry procedures that incorporate system monitoring, the detection of gases, ventilation practices, extinguishing methods, and information to gather before entry by firefighters. This needs to be supported by training of installers, operators and firefighters in the project development and commissioning process. This needs to be underpinned by procedures that are documented and available outside the BESS container or building, and reinforced through training which should be refreshed and updated periodically as part of ACTF&R's mandatory skills maintenance program.

The above measures should also be used in relation to charging facilities for vehicles such as electric scooters, garages where electric vehicles are parked, and showrooms / dealerships where electric vehicles are stored.

Recommendation 3

That the ACT Government mandate through planning legislation a requirement that ACT Fire and Rescue approval be required in the setting of standards and thresholds pertaining to the fire safety and suppression features of "Electric Vehicle Ready Buildings".

Recommendation 4

That the ACT Government support the further research of the work health and safety implications of firefighter chemical exposure arising from thermal runaway events.

Recommendation 5

That the ACT Government work with suppliers of electric vehicles and BESS, and with ACTF&R to develop and implement public awareness materials on the dangers of thermal runaway events.

VEHICLE COLLISION AND ENTRAPMENT CHALLENGES

Knowing the car and its design will be more important. Labelling of number plates on vehicles should be mandated.

Safe practices will need to be developed for firefighters, paramedics, Police and public. Intensity of flames can easily burn PPC.

The risk of explosion is a particular challenge especially where passengers are entrapped in an electric vehicle. Watch the first video shown in this link https://www.youtube.com/watch?v=UsuYxFBHsiQ and consider the following:

Scenario 2

A passenger is trapped in an electric vehicle. As crews set about rescuing the passenger, vapour starts to become visible rising from under the vehicle. Knowing that the risk of explosion is imminent, what choice does the Station Officer in charge of the crew make:

- Remove the crew to safety and seek to suppress the thermal runaway from a distance?
- Attempt to free the passenger, knowing that vapour signals a likely explosion in seconds?

Recommendation 6

That the ACT Government provide additional funding the ACTF&R to develop specific bespoke information, instruction and training for firefighters in relation to electric vehicle emergencies such as thermal runaway events and entrapments.

ENVIRONMENTAL RUN OFF

Noting the large amounts of water (30-60,000 litres) required to combat thermal runaway, consideration of capture and decontamination of water requires serious consideration. Generally, water utilised for structure fires and vehicle fires is required to be potable, for health and safety reasons and for reasons of longevity of equipment such as pumps.

In circumstances where a battery is to be cooled (rather than extinguished), capture is less problematic than where a battery is alight: however, neither circumstance is simple. Noting that in NSW where hose and / or boots are in contact with run off, the hose is disposed of, the prospect of large volumes of contaminated water finding its way into storm water drains is particularly unpalatable.

Recommendation 7

That the ACT Government facilitate partnerships with academic institutions, the UFU and ACT Fire and Rescue to study approaches to suppression, capture and treatment of run off from vehicle and BESS thermal runaway events. An avenue such as Australian Research Council linkage grants should be pursued.

CONCLUSION

The matters raised herein are by no means comprehensive, however they are somewhat sobering. Fire and Rescue Services such as ACTF&R are inherently innovative, and are frequently called upon to respond when there is literally no one else who can help. Swift action by all levels of government is required to ensure that fire services are not overwhelmed by the proliferation of this developing technology. Early interventions such as those proposed herein are essential to ensure that increased utilisation of renewable energy sources is genuinely sustainable.

ENDNOTES

[i] UFU members in ACTF&R Risk and Planning, personal communication

[ii] McMicken Battery Energy Storage System Event -Technical Analysis and Recommendations, Arizona Public Service, July 18, 2020

[iii] Ibid.

[iv] https://cordis.europa.eu/project/id/684817

[v] https://apfmag.mdmpublishing.com/safely-tackling-electric-vehicle-and-internal-combustion-engine-fires/

[vi] Larsson et al., "Toxic fluoride gas emissions from lithium-ion battery fires" https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5577247/

[vii] Mayer et al., "Characterizing exposure to benzene, toluene, and naphthalene in firefighters wearing different types of new or laundered PPE" International Journal of Hygiene and Environmental Health 240 (2022) 113900.

[viii] McMicken, op cit, p.64