

Hawai'i Chemical Safety Days 2022

Responding to Battery Fires

Fires Related to Lithium Ion

- Surprise Arizona, ESS Installation April 2019
- Lime Scooter warehouse fire October 2019
- An explosion occurred as firefighters were dealing with a fire in a 25 MWh lithium-iron phosphate battery associated with a 1.4 MW rooftop array at a shopping mall April 2021
- Morris, IL, June 2021 Warehouse Fire of New Batteries
- Remi Miguel Gomez-Hernandez Killed When E-Scooter Battery Catches Fire Inside Queens Home, New York September 2021



Recent lithium-ion battery incidents

Over the last year, there have been several major lithium-ion battery ESS incidents.

- September 15, 2020 — Liverpool (20 MW)
- December 1, 2020 — France
- June 19 2021 Morris IL Storage of batteries in warehouse
- April 6, 2021 — South Korea
- April 16, 2021 — Beijing (25 MWh)*

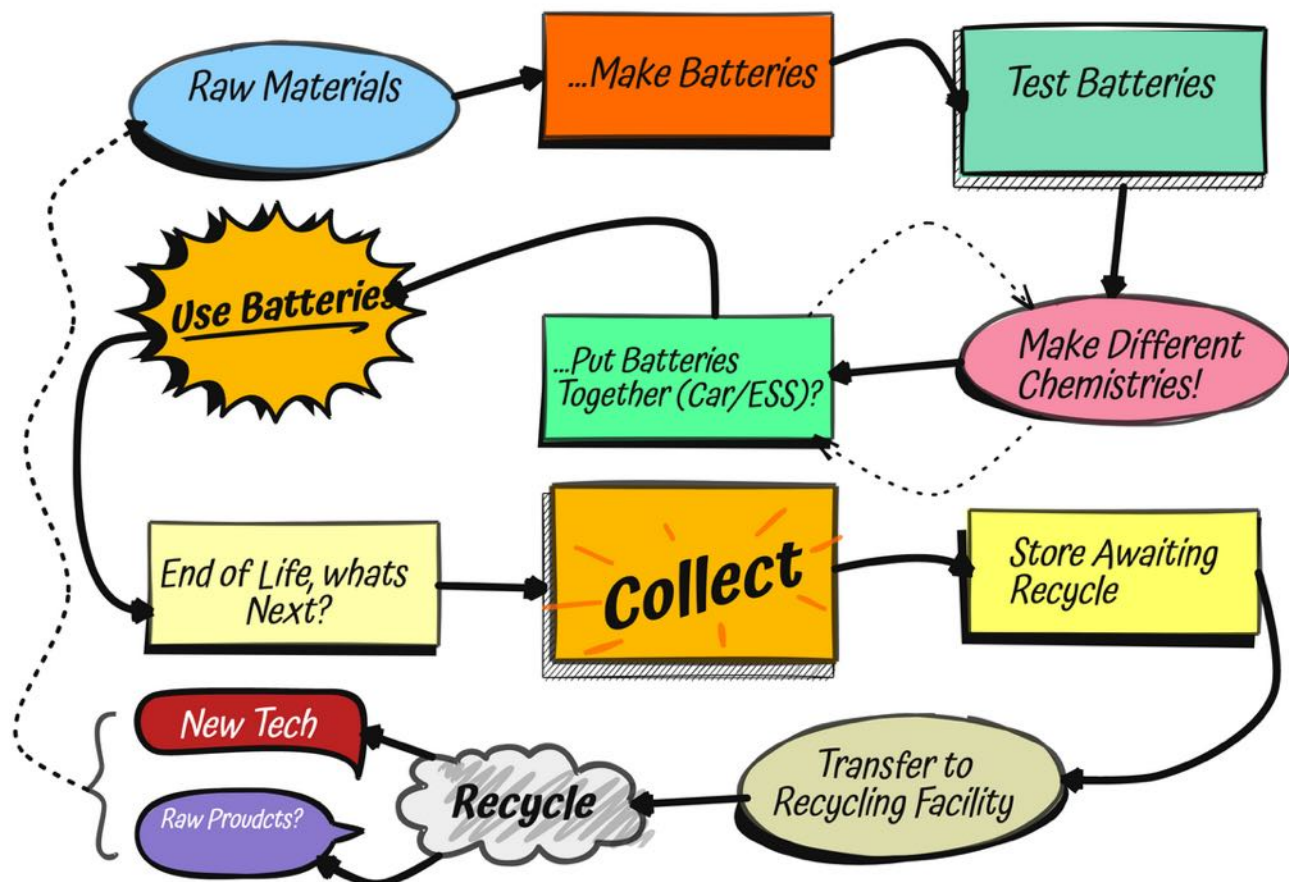
*Two firefighters died in suppression efforts.

Battery Fires

- Brighton MI, 2020 Semi Trailer Carrying batteries head to recycling center
- Victorian Big Battery in Australia, A single pre-manufactured 3MWh Megapack unit caught fire on 30 July 2021, spreading to a neighbouring Megapack. The spread stopped there and the fire burned itself out over a six hour period.
- Moss Landing Scorched Rack September 4, 2021
- Moss Landing (CA) February 13, 2022
- Felicity Ace off the coast of Portugal's Azores islands, February 2022
- Storey County ESS Fire 2022, Utility Grid installation
- Storey County 2022, Outside battery recycling, storage fire
- Chandler AZ, April 18 2022, ESS Battery Building, 3 week incident
- Honolulu HI, May 3, 2022 Recycling facility



Cycle Of Batteries!





Not All Batteries Create Fire

- **What is the fire department use of batteries**
 - **New apparatus**
 - **Vehicles**
 - **Extrication Equipment**
 - **Lighting**
 - **Portable Equipment**
 - **Backup power at our Fire Stations**

Battery Stuff

- Discuss lessons learned in battery response
- ESS Battery systems
- Battery Manufacture
- Battery Storage
- Recycling of Batteries
- Transport Between

Batteries have been around a long time

So what is going on with lithium ion?

- Evolving technologies and uses
- Respect for the listing and the use
- High energy capacity

Making the Batteries

- Dust
- Ovens
- Testing
- Storage
- Raw to Finished Materials
- What is the State of Charge?
- What are the Codes doing to protect firefighters?
- What is our response plan?



SCAN ME



EV Response

- Joint meeting with SHS/FLSS
- Discussion on training/SOP
- When to let it burn
- Post incident



Fire Department Response to Electrical Vehicle Fires

Adapting our response plans through training, research, and experience is critical in the Fire Service. As sales of Electric and Hybrid vehicles increase, the fire service must continue to modify our tactics to properly respond and protect our firefighters. Fighting vehicle fires is inherently dangerous. When responding to a Electric or Hybrid vehicle fire there are additional challenges responding crews must consider.

Additional response-specific information can be found on most automobile manufacture web pages. [NFPA Quick Vehicle Response Guide](#)

Pre-Incident

Modify or establish your department policy or standard response guideline to vehicle fires and ensure it includes practices for electrical vehicle fires. Include guidelines for limited interaction and when crews should allow the vehicle to burn.

When working on roadways protect the work area per department policy. Staff should consider that this may include a vehicle fire or extrication. Staff operating on roadways should anticipate possibly longer timeframes to manage/control EV vehicle fires and maintain heightened situational awareness.

NFPA has a full series of documents on various EV safety response (including emergency response guides by manufacturer).

Review response and post incident procedures with law enforcement and towing companies.

Batteries that have been or are suspected of damage or otherwise compromised, but have not caught fire, need to be monitored for thermal runaway.

Train on department policy and perform practical scenarios which support the response plan



INCIDENT ACTIONS

When arriving on scene, the first arriving company should perform a proper size up. This includes the extent of the fire and if it is a compartment fire or includes the electric components of the car. Similar to other vehicle fires, is the "engine" compartment or the passenger compartment on fire? The best method for managing or controlling a battery fire is with water. Battery fires will initially show from under the vehicle.

- Protect your work area through established department policy and establish tactical priorities (fire, extrication, victim care) and ensure the vehicle is in park and off, if possible.
- Wear full PPE with SCBA with face-piece and establish an appropriate command structure.
- Consideration and tactics may be categorized in offensive or defensive mode. This may be based on exposures and the extent of fire which may include actions to let the vehicle burn. Use a thermal imaging camera to help with the 360 size-up
- Secure a large, continuous and sustainable water supply from one or more fire hydrants or multiple water tenders (3,000-8,000 gallons)
- Where safe, consider chocking the wheels. EVs move silently, so never assume it is powered off. Never assume that an EV will not move.
- Extinguish small fires that do not involve the high voltage battery using typical vehicle firefighting procedures
- When attacking the vehicle fire, understanding that once the contents of the fire are extinguished, sustained suppression on the battery pack may be necessary. Use a large volume of water such as multiple 1 1/2-inch hand-lines to suppress and cool the fire and the battery. Put water on the burning surfaces
- Have sufficient fire personnel and apparatus on scene for an extended operation to monitor the battery's heat or possible secondary ignition. The heat from the fire may have damaged additional cells, which may require additional suppression activities.
- Batteries should always be treated as energized. During overhaul do not make contact with any high voltage components.

Post Incident

Brief the towing company and their personnel on the hazards, including providing 50' clear space around the vehicle once stored and never inside a building. An engine company may need to escort the vehicle to the recovery location.

Batteries should always be treated as energized and pose an ongoing risk to the investigator. Follow NFPA 921 protocol for vehicle safety during post-response investigation, arson investigation, and vehicle investigation.

Thermal events with the battery system could continue for some time after the initial incident. Establish response protocol for secondary fires.



Pre Response

- Training for First Responders
- General understanding
- Burn or not burn
- Extinguishing methods
- Vehicle Extrication resources



Let it Burn or Water

- Entrapment
- Compartment vs battery pack
- Exposures
- Limited involvement
- Charger shutdown
- Vehicle from roll away





Post Incident

- Storage for Police
- Inside or outside
- Fire or just an accident
- Discussion with towing yards
- Recycle?

ESS DRAFT position Response

- Difficulty due to complexity of events
- Utility support vs residential
- Understanding technical response from manufacture
- Safety to first responders



Recommended Fire Department Response to Energy Storage Systems (ESS) Part 1

Events involving ESS Systems with Lithium-ion batteries can be extremely dangerous. All fire crews must follow department policy and train all staff on response to incidents involving ESS. Compromised lithium-ion batteries can produce significant amounts of flammable gases with potential risk of deflagration and fire.

1. If a commercial or utility install, follow pre-plan and **do not** enter structure.
2. Residential setting response, control power to the unit, ventilate the area, and protect exposures.
3. In all cases contact manufacture technical support as soon as possible.

This guide serves as a resource for emergency responders with regards to safety surrounding lithium ion Energy Storage Systems (ESS). Each manufacturer has specific response guidelines that should be made available to first responders prior to activation.

ESS systems come in many shapes and sizes. They may be affiliated with renewable systems (wind, photovoltaic systems, etc) or used as standby power. ESS Systems can be installed in single family homes too large commercial and utility applications.

Pre-Incident

Modify or establish your department policy or standard response guideline to ESS incidents. Include guidelines for mitigation of the event which may include a defensive operations such as non-intervention and manage fire propagation or protect exposures.

Review installation procedures for systems with the various code officials including Building, Fire, and Electrical

ESS systems must be installed per the adopted fire and building codes in the region.

For the 2015 editions of the International Fire Code and NFPA 1 Fire Code and earlier editions the necessary safety requirements are not present (Consider language in 2021 Fire Codes or NFPA 855).

Ensure pre-incident plans are covering location, type, disconnect, and other contact information

Pre-incident plans should provide rapid response resources for company officers specific to your area and region including OEM emergency contact information

Train on department policy and perform practical scenarios which support the response plan

INCIDENT ACTIONS

The fire crew should allow the battery to burn itself out, during which it is recommended to apply water spray to neighboring battery enclosures and exposures to further mitigate the spread of the hazards rather than directly onto the burning unit.

Applying water directly to the affected enclosure will not stop the thermal runaway event, as the fire will be located behind several layers of steel material, and direct application of water has shown to only delay the eventual combustion of the entire unit.

- Firefighters must wear full personal protective equipment, including SCBA with face-piece.
- If identified in pre-incident plan, shut off the unit/system by operating any visible disconnects or E-stops (shutting off the disconnect does not remove the energy from the battery). To isolate any PV system and ESS in an emergency, multiple disconnects may need to be shut off. This could include circuit breakers, knife-blade disconnects, or other switches.
- Lithium ion batteries that are in thermal runaway or off gassing will create hazardous atmospheres. Firefighters must stay out of the vapor cloud and not rely on gas monitors (without consideration of cross contamination of the gas sensors)
- Due to construction of the unit, thermal imaging cameras may not give true thermal conditions.

Events can occur from damage, exterior fire, or a malfunction. Smoke or suspicious odor from an ESS system can be an indication of a hazardous condition. When batteries or cells enter thermal runaway, there is typically a period of smoke (may be under pressure). The smoke is most likely flammable and may ignite at any time.

Responding to a venting ESS product

- **Evacuate the area. Never open any doors or remove panels to ESS units.**
- Contact vendor-specific technical support for assistance including BMS data.
- Residential units that are located inside a dwelling unit or garage, the space should be properly ventilated with charged hand-lines in place.
- Maintain a safe distance from the ESS and monitor. A remote FDC may be present on larger commercial or utility ESS to support a sprinkler system inside the enclosure.
- Each manufacturer will have a recommended time for a battery pack to cool down. This can be near a full work cycle of 12 hours or more.
- **Defensive Firefighting.** Water spray is the preferred agent for response to lithium-ion battery fires (Lithium-ion is not water reactive).
 - If a fire has not developed and only smoke is visible, take a defensive stance toward the system and be prepared to apply water spray.
 - If a fire develops, take a defensive stance toward the burning unit and apply water spray to neighboring battery enclosures and exposures.
- Maintaining a safe distance from the unit involved (large commercial systems, at least 300').
- Response crews should allow the battery to burn out. Water should be applied to adjacent battery enclosures and exposures (building).





Energy Storage Response


- Quality plan check and installation
- Work with code officials on what is right and where they go
- Pre 2015 standards do not meet industry safe guards
- Pre-plan, training of our first responders
- Isolate
 - Turning off power to the unit may not be the answer
- Protect Exposures
- Contact Technical Support of unit
- Long term incident

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4 In Case of Emergency

 **WARNING:** In case of emergency, severe physical impact, or transportation accident, do not approach the product or open any of its doors.

 **WARNING:** In case of severe physical impact or transportation accident, it may take time before any visible indication of an abnormal and hazardous condition (e.g. smoke or fire) can be observed. Contact Tesla Energy Technical Support for guidance (*Identification of Company and Contact Information on page 4*).

 **CAUTION:** Response should only be performed by trained professionals.

4.1 During Storage or Operation

During storage or operation, cases of emergency include but are not limited to:

- Suspicious odor observed near a Tesla Energy Product
- Smoke or fire emanating from a Tesla Energy Product
- Severe physical impact on a Tesla Energy Product

In case of emergency, the following should be performed:

1. If possible, shut off the unit/system (see *Shutting Down in an Emergency on page 25*).
2. Evacuate the area.
3. If not already present, notify appropriately trained first responders, the local fire department, and any appointed subject matter expert (SME) if available.
4. Contact Tesla Energy Technical Support for guidance (*Identification of Company and Contact Information on page 4*).



5 Firefighting Measures

WARNING: Response should only be performed by trained professionals. In the event of a response to a Tesla product fire or hazardous event, contact Tesla Energy Technical Support for guidance (*Identification of Company and Contact Information on page 4*).

5.1 Responding to a Venting Tesla Energy Product

Smoke or suspicious odor emanating from a Tesla Energy Product can be an indication of an abnormal and hazardous condition. Battery thermal runaway fires are preceded by a period of smoke. The smoke is likely flammable and may ignite at any time. If fire, smoke, or suspicious odor is observed emanating from a Tesla Energy Product at any time, the following should be performed:

1. If possible, **shut off the unit/system** (see *Shutting Down in an Emergency on page 25*).
2. **Evacuate the area.**

WARNING: When responding to a fire event with the **Powerpack System**, do not approach the Powerpack units from the front (door-side) or the rear. Perform all incident response from the sides of the units. Do not attempt to open the enclosure doors or come in contact with the units.

WARNING: When responding to a fire event with **Megapack**, do not approach the unit and attempt to open any doors. The doors are designed to remain shut, and built-in deflagration vents in the roof of the unit will vent any smoke and flame out of the top of the unit and front thermal system intake louvers.

3. If not already done, **contact Tesla Energy Technical Support** for assistance (*Identification of Company and Contact Information on page 4*).
4. **Maintain a safe distance from the unit and monitor** (*Defensive Firefighting on page 24*) for evidence of continued smoke venting or fire.

WARNING: There may be periods of up to three hours at a time during which the thermal runaway propagates from battery modules to battery modules. During such time, the battery may not generate visible signs of thermal event although the event can still be active and the battery can flare up.

- a. **If a fire has not developed** and only smoke is visible, take a defensive stance toward the system and be prepared to apply water spray to **neighboring exposures and neighboring battery enclosures**.
 - b. **If a fire develops:**
 - **Continue to take a defensive stance toward the burning unit.** Applying water to the burning unit will only slow its eventual combustion (see *Defensive Firefighting on page 24*).
 - **If advised by Tesla, apply water to neighboring battery enclosures.** If communication cannot be established with Tesla, apply water at the discretion of first responders.
 - **At the discretion of first responders, apply water to other neighboring exposures.**
5. **Allow the battery pack to cool down** for a minimum of 12 hours after all fire and smoke has visibly subsided.



6. **Monitor the temperature** of the battery pack using a thermal imaging camera to determine if it is safe to interact with the unit.
7. **Contact Tesla Energy Technical Support** for next steps (*Identification of Company and Contact Information on page 4*).

5.2 Defensive Firefighting

Tesla's recommendation is to fight a Tesla Energy Product fire defensively. The fire crew should maintain a safe distance in any direction of, at least:

- 5 m from Powerwall
- 10 m from Powerpack
- 20 m from Megapack

WARNING: Depending on the conditions of the event (such as location of the burning battery, wind speed and direction) a safe distance may be higher than those prescribed above.

As outlined in the procedure above, **the fire crew should allow the battery to burn itself out.** To further mitigate the spread of the hazards, Tesla may recommend the application of water spray to neighboring battery enclosures, and first responders may apply water spray to neighboring exposures. **Applying water directly to the affected enclosure will not stop the thermal runaway event, as the fire will be located behind several layers of steel material, and direct application of water has shown to only delay the eventual combustion of the entire unit.**

WARNING: In confined spaces, if water is used directly on the enclosure that is burning, electrolysis of water (splitting of water into hydrogen and oxygen) may contribute to the flammable gas mixture formed by venting cells, burning plastic, and burning of other combustibles.

Water spray has been deemed safe as an agent for use on exposed Tesla Energy Products. Water is considered the preferred agent for managing lithium-ion battery fires. Gaseous agents such as CO₂, Halon, or dry chemical suppressants may temporarily suppress flaming of lithium-ion battery packs, but they will not cool lithium-ion batteries and will not limit the propagation of cell thermal runaway reactions. Metal fire suppressants such as LITH-X, graphite powder, or copper powder are not appropriate agents for suppressing fires involving lithium-ion battery packs as they are unlikely to be effective.

A battery fire may continue for several hours and it may take 24 hours or longer for the battery pack to cool after it has been fully consumed by a thermal runaway event. After all fire and smoke has visibly subsided for at least 12 hours, a thermal imaging camera can be used to actively measure the temperature of the unit and determine if it is safe to interact with.

5.3 Firefighter PPE

Firefighters should wear self-contained breathing apparatus (SCBA) and fire-protective turnout gear. Regulatory testing has shown that the products of combustion of Tesla Energy Products can include flammable and nonflammable gases. Based on those regulatory tests, the flammable gases were found to be below their lower flammable limit (LFL) and would not pose a deflagration or explosion risk to first responders or the general public. The nonflammable gases were found to be comparable to the smoke encountered in a typical Class A structure fire and do not contain any unique, or atypical, gases beyond what you would find in the combustion of modern combustible materials.



6 Shutting Down in an Emergency

WARNING: Shutting off power to a Tesla Energy Product does not de-energize the battery, and a shock hazard may still be present.

WARNING: If smoke or fire is visible, do not approach the product or open any of its doors.

WARNING: In case of flooding, stay out of the water if any part of the Tesla Energy Product or wiring is submerged.

To shut off the Powerpack System, Megapack, or Powerwall in an emergency, perform the appropriate steps and then contact Tesla (*Identification of Company and Contact Information on page 4*).

6.1 Powerpack System

1. If an external emergency stop (E-Stop) button or remote shutdown contact to the Powerpack is present, engage it.
2. If the Powerpack is serviced upstream by an external AC breaker or disconnect, open the breaker or disconnect.

6.2 Megapack

1. If an external E-Stop button or remote shutdown contact to the Megapack is present, engage it.
2. If the Megapack is serviced upstream by an external AC breaker or disconnect, open the breaker or disconnect.



What is the Decommissioning Plan

Mobility Device Incidents

- Hoverboard incidents, non-listed products
- Vancouver, “Batteries leading cause of Fatal fires”
- New York City Incidents
- India and Scooter Related Issues



Tips from Training



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Revel E-Bike Battery Transport Vans

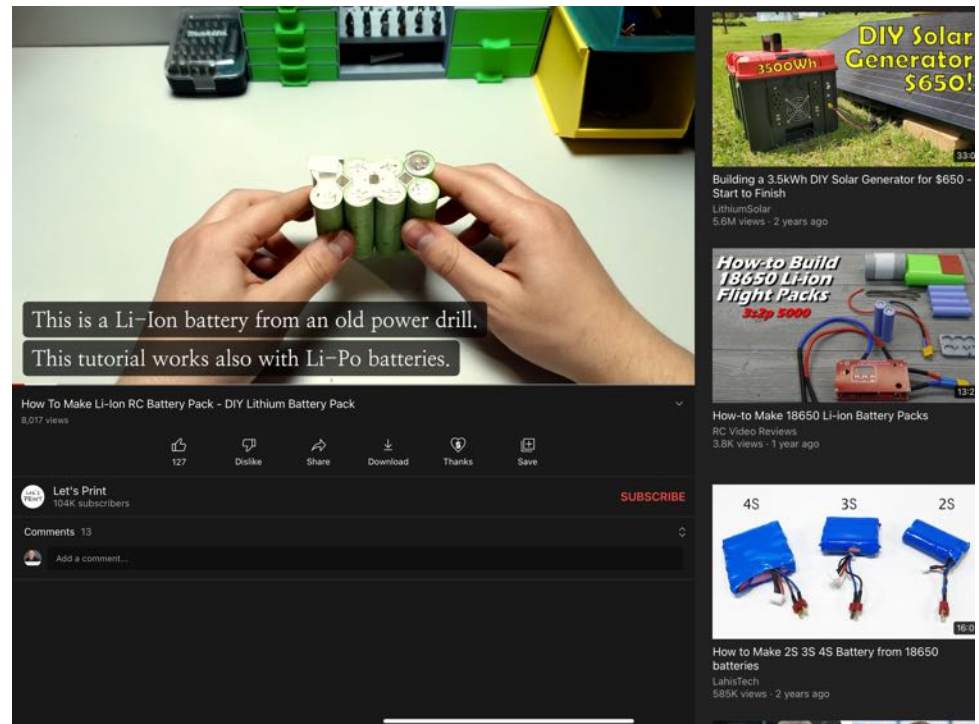


FDNY units recently encountered a Revel e-bike van transporting numerous lithium-ion batteries. According to the van's driver, this is one of approximately 15 vans citywide that drive around the city replacing batteries on these e-bikes when they are showing a low charge. The vans hold approximately 60 batteries. All members should recognize these vans and understand the dangers posed by lithium-ion batteries.

Tech companies **Lime, Bird and Veo** were picked for a pilot program involving 3,000 e-scooters for rental from selected sidewalks in the Bronx. It can be assumed that these companies have similar battery transport vans for the

Community Risk Reduction

- Educate home owners on listed equipment and using the right charger for consumer electronics and mobility devices
- Educate business owners on related business to mobility and charging of electrical equipment
- Utilize newest codes and standards on charging in commercial occupancies
- Educate on how to charge, where to charge and when to stop using a product



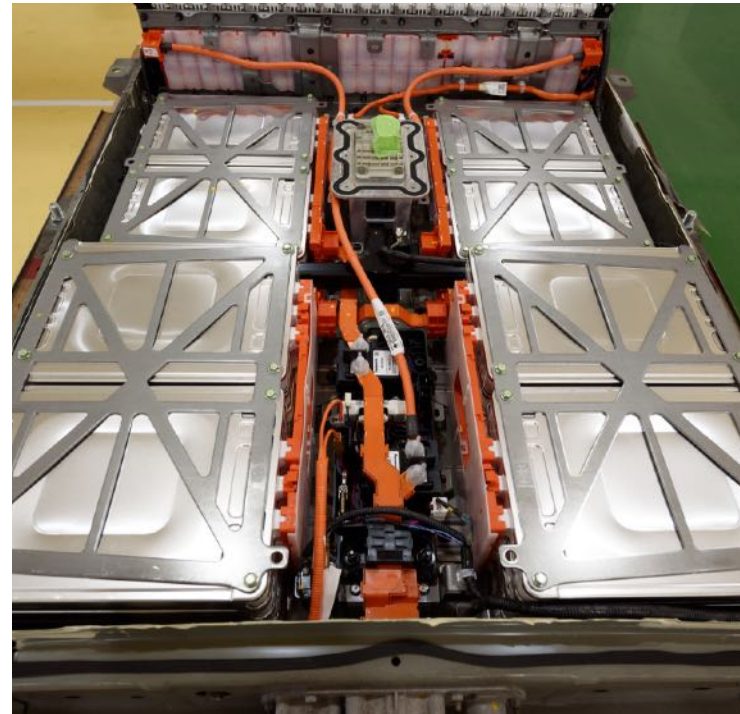






Battery Storage Best Practices

- New vs used batteries and State of Charge
- Only in buildings provided with automatic sprinkler systems
- Early notification, Utilization of new thermal detection, smoke sensing detectors
- Sort by chemistry, store used product outside. Caution on storage in buildings and product of off-gassing





Research Opportunities/Lessons Learned

- Used battery shipping/storage
- Code changes referenced the above
- Extinguishing methods
 - Special items F500/Blanket/Cell Block Etc.
- Others

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