Attachment 1 - Concerns Identified With
Solar Electricity and Battery Storage Systems
Safety Handbook for Firefighters

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The “Handbook” developed by the Canadian Renewable Energy Association (CanREA) in partnership with the Ontario Association of Fire Chiefs, was announced in a September 6, 2023 press release.

https://www.oafc.on.ca/sites/default/files/MediaReleases/2023-09-06 Press Release - Solar Electricity and Battery Storage Systems Safety Handbook.pdf

The Handbook itself is available via this link.

https://www.oafc.on.ca/sites/default/files/Solar Safety/FINAL 2022 Solar Electricity and Battery Storage System Safety Handbook for Firefighters April 2023.pdf

A significant challenge is that while the press release states that the handbook, *“addresses the pressing need for up-to-date safety guidelines,”* and continues, *“the handbook prepares firefighters for potential hazards that might arise during emergency situations involving solar PV and battery storage systems,”* the descriptions, examples, and photographs deal primarily with smaller residential scale systems. Other than for a few photos of larger solar arrays of panels, and photos of BESS fires on P25 and P33, the bulk of the material and descriptive photographs of electrical disconnect equipment on Pages 6, 7, 8, 11, 12, 26, and 33 show smaller residential scale equipment. The specific electrical hazards of Battery Energy Storage Systems (BESS) connected to high voltage transmission lines, and battery arrays that may cover acres, are very poorly described. A firefighter whose training was based on the handbook would be very inadequately prepared to deal with BESS installations, in spite of what the press release says.

While the handbook definitions for BESS on page 2 defines the Battery Management System (BMS) noting that it *“monitors, controls and optimizes performance of an individual or multiple battery modules in an ESS and can control disconnection of the module(s) from the system in the event of abnormal conditions,”* there is no information on the necessity to contact the system operator to ensure BESS shutdown, and for information about hazards (such as toxic gases) before approaching the system. The closing thought of the Introduction on page 3, identifying the desirability *“for Fire Departments to be aware of existing large-scale battery and solar projects operating within their jurisdiction, and work with operators to be sure they are aware of any unique safety and emergency response procedures for projects in their area,”* is a bit understated and should be reinforced.

The handbook provides a reasonable description of individual Photovoltaic (PV) systems on Pages 4 through 13. Although it does not address the particular risks of larger scale (farm sized) solar arrays that may incorporate acres of installed PV panels, discussing those risks is not the intent of this document, focused on inadequate coverage of BESS concerns in the handbook.

Page 14 initiates the discussion of Battery Energy Storage Systems (BESS). It gives a brief description of the system building blocks of battery cells, battery modules, and battery racks. The description is incomplete as it does not explain that in a larger sized BESS, the battery racks will be typically assembled together into container sized parcels, often with their individual Battery Management Systems, charge controllers, and inverters, whose output is then paralleled to feed into (a) high voltage step up transformer(s), then to connect via appropriate switchgear to the high voltage transmission grid or distribution system.

Pages 15, 16, and 17 briefly outline three types of batteries for a BESS, as Flooded Lead Acid, Valve Regulated Lead Acid, or Lithium Based Batteries. The handbook does not identify that the Flooded Lead Acid batteries or Valve Regulated Lead Acid batteries were the system of choice in older, smaller scale installations, as might be used for starting backup generators, or supplying uninterruptible power supplies for computers or telephone systems, but that lithium Based Batteries are the more likely to be the encountered system in modern larger "utility-scale" Energy Storage Systems.

The handbook fails to identify that the significant difference between the battery types that impacts the risk of each is the stored energy density of each type. While Lead Acid batteries typically have a stored energy density of 30 to 50 Wh/kg, Lithium Based battery can have a stored energy density of 150 to 250 Wh/kg. This up to 8 times greater stored energy density impacts the release of energy (and heat) in combustion, greatly increasing the challenge of suppressing the released heat.

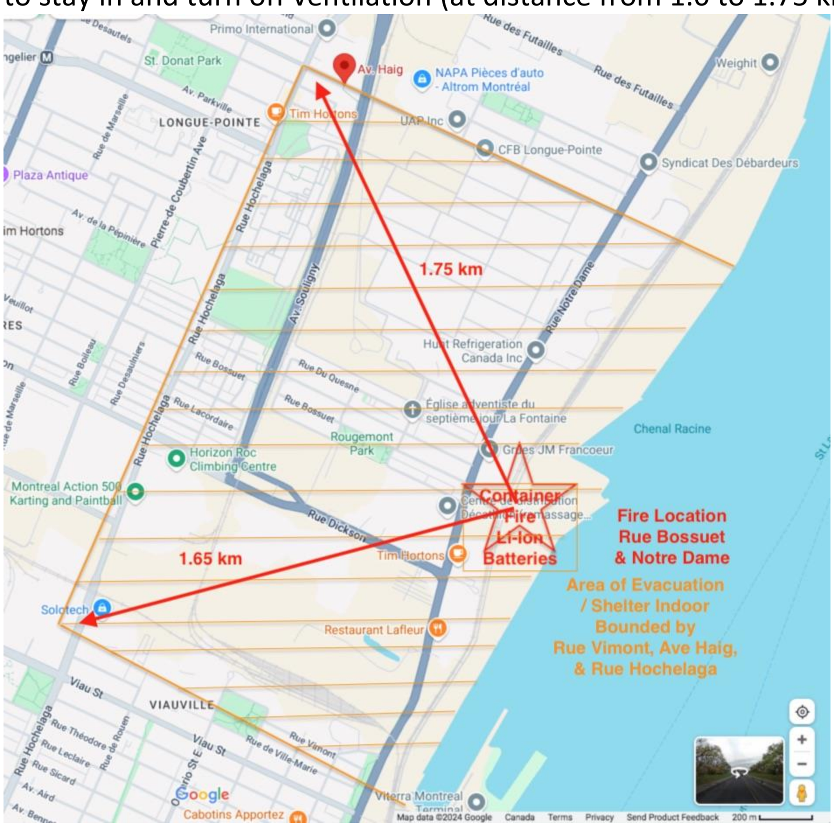
It is only in the last lines of the description of Lithium Based Batteries on Page 17, that the risks of these batteries, as used in BESS currently being installed under the Independent Electricity System Operator (IESO) Long Term – Request for Proposals (LT1-RFP) and (LT2-RFP) are first discussed. *"These batteries are high energy density, but have temperature limitations. There are more safety concerns with lithium-ion batteries since they contain flammable electrolytes, and if damaged or incorrectly charges can lead to explosions and fires."* The description lacks the warning that charging these batteries if too cold, or too hot increases the risk of formation of a sharp crystalline structure (dendrites) that can penetrate the separator between the anode and cathode, and result in the uncontrolled heating of thermal runaway. The description of the hazards is expanded on Page 25, in the continuation that, *"Lithium-ion batteries deliver good energy density in a small, cost-effective footprint, however that comes with a risk. When a lithium-ion cell fails, or is subjected to abuse, a potentially catastrophic event known as thermal runaway can occur, where chemical energy is converted to thermal energy. Once an ignition threshold is reached, the process will continue to propagate, or spread, from cell to cell consuming the BESS, and where adjacent structures are present, potentially facility wide."* Again, this description does not identify that this catastrophic event can be caused by charging when too cold, or if the cell gets too hot, or that the risk is enhanced if the cells are maintained at a high state of charge, as they will by design in a BESS.

The only hazard discussed in the handbook on Page 29 under the heading "Lithium-Ion Batteries" is Thermal Runaway. This significant deficiency neglects many of the risks, even more serious ones, and needs correction. A more comprehensive description of Lithium Battery hazards is found in the report of the EV FireSafe study (Attachment 2) conducted for the Australian Government, Department of Defence, intended to enhance safety for emergency responders at electric vehicle traction battery fires (but applicable to the case of many battery modules collected together in a BESS.) The listing of hazards in the EV FireSafe study includes:

- Toxic vapour cloud of flammable gases poses respiratory and explosion risks.
- Thermal runaway makes it difficult to extinguish a traction battery fire
- Even once suppressed, there is risk of fire re-ignition (hours or days later)
- EV traction battery fires are not yet well understood by emergency agencies
- A traction battery with a state of charge of under 50% is less likely to ignite *(BESS batteries are intended to be maintained at full charge, unless discharging to supply load, when the intent would be to rapidly recharge the battery to 100% as soon as excess generation is available.)*

Nowhere in the handbook is the requirement to take action to protect citizens, from either the toxic vapour cloud, or the liquid effluent from fire suppression discussed. Here are a few recent examples of fire protection services taking action to evacuate citizens, or to advise sheltering in place, with windows closed and ventilation systems isolated in a Lithium battery fire:

- Montreal port fire – September 2024, lithium battery fire in shipping container.
    - Firefighters evacuate ~ 100 people and warn others in Hochelaga-Maisonneuve to stay in and turn off ventilation (at distance from 1.0 to 1.75 km)



Photos from Global television website:

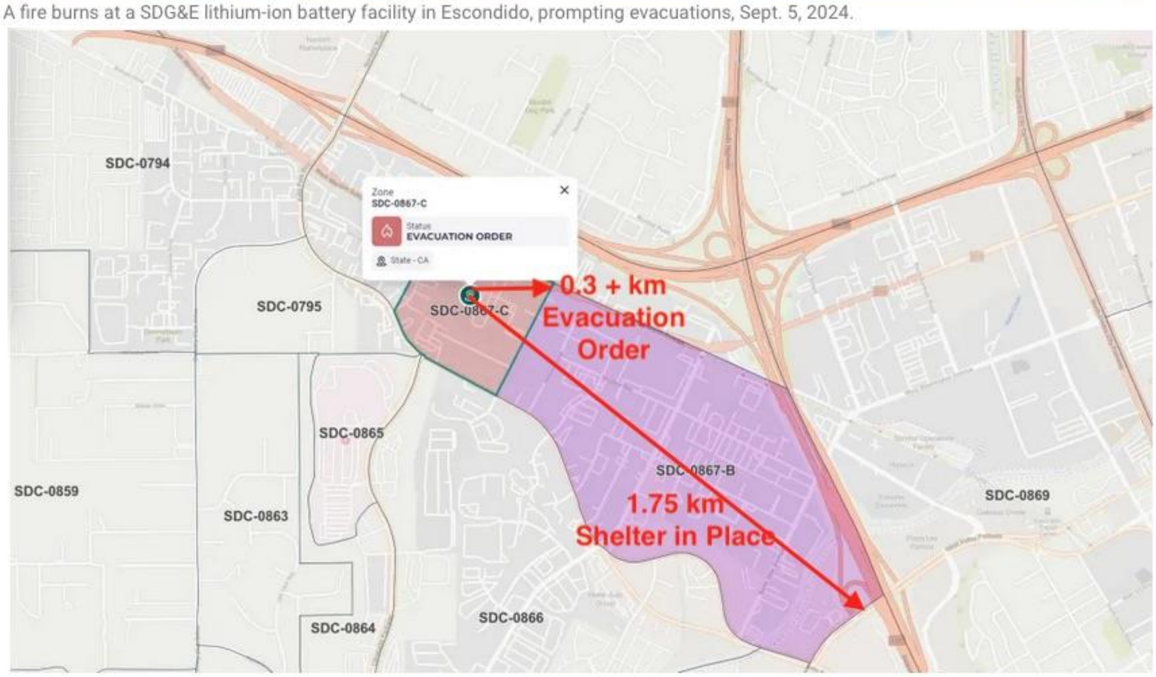
A fire at a shipping container at the Port of Montreal on Sept. 23, 2024. **Global Montreal**

Montreal's fire department goes door to door after a fire involving lithium batteries at the Port of Montreal on Sept. 23, 2024. **Global News**

- The last photo reveals a hint of the concern felt by citizens when firefighters outfitted in full bunker suits and SCBA visited their homes to advise citizens to shelter or evacuate due to toxic fumes in the air they were breathing.

- September 2024, lithium-ion battery fire at SDG&E facility in Escondido (30 MW, 150 MWh) prompted evacuations of more than 500 businesses and 1,500 SDG&E customer homes, according to the electricity agency.

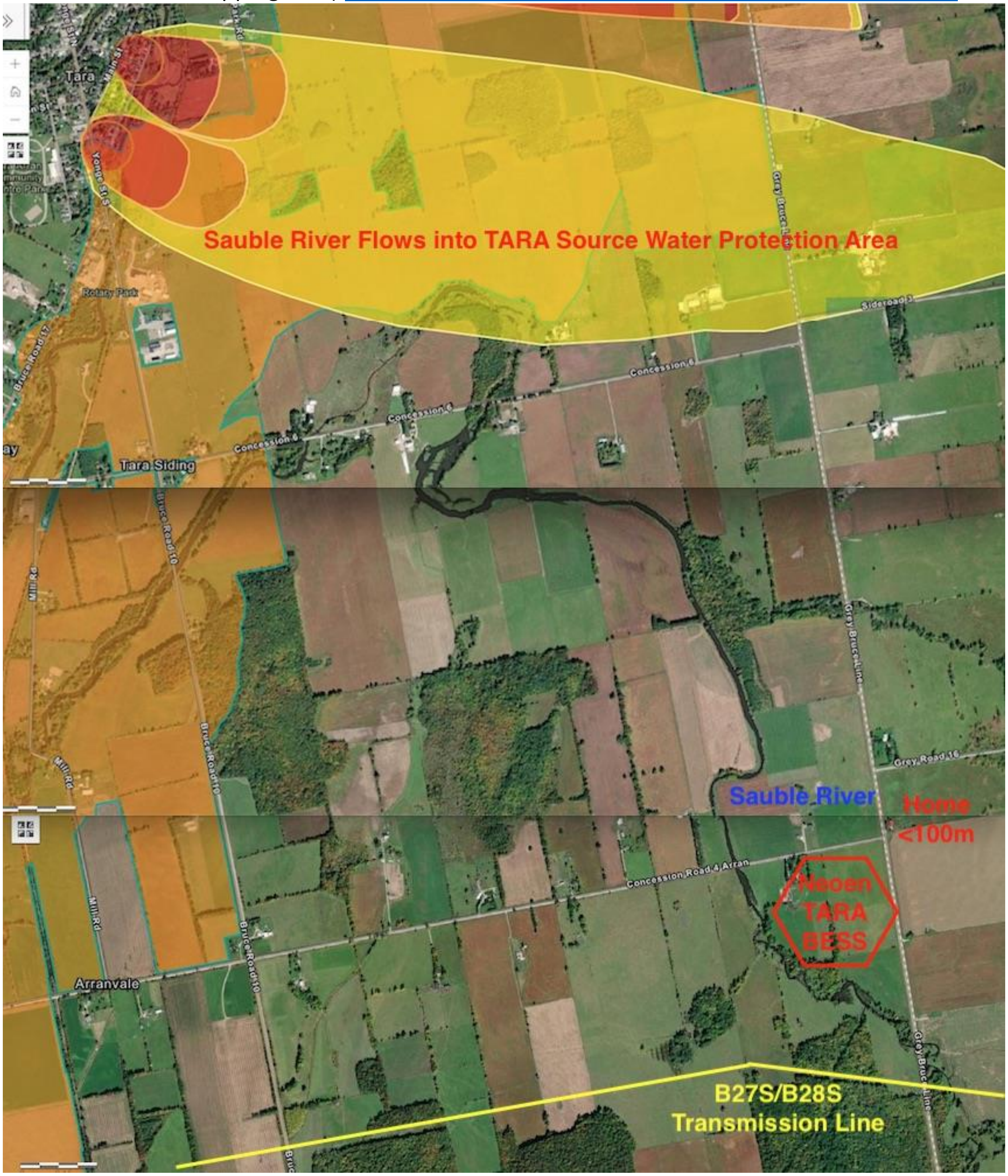
A fire burns at a SDG&E lithium-ion battery facility in Escondido, prompting evacuations, Sept. 5, 2024.



Residents in the pink highlighted area are under a mandatory evacuation order, while those in the purple area have been ordered to shelter in place.

- September 2023, as a result of a fire at the Valley Energy Storage Facility near San Diego, CA, fire officials evacuated citizens within one-quarter of a mile (400 metres) of the facility, and for those within one-quarter to one-half of a mile (800 metres) shelter in place orders were issued.

Neither does the handbook does not consider toxic liquid effluent from firefighting. Here is the NEOEN Tara BESS site (Composite Map from Drinking Water Source Protection Water - Vulnerable Areas Mapping Tool) https://home.waterprotection.ca/interactive-map-viewer/



The approved site for the Neoen TARA BESS is less than 100 m from an offsite home, and water from firefighting will drain directly into the Sauble River, upstream of a source water protected area. The site where the BESS containers will locate grew soybeans this year as an active farm.

Additional Resources and References are identified in Attachment 3 providing links and highlights from a number of relevant current publications that identify why including additional information related to hazards to firefighters and the public are required in the handbook, particularly related to toxic vapours emitted during Lithium battery fires, and to toxic effluents in the runoff water used to fight battery fires.

The handbook description of “Hazards” on Page 29 listing only “Thermal Runaway” is inadequate, as outlined in the description of Toxic gas hazards both to the firefighters and to the public. Consideration of the BESS site location, relative to neighbours, and considerations for immediate protection of downwind neighbours is an immediate concern. The recent examples shown identify evacuation of neighbours at distances in the order of 500 metres, and shelter in place for downwind neighbours, and livestock within distances in the order of 1.75 km have been used. Given that shelter in place with ventilation turned off is often not possible for livestock suggests that location of BESS installations needs to be controlled.

Neither does the handbook mention that the current design for BESS containers includes pressure relief panels. These help the containers themselves to not burst with pressure from emitted gases from the lithium ion batteries undergoing thermal runaway that usually occurs just before fire initiation. While protecting the container structure, the pressure relief panels permit immediate, unprotected release of the toxic gases to the atmosphere to impact the public, before any protective action is possible to ensure evacuation or sheltering in place.

The handbook identifies on Page 29 that “Water is considered the preferred agent for suppressing lithium-ion battery fires.” Literature based on actual Lithium-ion battery fires gives alternative opinions regarding this subject. There is general agreement that use of water to cool battery modules surrounding the module on fire may prevent the surrounding modules from heating up to also proceed to thermal runaway and fire. However, the literature identifies that in some cases, the preferred option was to permit modules actually on fire to “burn themselves out,” as adding water only extends the duration of the fire and toxic gas emission, while not actually reducing the quantity of toxic gas actually emitted. The literature also gives numerous examples of lithium battery fires which have reignited hours or even days after initially suppressed, if the battery was not fully consumed, as the fire is a result of a chemical reaction. This hazard needs to be more fully discussed in the handbook to prepare firefighters of the possibility. Both the “Best practice” of allowing a lithium battery to burn out, and the possibility of re-ignition risk are discussed in the findings of the Australian EV FireSafe study.

Literature also cautions about the consequence of lithium ion batteries that are immersed in salt water entering thermal runaway at time periods ranging from hours to weeks after the immersion. One of the referenced papers in Attachment 3 from the International Association of Fire and Rescue Services website describes that 11 EV’s and 48 lithium batteries caught fire hours or weeks after salt water wetting. The handbook does include on Page 30, under the heading BESS Tactical Considerations, that “Water from drafting or wells maybe more conductive especially if from winter roadway run-off due to contaminants, including those dissolved in water.” As water used to suppress fires in rural settings such as the Tara BESS, would be in all likelihood be derived from drafting from sources near roadways, subject to winter road salt runoff, the risk of subsequent fires in batteries not involved in the initial fire, but cooled with the drafted water needs to be expanded on in the handbook.

Although deficiencies in the handbook on Pages 29 (BESS Fire Safety Considerations) and Page 30 (BESS Tactical Considerations) have been discussed at some length, other conflicts in the material presented are also apparent.

- Page 29 identifies Suppressing Agent Choice (a subject already addressed for Lithium-ion batteries, which identifies "Water is considered the preferred agent"), while Page 30 notes, "Type of extinguishing agent – CO2 best or other inert gas, water, or dry chemical." This conflict needs to be addressed.
- Page 30 identifies, "DO NOT use foam unless electrical hazards are removed" while the literature identifies various agents, such as F-500 EA (described as an "encapsulation agent" as opposed to "foam"), added to water to enhance fire suppression. This potential item of confusion should be addressed.

In Summary:

- The "Solar Electricity and Battery Storage Systems Safety Handbook for Firefighters" does not adequately prepare firefighters for potential hazards that may be met in emergency situations involving Battery Energy Storage Systems, particularly those involving Lithium batteries
- The handbook does not adequately identify that the comparative risk in systems with Lithium batteries (compared to Lead acid batteries) is increased due to significant increase in the stored energy density
- The handbook is inadequate in describing a Lithium BESS that might be encountered by a firefighter where many "racks" of batteries are assembled into a container, and then multiple (hundreds) of containers are collected on the same site.
- The handbook is inadequate in describing that while suppressing the fire in a lithium battery is challenging, it fails to identify that the bigger challenge is to prevent the progression of the fire from module to module, and container to container by cooling batteries not involved in the initial fire.
- The handbook is inadequate at describing protective measures necessary to protect the firefighter and surrounding public from toxic gases emitted from the fire
- The handbook is inadequate at describing the hazard caused by runoff of contaminated fire protective water used to cool adjacent modules, or to suppress the active fire in modules, when that runoff water enters the environment
- The handbook is inadequate at even considering what might be identified as best practices regarding letting a battery on fire to burn itself out, while preventing fire progression to surrounding modules.
- The handbook is inadequate at describing the risk to later failure of lithium batteries if cooled with water containing contaminants, such as road salt.
- The handbook should consider additional resources and references identified in Attachment 3