Li-Ion Battery Response Considerations

Presented By:

Keith Glenn & Steve Simonetti — U.S. EPA Region 2 On-Scene Coordinators

Eddie Murphy — U.S. DOT-PHMSA


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DRAW DATE: THURSDAY, JAN 6

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Li-Ion Battery Response Considerations

OBJECTIVES & TOPICS

Basic Understanding & Principles of Li-Ion Batteries
Hazards and Risks
Types of Energy Storage
Different Chemistries
DDR and Misuse
Packaging, Disposal, Recycling
Fire Response Tactics
Air Monitoring
Other Considerations

Li-Ion Battery Response Considerations

COURSE OUTLINE

- Li-Ion Battery Awareness
- Waste Profile and Disposal
- Tactical Considerations
  - Micro-mobility
  - Electric Vehicle
  - Larger Scale
- Health and Safety
  - Air Monitoring
  - PPE
- Battery Burn (optional & outdoors)

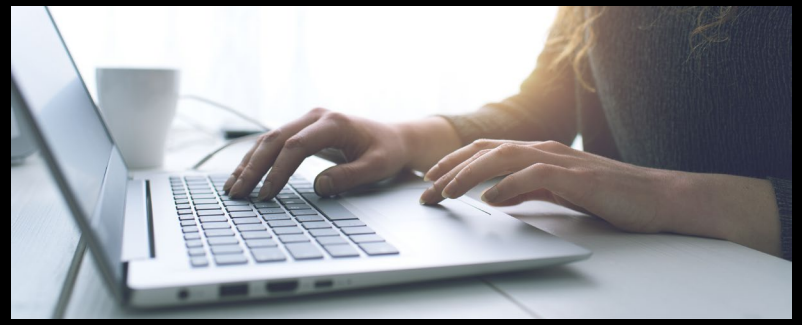
Li-Ion Battery Response Considerations

Module One: Awareness

Uses in the consumer marketplace
Trends in energy storage
Types of batteries
Chemistries
Hazards and risks

Li-Ion Battery Response Considerations

Communications



Li-Ion Battery Response Considerations

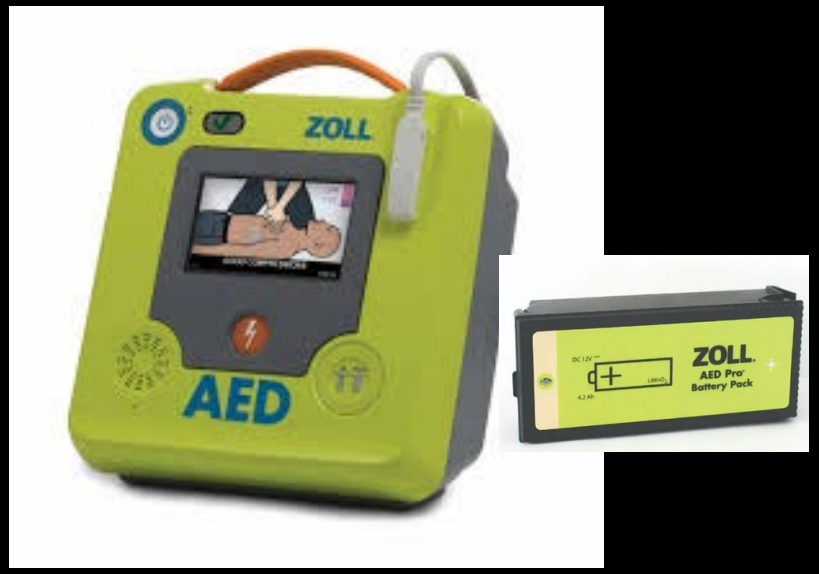
Transportation

Li-Ion Battery Response Considerations

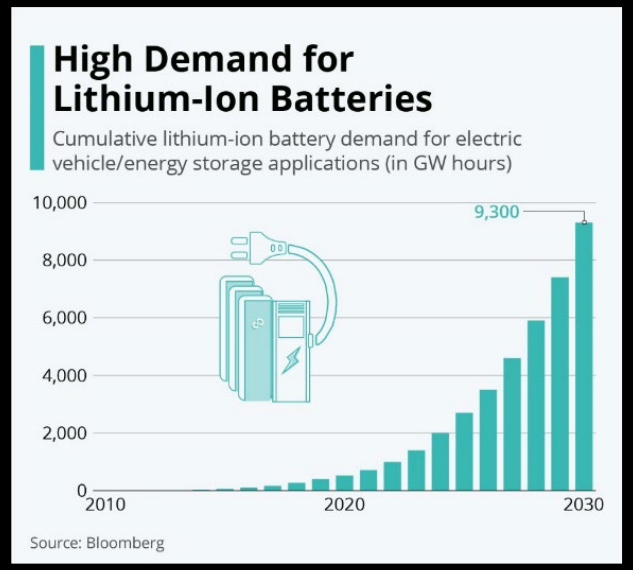
Energy Storage

Li-Ion Battery Response Considerations

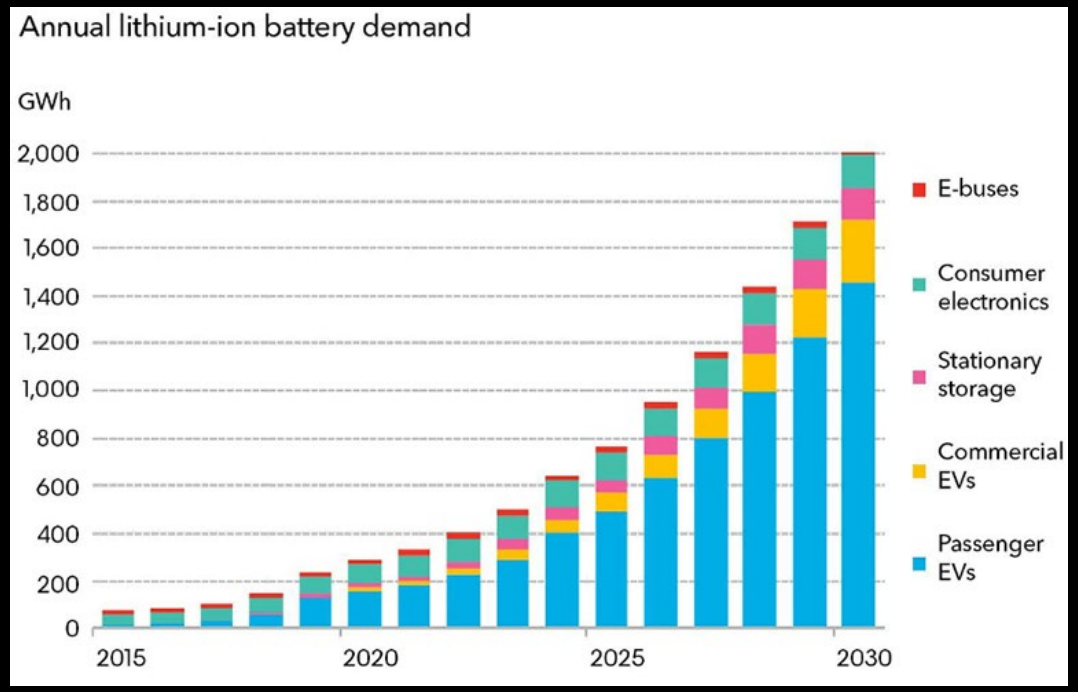
Household/Medical

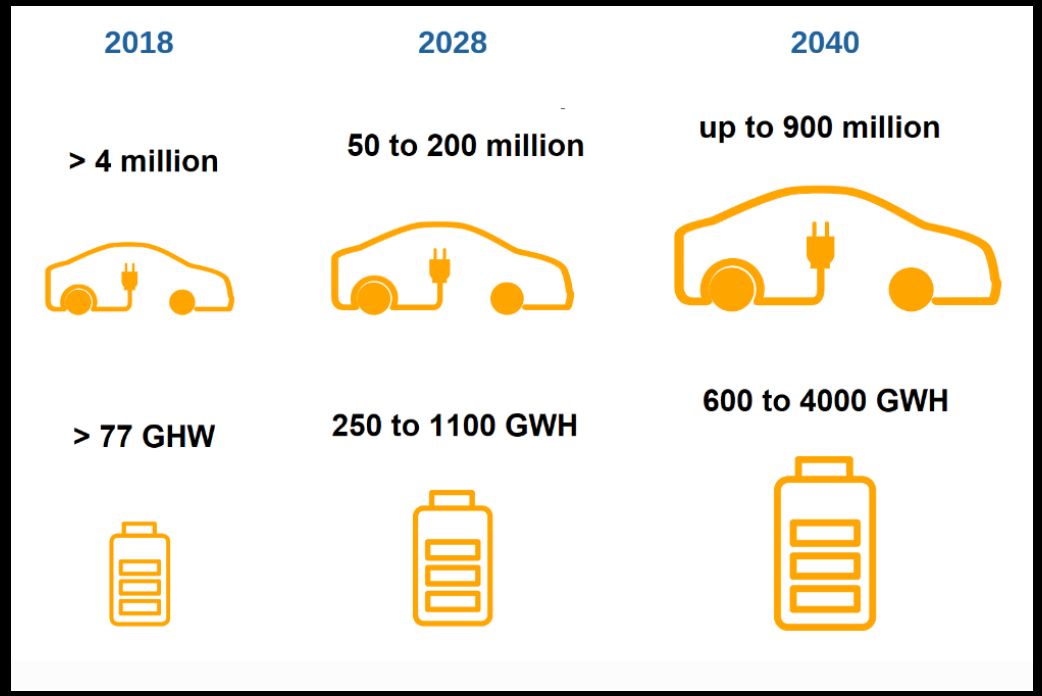


Trends in Li-Ion Batteries



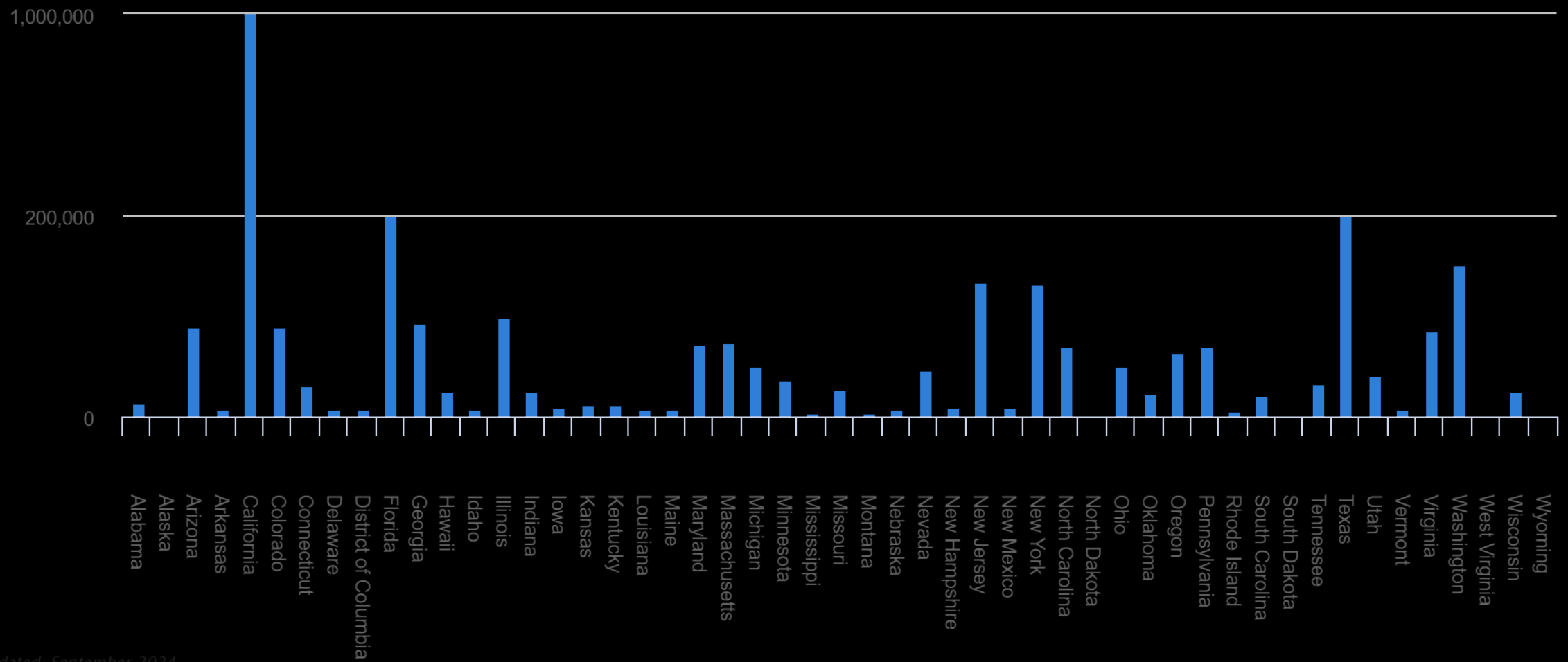
- Demand is increasing
- Energy density of batteries is increasing
  - Thermal runaway severity increases
- Production increasing
- Cost per kilowatt hour decreasing
- Products reaching “end of life” increasing





Trends in Li-Ion Batteries

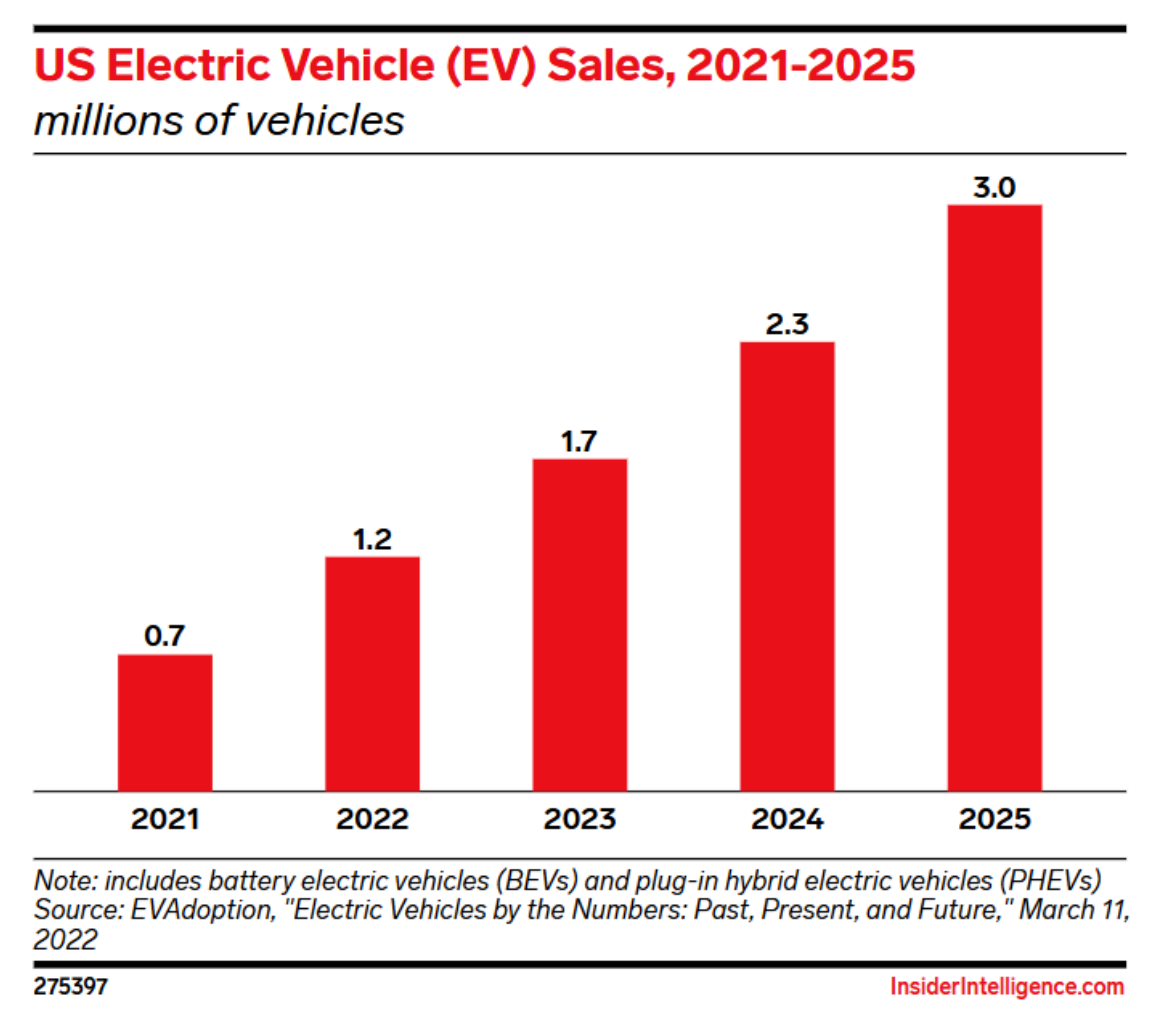
Electric Vehicle Registration – Sept. 2024

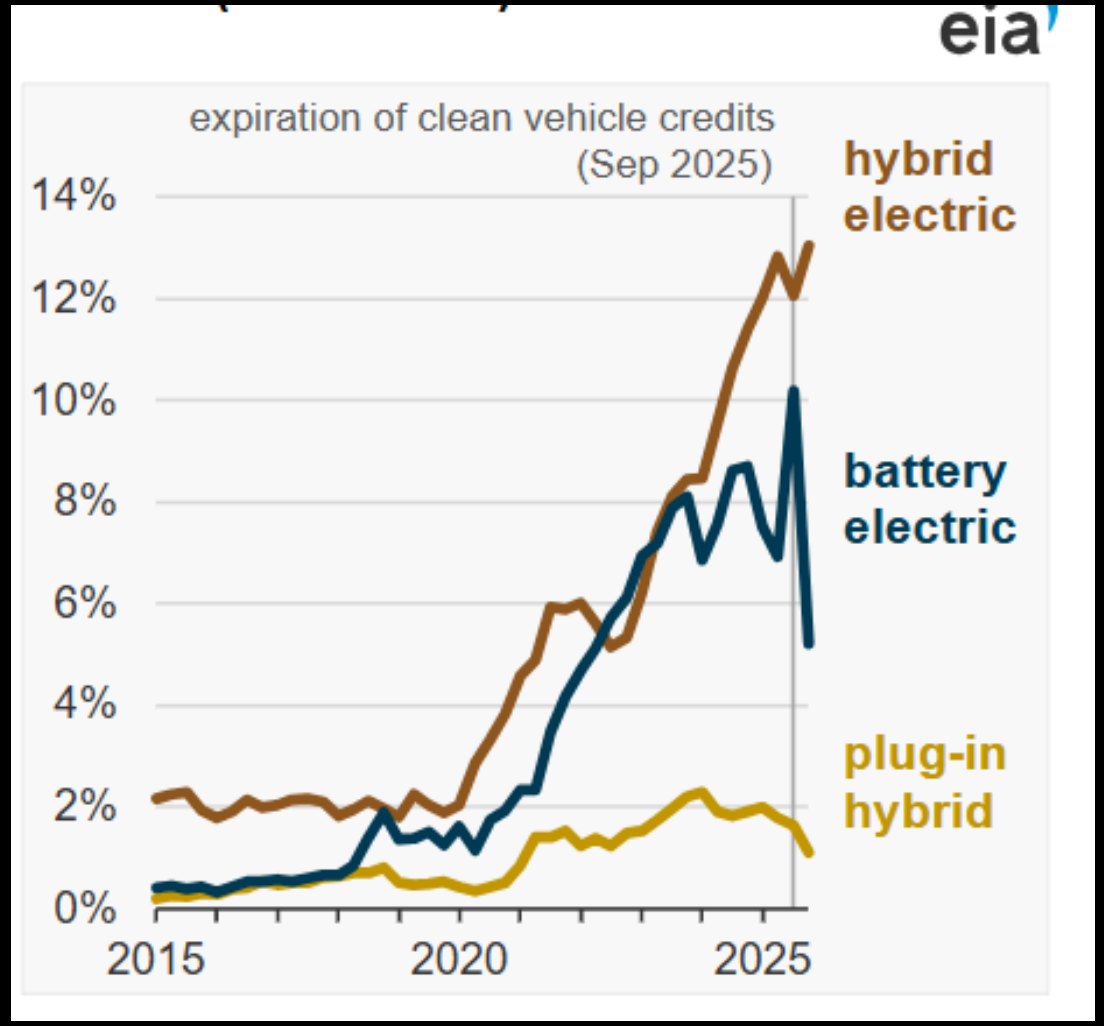


Last updated: September 2024
Printed on: April 29

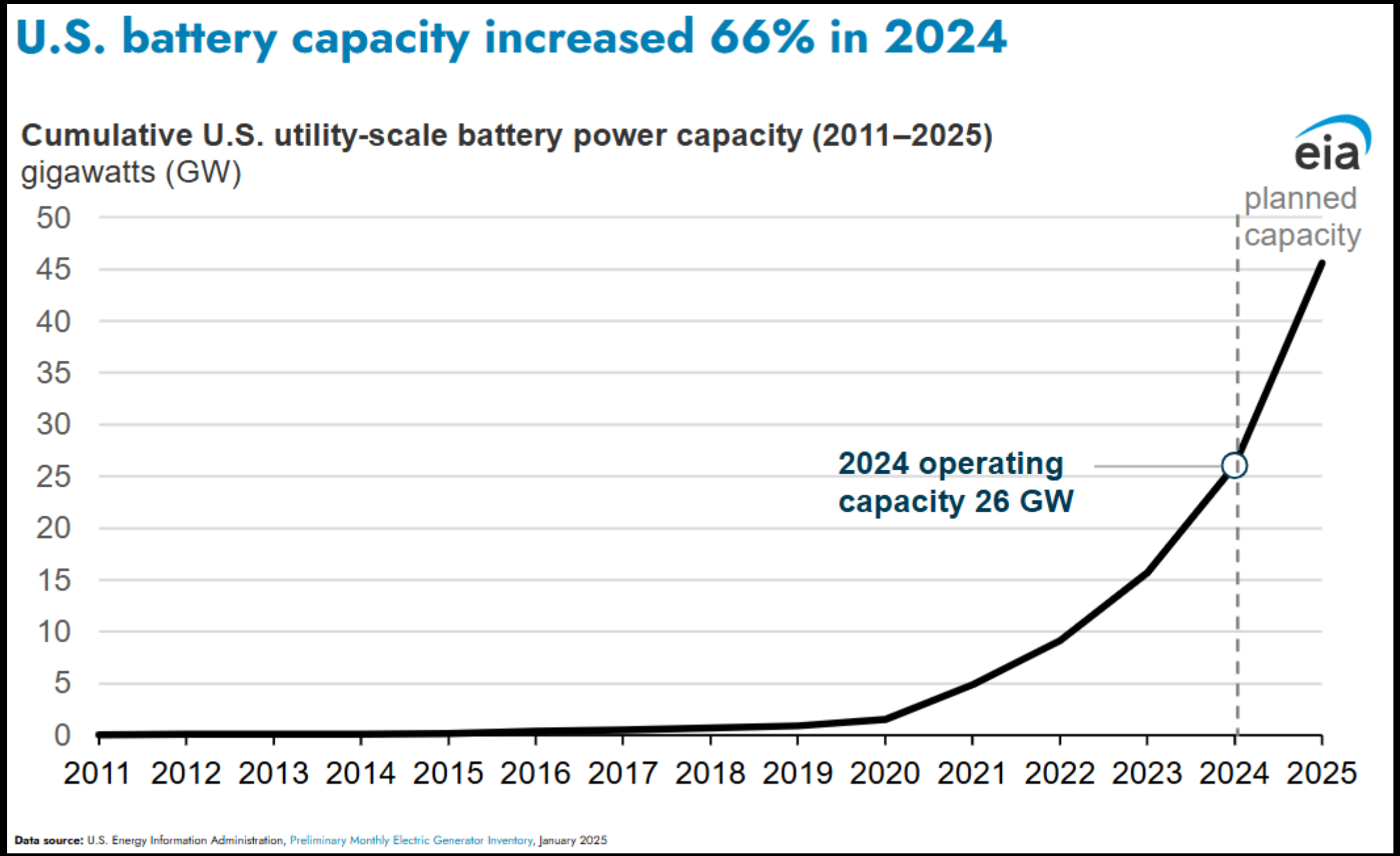
Trends in Li-Ion Batteries

Electric Vehicle Sales – CY 2025

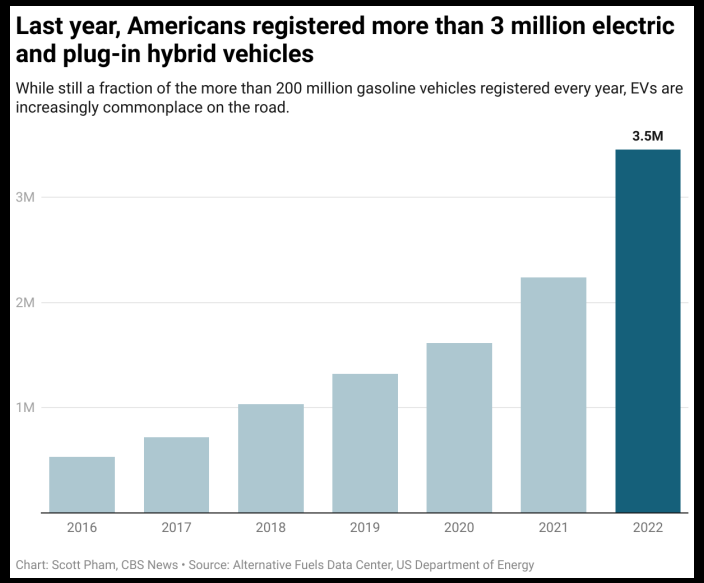


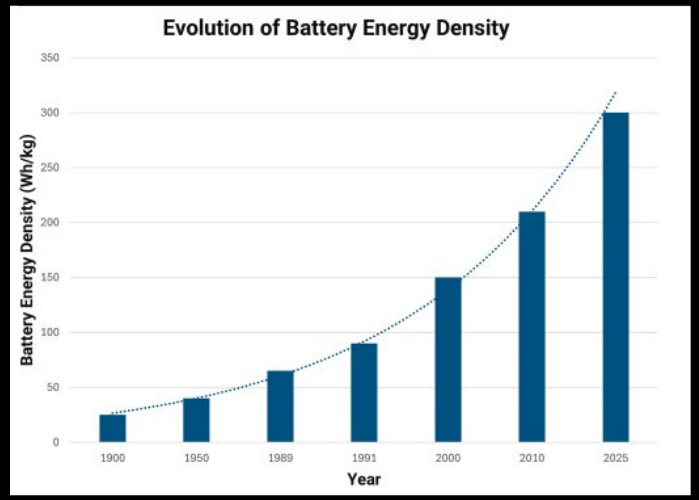


Trends in Li-Ion Batteries



Trends in Li-Ion Batteries





A Shifting Risk Profile for Lithium-Ion Batteries

- Increased availability and involvement
- Energy grid stabilization
- Higher energy density of product
- Phaseout gas-powered lawncare and generator
- Right-to-Repair Laws in numerous states
- Growth in Recycle/Reuse/Refurbish Market
- Growth & availability in off-market products
- Increase in micro-mobility (scooters/e-bikes) & energy storage


WARNING - FIRE and EXPLOSION RISK
These 18650 batteries sold on Amazon may be dangerous or deadly


DEWALT
20V XR 5 AH LITHIUM ION
DEWALT
VS
DEFAKE
ebay
20V XR 4 AH LITHIUM ION


Knockoff Battery Dangerous?
M18 REDLITHIUM
HIGH OUTPUT XC6.
18V LITHIUM ION
6.0Ah
$90
$22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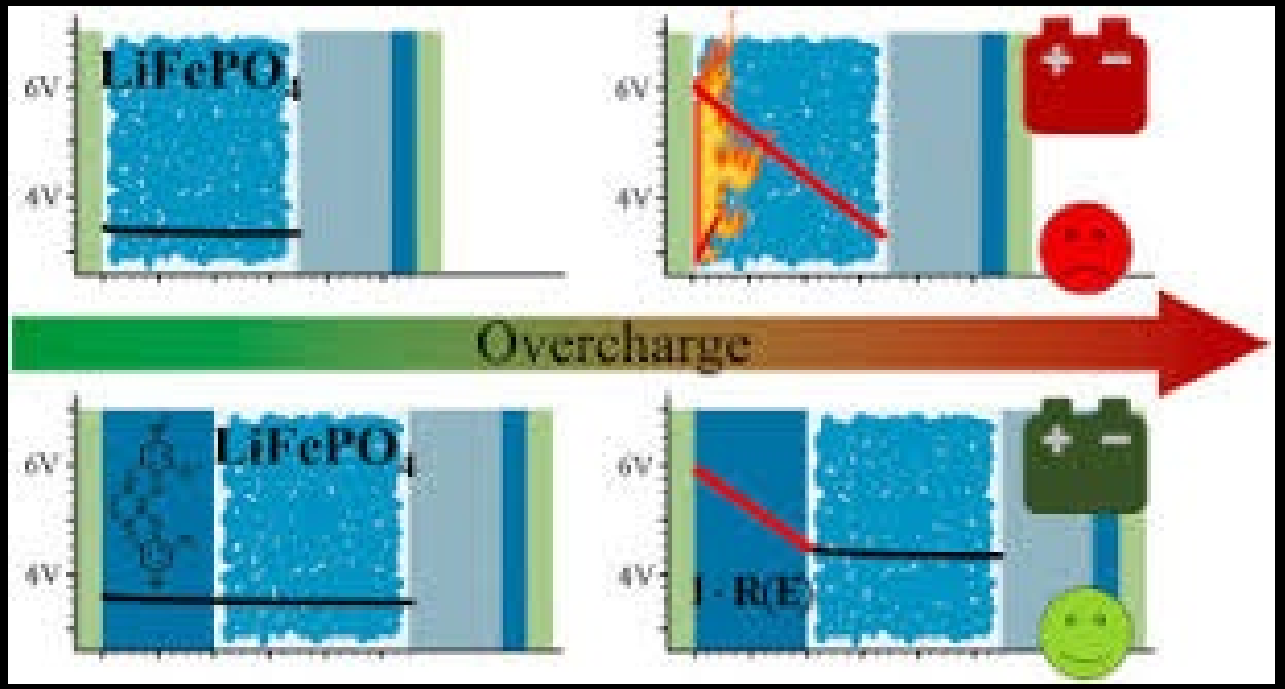
63,431%
BATTERY OVERCHARGING ACTIVE


6V
4V
LiFePO4
6V
4V
Overcharge
6V
4V
LiFePO4
6V
4V
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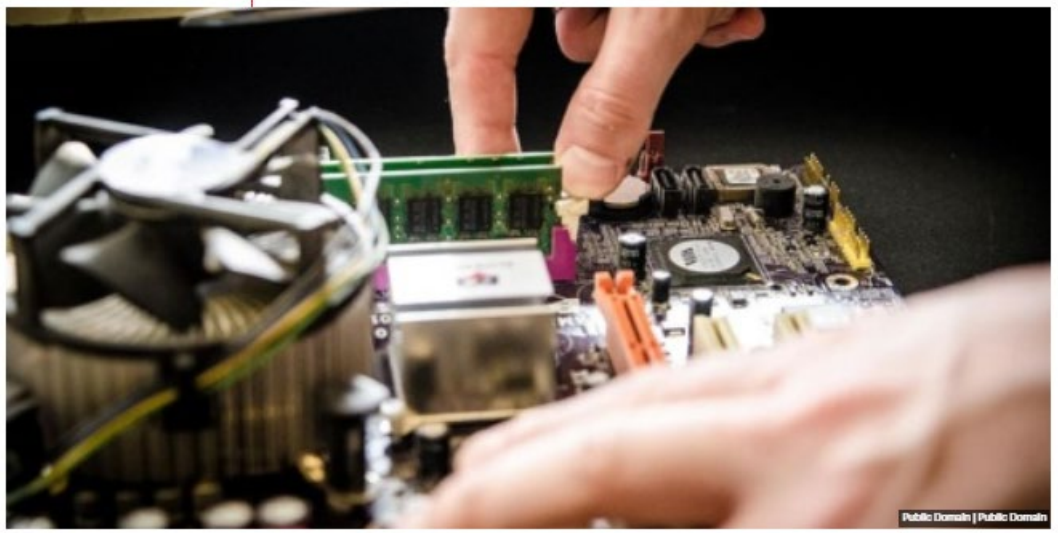
RIGHT TO REPAIR

DECEMBER 22, 2023

New York's Right to Repair law is going into effect. Here's what will change

New York passed the first ever consumer electronics Right to Repair in 2022, which goes into full force on Dec. 28, 2023.



Public Domain | Public Domain

Nathan Proctor
Senior Director, Campaign for the Right to Repair, PIRG

On Dec. 28, 2022, New York's Right to Repair bill was signed into law, and now, one year later, its requirements come into effect.

Here's what that law means for consumers and repair shops in New York and around the country.

What products are covered by the New York Right to Repair law?

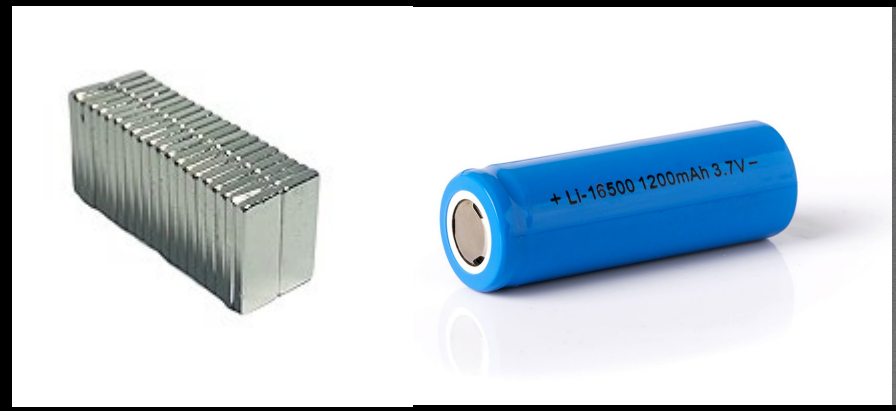
Types of Lithium Batteries

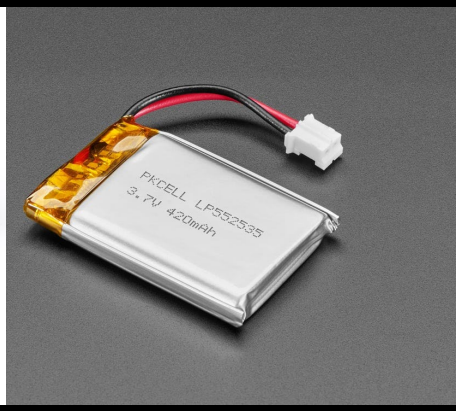
Lithium Metal

- Metallic lithium or alloy
- Tend to be single use and not rechargeable
- Typical Configurations:
  - Cell or button
  - Cylindrical
  - Rectangular
- Found in:
  - Watches, digital cameras, flashlights, toys

Lithium Ion

- Lithium compound
- Tend to be rechargeable
- Typical Configurations:
  - Cylindrical
  - Pouch
  - Prismatic/Rectangular
- Found in:
  - Laptops, power tools, e-bikes, vehicles, ESS





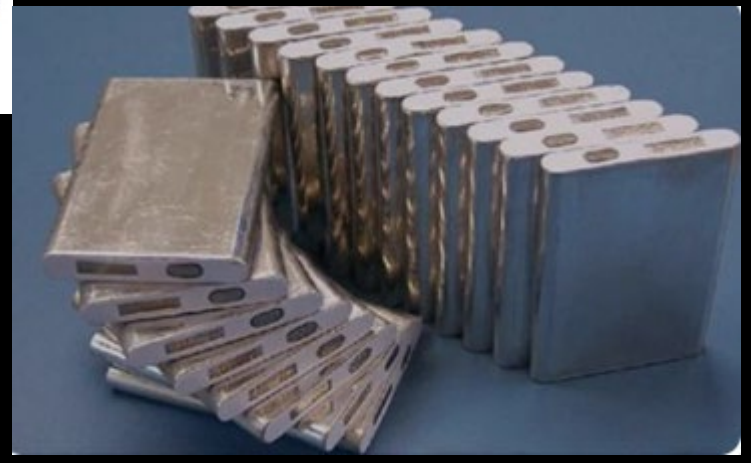
Four Primary Presentations of LIB

- Energy Storage Systems
- Electric Vehicles
- Micro-mobility
- Personal Electronic Devices

Types of Li-Ion Batteries

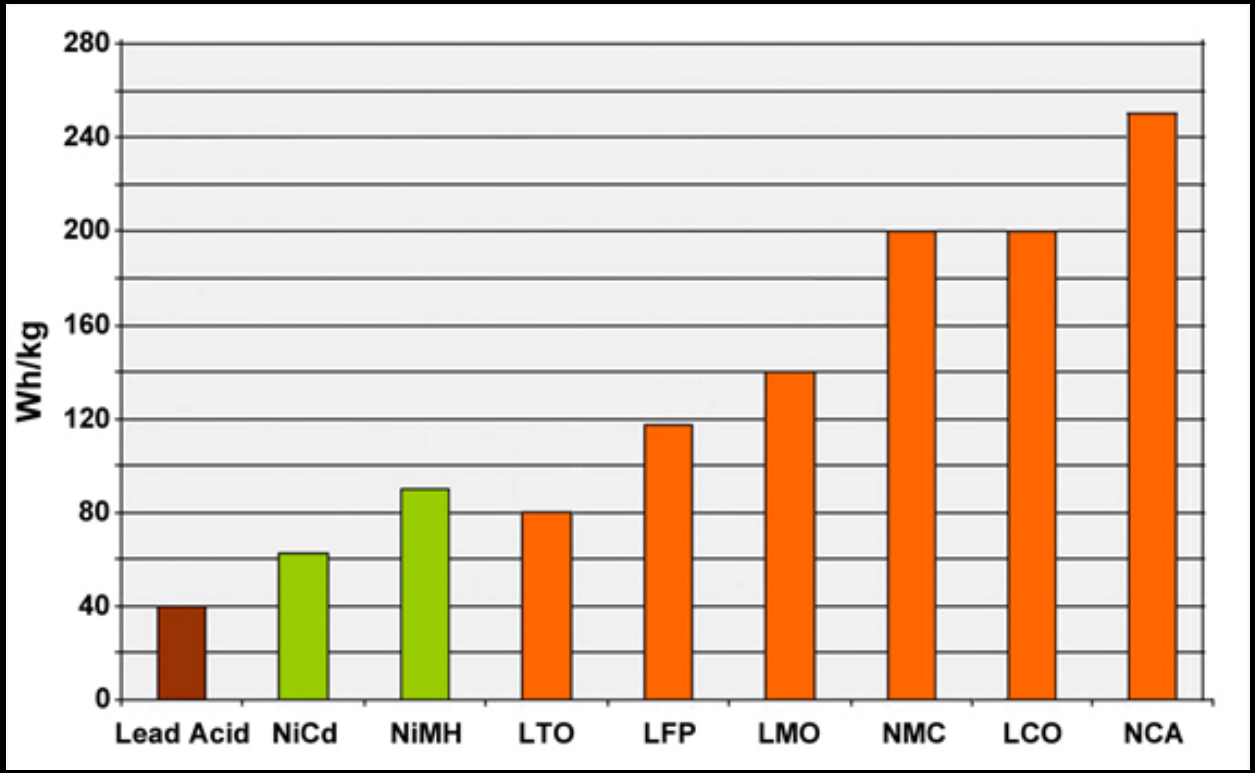
Styles

- Cylinder
- Pouch
- Prismatic



How do Lithium-ion batteries work?

Li-Ion Battery Chemistry



Chemistry

- Lithium Cobalt Oxide($LiCoO_2$) — LCO
- Lithium Nickel Cobalt Aluminum Oxide ($LiNiCoAlO_2$) — NCA
- Lithium Nickel Manganese Cobalt Oxide ($LiNiMnCoO_2$) — NMC
- Lithium Manganese Oxide ($LiMn_2O_4$) — LMO
- Lithium Iron Phosphate($LiFePO_4$) — LFP
- Lithium Titanate (Li2TiO3) — LTO
- Lithium Manganese Rich (LMR)

Li-Ion Battery Electrolyte

Type

- Liquid
- Solid
- Gel

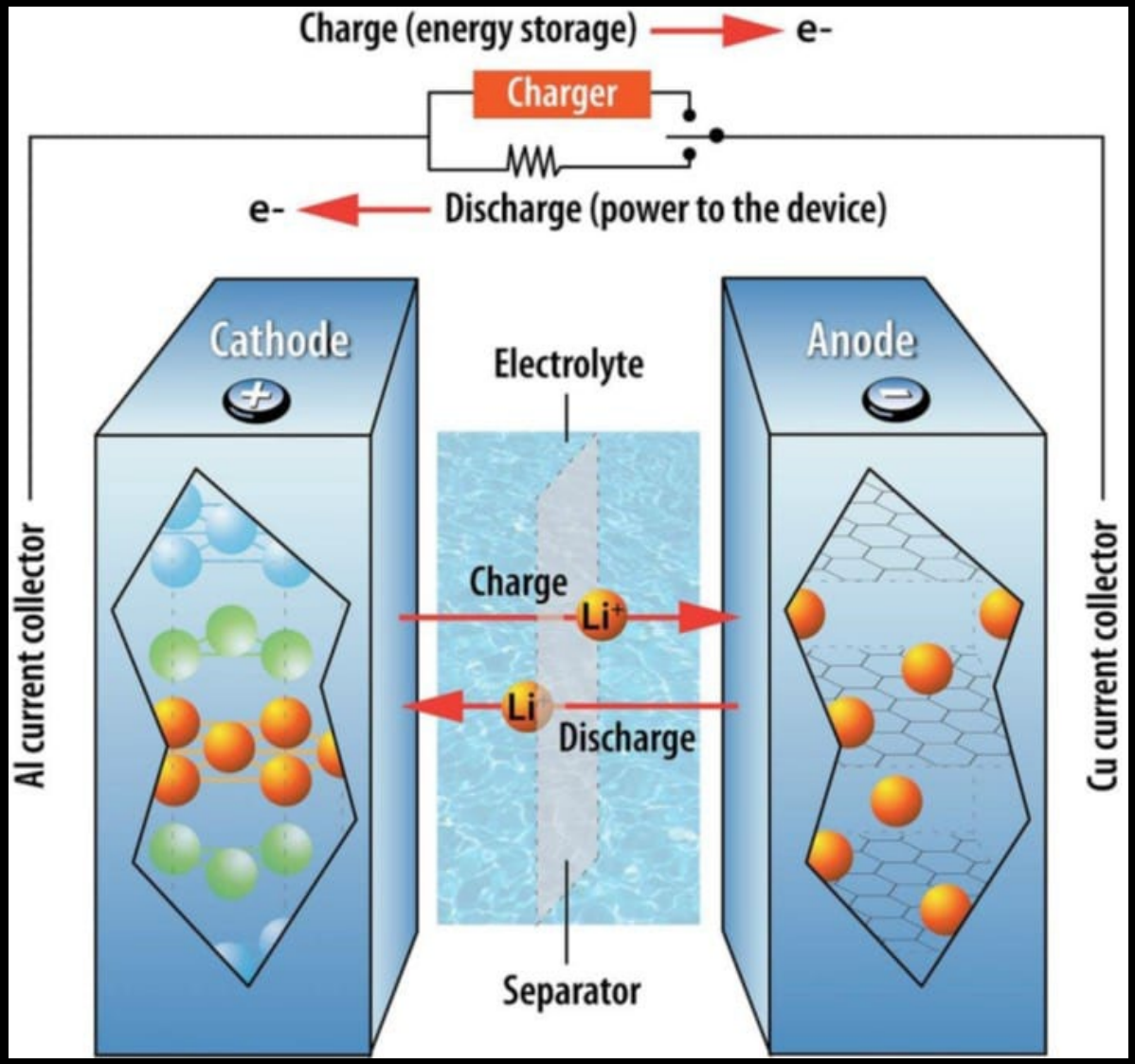
Lithium Salt

- Lithium Hexaflurophosphate (LiPF6) – LHP

Solvents

- Ethylene carbonate
- Propylene carbonate
- Dimethyl carbonate
- Ethyl methyl carbonate
- Fluoroethylene carbonate
- Methyl acetate
- Methyl propinate

CONFIDENTIAL INFORMATION



Dangers of Li-Ion Batteries: Terms to Know

“End-of-life” means batteries meeting their end of service life. They will be scrapped/shredded into precious metals or “Black Mass” or incinerated or landfilled.

Alternatively, “second life” for lithium batteries refers to their repurposing or refurbishing. These are not eligible for the recycling exceptions in the HMR.

“DDR” means damaged, defective, or recalled. These are batteries that are a greater risk and have greater regulatory restrictions. Common in recycling and disposal streams, and commonly found to be the cause of incidents.

“Thermal runaway” means the fire event that occurs in lithium batteries. It is uncontrollable, self-heating, and has a reignition risk that can last weeks.

“Propagation” means fire initiating from one battery causing other batteries in close proximity to go into thermal runaway, resulting in additional fires at the same time.

Propagation

- Propagation
  - Domino effect
  - Thermal Runaway heat from one battery-cell is likely to trigger Thermal Runaway in neighboring battery-cells

- Limiting propagation is primary goal
  - Cooling neighboring cells may prevent propagation
  - Removing exposed cells (i.e., removing other e-bikes, loose cells, etc.)

Dangers of Li-Ion Batteries: DDR

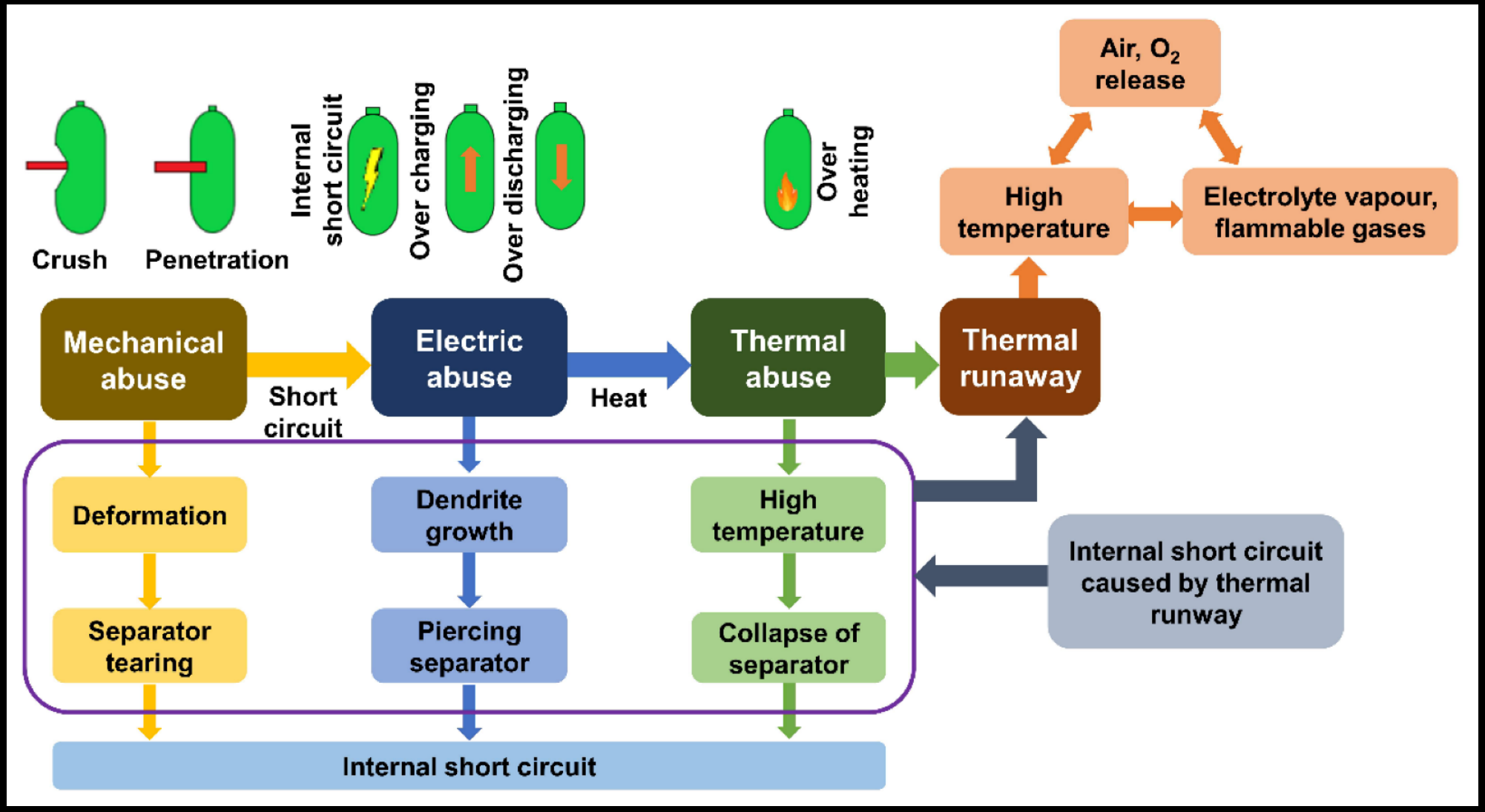
Can be caused by:

- Misuse & Abuse
- Imperfections
- Overcharging
- Incompatibility/Modifications
- Damage through impact

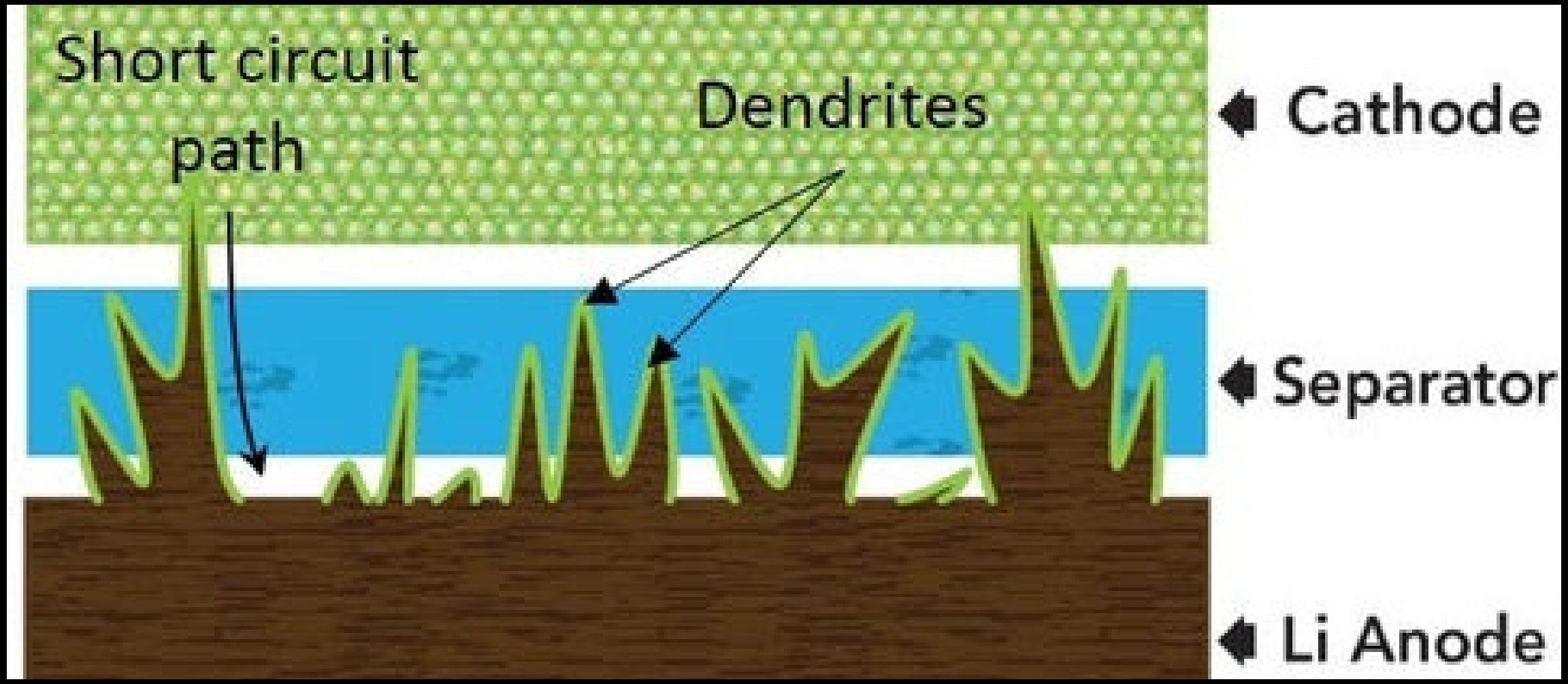
Are characterized as:

- Unreliable
  - No longer working appropriately
- Unpredictable
  - Overheat
  - Expansion/Swelling
  - Fire
  - Explosion
- Hazardous Waste
  - Disposal concerns
  - Expense

Why do batteries fail?

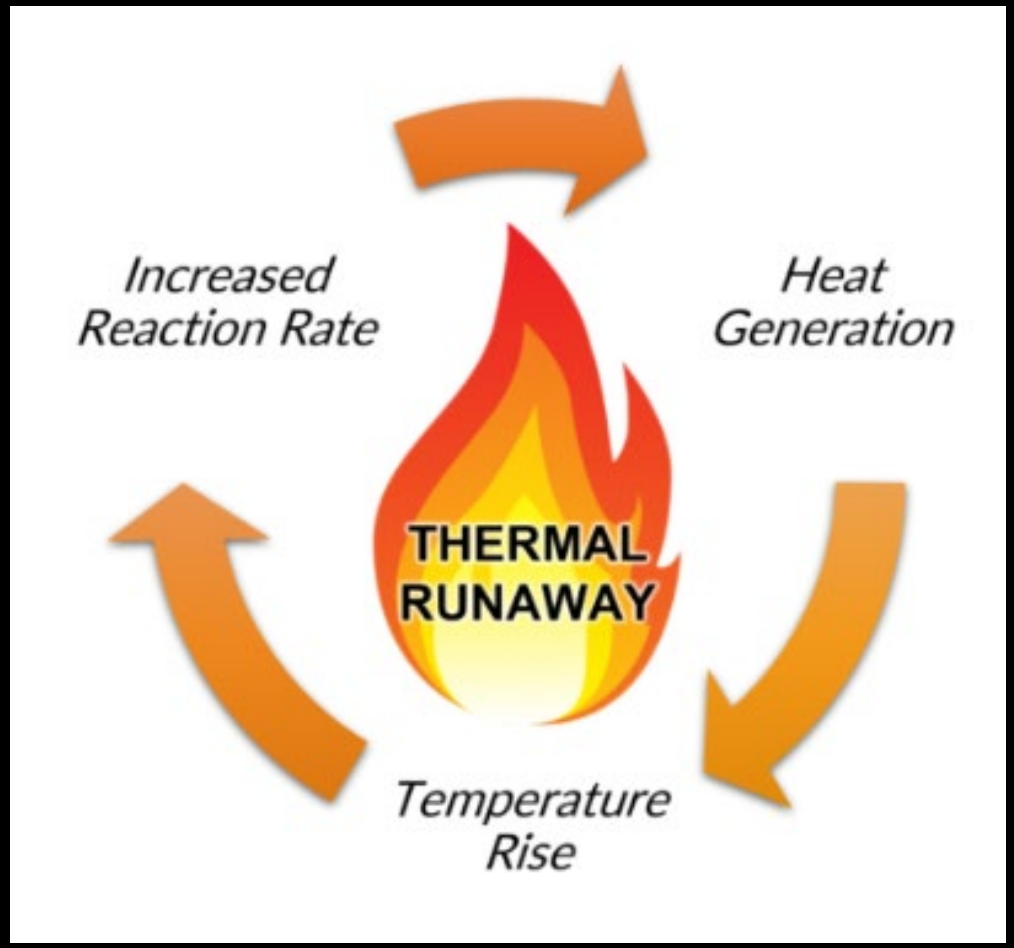


Why do batteries fail?



Characteristics of Li-Ion Fires

- Very toxic atmospheres – H, HF, HCN, CO, heavy metals
- ~6L/Wh gas produced/released
- Burn temperatures are higher than normal - >2,000°F
- Battery fires can burn without Oxygen – can't smother!
- Explosive potential – Hydrogen Gas
- Thermal Runaway reaction
  - Chemical reaction – rapid degradation
  - Does not require Oxygen
  - Nearly impossible to stop once it starts
  - Rapid event that can propagate to other cells
- Rekindle is common and cannot be predicted – can happen minutes, hours, days, weeks, months later



DO YOU KNOW THE DIFFERENT TYPES OF FIRES?

Not all fires are the same. Per NFPA 10, items burning may be classified into one or more of the following fire classes and your fire protection specialist will select the right fire extinguisher size and agent for the hazard.

CLASS	SYMBOL	PICTOGRAM	MATERIALS	EXAMPLES
A	A		Ordinary combustible materials	Wood, paper, cloth, rubber, and many plastics
B	B		Flammable liquids and gases	Gasoline, petroleum greases, tars, oils, oil-based paints, solvents, alcohols, propane, and butane
C	C		Energized electrical equipment	Computers, servers, motors, transformers, and appliances
D	D		Combustible metals	Magnesium, titanium, zirconium, sodium, lithium, and potassium
K	K		Cooking oils and greases	Animal and vegetable fats

WWW.FEMALIFESAFETY.ORG

FIRE EQUIPMENT MANUFACTURERS' ASSOCIATION

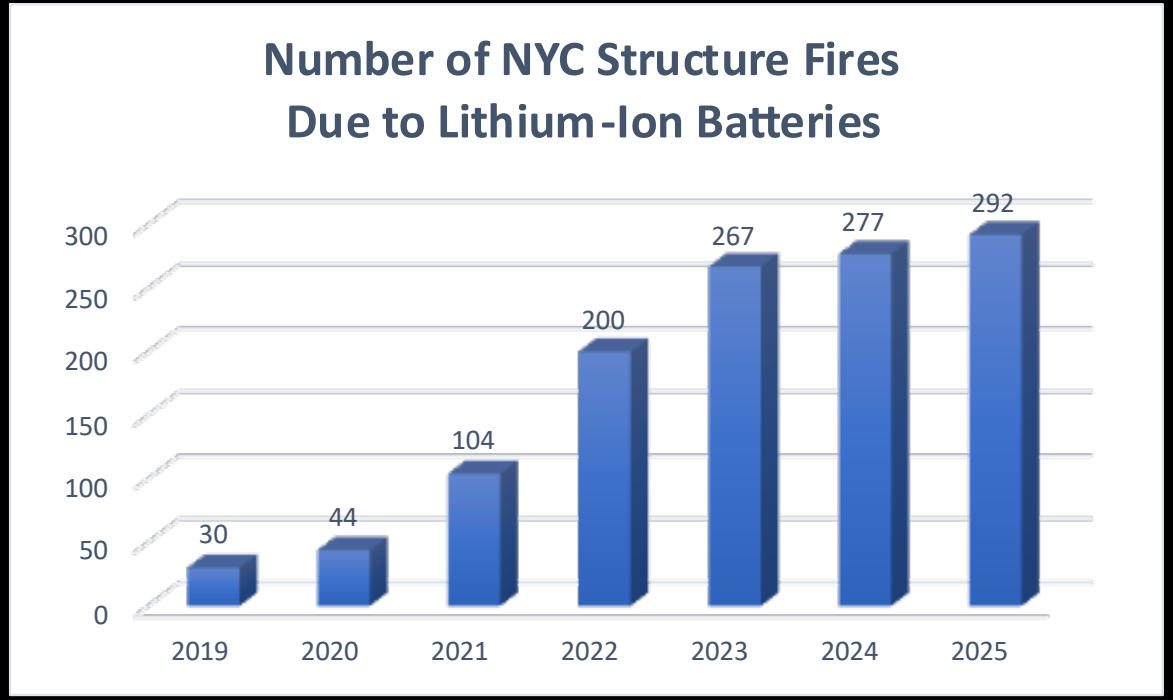
Saving Lives, Protecting Property

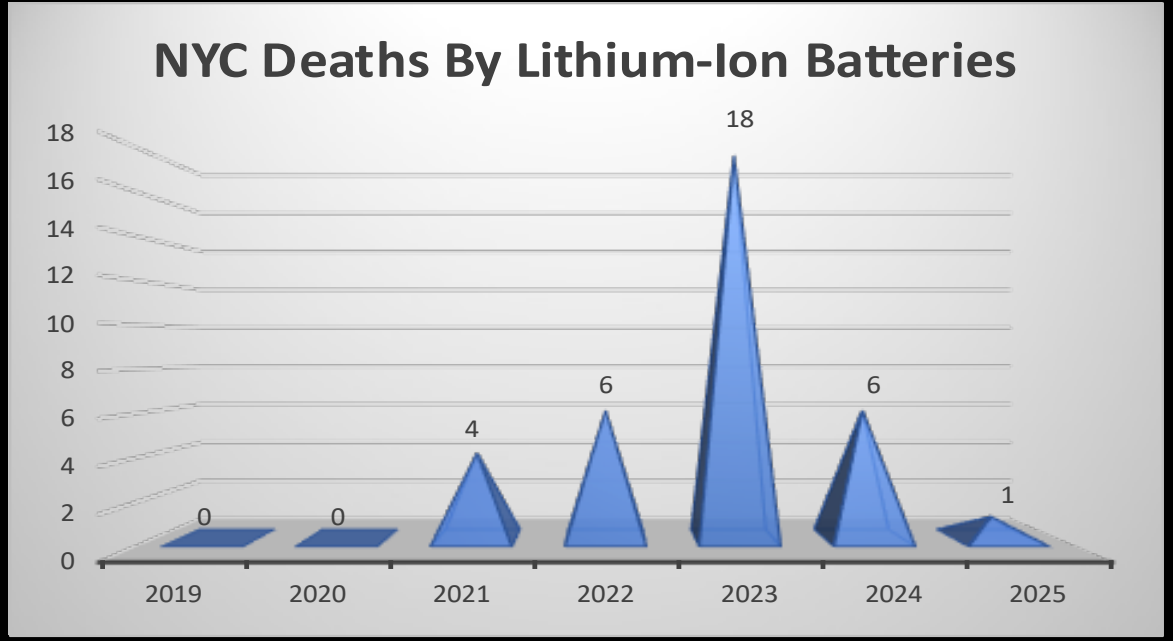
Characteristics of Li-Ion Fires

- Signs of trauma
- Gasses emitting
- Increase in temperature
- Pop and hiss
- Projectiles
- Intense fire
- Propagation
- Secondary fires

Characteristics of Li-Ion Fires

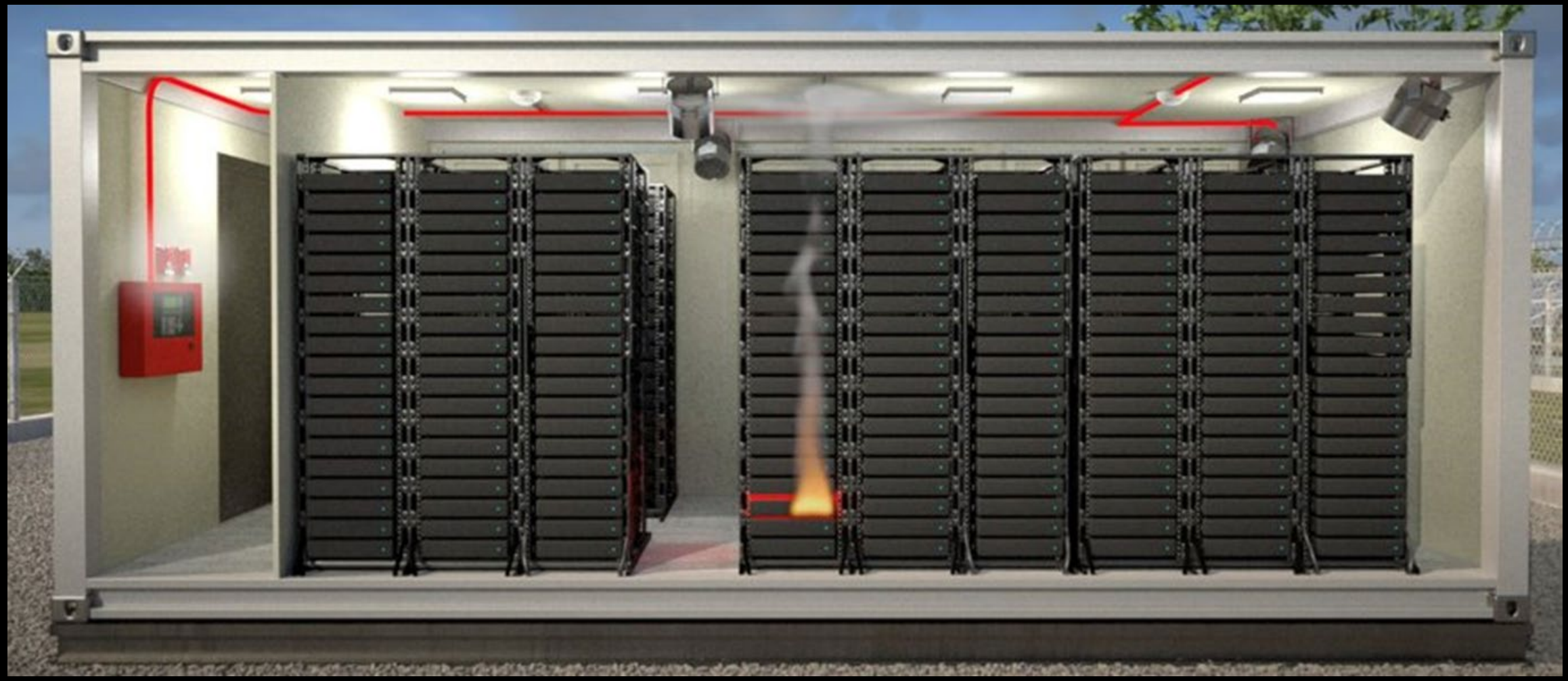
- Largest number of LIB incidents
- FDNY LIB fires:
  - 44 in 2020
  - 104 in 2021 (4 killed, 79 injured)
  - 219 in 2022 (6 killed, 147 injured)
  - 268 in 2023 (18 killed, 150 injured)
  - 279 in 2024 (6 killed, 99 injured)
  - 292 in 2025 (1 killed, 51 injured)
  - 4 in 2026
- Public exposure concerns
  - Stored and charged inside occupied residences and businesses
  - Stored near entry and exit ways
  - Can ignite with little-to-no warning
  - **<u>Rekindle is likely.</u>**






Newsflare

BESS Incidents



Flooded Car Incidents

Hurricane Ian – September 2022

Hurricane Idalia – August 2023

Flooded Car Incidents

Hurricane Helene
September 2024

Shipping Incidents
S-Trust Crude Tanker

Shipping Incidents
M/V Genius Star XI


DVIDS / REUTERS
USA TODAY
Cargo ship carrying EVs catches fire off Alaska coast
USA TODAY
C O S C O

Batteries may be involved in the incident OR they may be the cause of the incident

All Incidents

Li-Ion Battery Response Considerations

Module Two:
Waste Profile & Disposal

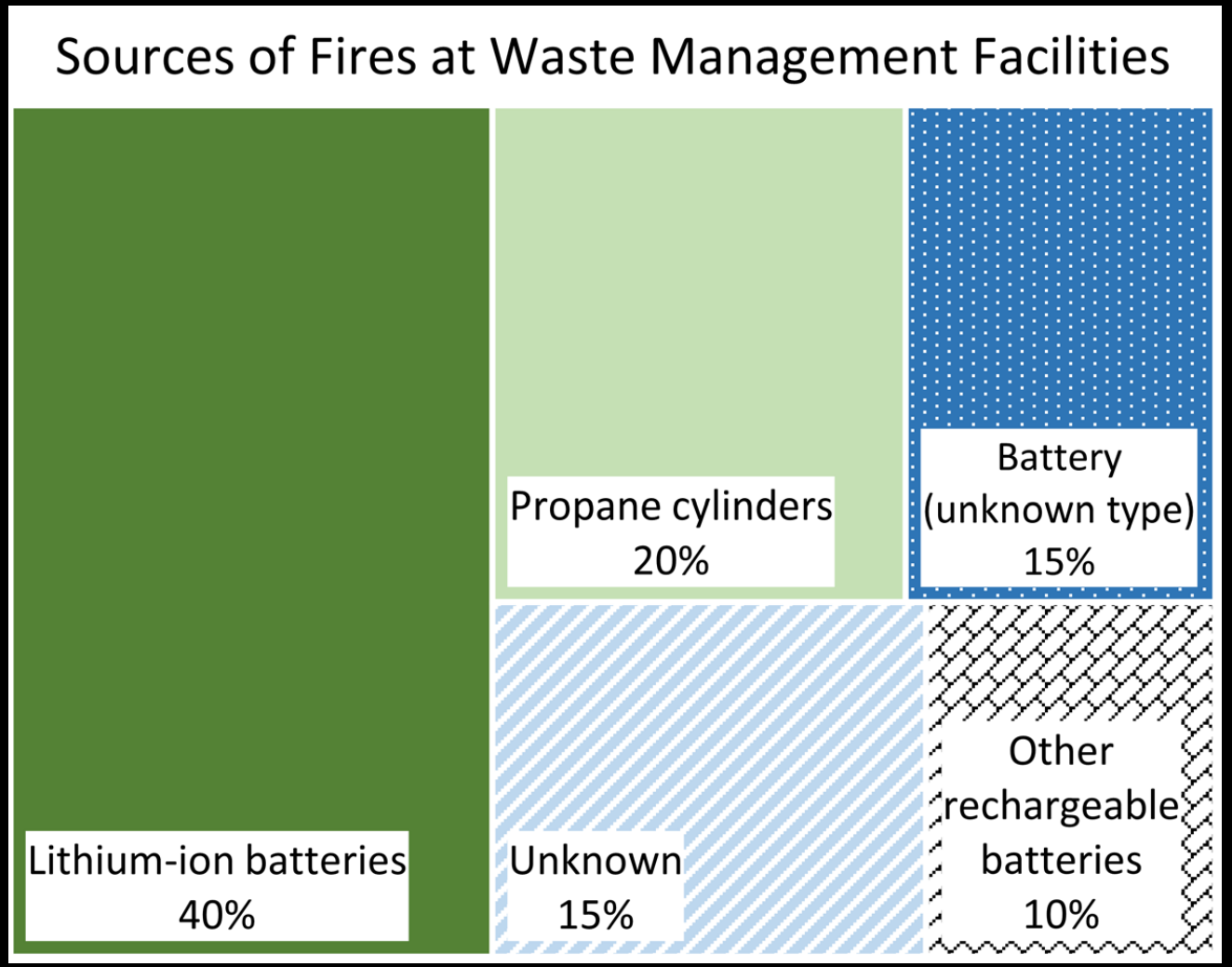
Hazardous waste regulations
Challenges
DDR packaging options
Transportation of materials
Disposal and Recycling


RECHARGEABLE
OKAY IN TRASH
REQUIRES SPECIAL RECYCLING


1249
REPURLIC
SERVICES
208-345-1265

Consumer Disposal

- Trash trucks/recycling facilities
- 60% of trash truck load fires



Union of Concerned Scientists

The EQUATION

SIGN UP EN ESPAÑOL DONATE MENU

Electric Vehicles, Batteries, Cobalt, and Rare Earth Metals

October 25, 2017 | 11:59 am

BATTERY PACK FOR BMW-I3 ELECTRIC VEHICLE (AT MUNICH TRADE-SHOW ELECTRONICA). PHOTO: RUDOLFSIHON CC-BY-2.0 (WIKIMEDIA)

Josh Goldman
Former Contributor

The case for switching to electric vehicles (EVs) is nearly settled. They are cheaper to use, cut emissions, and offer a whisper quiet ride. One of the last arguments available to the EV-hater club, which is largely comprised of thinly veiled oil-industry front groups funded by the Koch brothers, focuses on the impacts from the materials used to make an EV's battery pack.

Specifically, the use of lithium, cobalt, nickel, and other metals that are part of an EV lithium-ion battery pack has raised red flags about the poor human rights and worker protection records in the countries where these materials

EPA United States Environmental Protection Agency

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Hazardous Waste

CONTACT US

- Hazardous Waste Home
- Learn the Basics of Hazardous Waste
- Hazardous Waste Management
  - Generation
  - Identification
  - Definition of Solid Waste
  - Exclusions
  - Characterization
  - Delistings
  - Transportation
  - Permitting
  - Land Disposal Restrictions
  - Requirements for Importers
  - Requirements for Exporters
  - Recycling
  - Cleanups
- Regulations for Certain Wastes
- EPA Hazardous Waste Initiatives
- SW-846 Test Methods
- State Authorization
- A to Z Directory of Topics

Lithium-Ion Battery Recycling

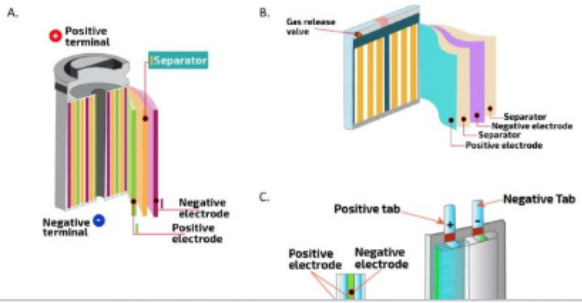
On this page:

- Background on Lithium Batteries
- Lithium-Ion Batteries as Waste
- How Lithium-Ion Batteries are Recycled
- Lithium-Ion Battery Reuse
- Additional Resources

Background on Lithium Batteries

Lithium-ion batteries are a type of commonly used rechargeable batteries that vary in size and design, but work in very similar ways. A battery is made of one or more cells, with each individual cell functioning to produce electricity.

A cell contains an anode layer, a cathode layer, and a separator, all of which are in contact with an electrolyte, which is most often a liquid. These components are stacked or rolled together and placed in an outer packaging— typically either a steel can or an aluminum/polymer pouch material.



Find a Recycling Location Near You

To find a battery recycling location near you, consult the following resources:

- Earth911.
- Call2Recycle.
- Consumer Technology Association's Greener Gadgets.

Disclaimer: These sites are listed for informational purposes only. U.S. EPA does not endorse any of these entities or their services.

Consumer Recycling

Recalls

https://www.cpsc.gov/Recalls

SEPTEMBER 18, 2025

Arizer Solo II Portable Vaporizers Recalled Due to Fire and Burn Hazards; Imported by 7111495 Canada

Hazard:
The internal lithium-ion battery can overheat, produce smoke, and/or eject material, posing fire and burn hazards.

Remedy:
Consumers should immediately stop using the Arizer Solo II portable vaporizers and contact 7111495 Canada for a free replacement. Customers whose serial number is confirmed as impacted will receive a free Solo II MAX replacement and wax to be used for disposal. The recalled unit must be disabled by inserting the provided wax into the charging port, then disposed of at a local hazardous waste or battery recycling facility in accordance with local regulations.

Note: Do not throw this recalled lithium-ion battery or device in the trash, the general recycling stream (e.g., street-level or curbside recycling bins), or used battery recycling boxes found at various retail and home improvement stores. Recalled lithium-ion batteries must be disposed of differently than other batteries, because they present a greater risk of fire. Your municipal household hazardous waste (HHW) collection center may accept this recalled lithium-ion battery or device for disposal. Before taking your battery or device to a HHW collection center, contact that office ahead of time and ask whether it accepts recalled lithium-ion batteries. If it does not, contact your municipality for further guidance.

Units:
About 5,460 (in addition, about 2,820 were sold in Canada)

Consumer Contact:

Website: https://arizer.com/solo-ii-voluntary-recall-submission-form/

E-mail: recall@arizer.com

Phone: (888) 291-0521

SEPTEMBER 18, 2025

Anker Power Banks Recalled Due to Fire and Burn Hazards; Manufactured by Anker Innovations

Hazard:
The lithium-ion battery in the power bank can overheat, posing fire and burn hazards to consumers.

Remedy:
Consumers should immediately stop using the recalled power banks and visit Anker's Recall Page at https://www.anker.com/rc2506 to verify the product serial number and register for the recall. Consumers with an impacted product should contact Anker Innovations Limited to receive a full cash refund, or an Anker gift card that can be used across a variety of Anker product lines. To receive the remedy, consumers will be required to submit a photo of their recalled power bank showing the model number, serial number, their name, the date of the photograph, and the word "recalled" written on the power bank in permanent marker. Anker will provide instructions for consumers on how to return or dispose of the recalled power banks.

Note: Do not throw this recalled lithium-ion battery or device in the trash, the general recycling stream (e.g., street-level or curbside recycling bins), or used battery recycling boxes found at various retail and home improvement stores. Recalled lithium-ion batteries must be disposed of differently than other batteries, because they present a greater risk of fire. Your municipal household hazardous waste (HHW) collection center may accept this recalled lithium-ion battery or device for disposal. Before taking your battery or device to a HHW collection center, contact that office ahead of time and ask whether it accepts recalled lithium-ion batteries. If it does not, contact your municipality for further guidance.

Units:
About 481,000

Consumer Contact:

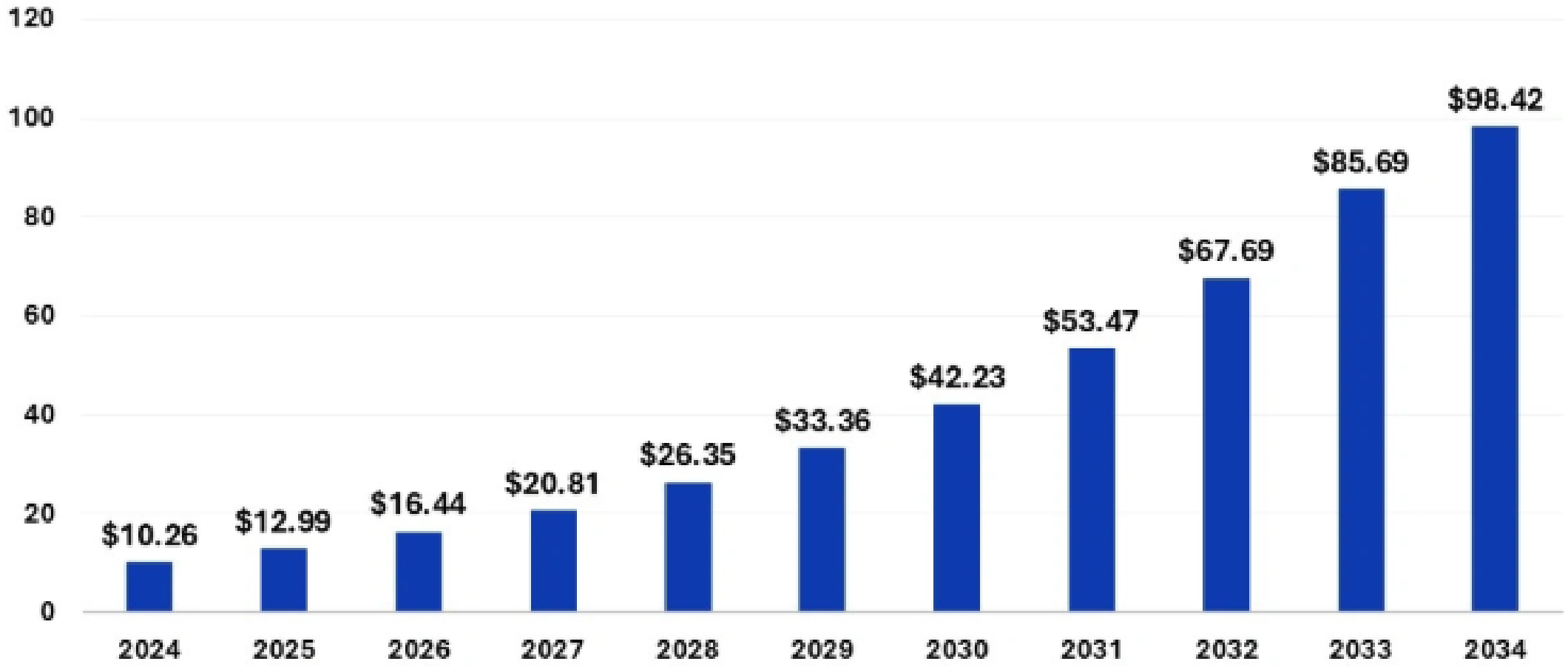
Website: https://www.anker.com/rc2506

E-mail: support@anker.com

Phone: (800) 988-7973

Precedence RESEARCH

Lithium-ion Battery Recycling Market Size 2024 to 2034 (USD Billion)



Source: https://www.precedenceresearch.com/lithium-ion-battery-recycling-market

Battery Shipping

Hazardous Material Description			
Proper Shipping Name	**Hazard Class/ Division**	**Identi-fication Number**	**Packing Group**
Lithium ion batteries	9	UN3480	N/A
Lithium ion batteries contained in equipment	9	UN3481	N/A

Battery Disposal

40 CFR 273.9

Battery means a device consisting of one or more electrically connected electrochemical cells which is designed to receive, store, and deliver electric energy. An electrochemical cell is a system consisting of an anode, cathode, and an electrolyte, plus such connections (electrical and mechanical) as may be needed to allow the cell to deliver or receive electrical energy. The term battery also includes an intact, unbroken battery from which the electrolyte has been removed.

49 CFR 171.8

Lithium ion cell or battery means a rechargeable electrochemical cell or battery in which the positive and negative electrodes are both lithium compounds constructed with no metallic lithium in either electrode. A lithium ion polymer cell or battery that uses lithium ion chemistries, as described herein, is regulated as a lithium ion cell or battery.

DDR Battery Disposal

<u>Damaged, Defective, Recalled Lithium-Ion Battery</u>

- Recycle (ship per DOT regulations)
- Recycle via DOT Special Permit
- Disposal as Hazardous Waste
- Create “Not a Battery”

DDR Battery Disposal

- Who will collect, containerize, store batteries?
- Who will be responsible for getting rid of them?
- How do you address these?

DDR Battery Disposal - RCRA

Characteristics:

- Ignitability – D001
- Reactivity – D003

Manage via:

- Hazardous waste under universal waste regulations
- 40 CFR 273
- Universal Waste regulations do not require hazardous waste manifest
- Must go to permitted facility
- Household hazardous waste exemptions apply

DDR Battery Disposal

- Highly unstable material
- Cannot be transported via air cargo
- Ocean carrier limitations
- Are hazardous waste / universal waste
- DDR batteries may not be accepted at consumer recycling points
- DDRs may not be accepted at hazardous waste collection sites
- Regulations are burdensome, expensive and ineffective to address all safety concerns

Transport & Disposal Challenges
Shipping – DOT Restrictions for DDR Batteries

(f) ***Damaged, defective, or recalled cells or batteries.*** Lithium cells or batteries that have been damaged or identified by the manufacturer as being defective for safety reasons, that have the potential of producing a dangerous evolution of heat, fire, or short circuit (*e.g.*, those being returned to the manufacturer for safety reasons) may be transported by highway, rail or vessel only, and must be packaged as follows:

(1) Each cell or battery must be placed in individual, non-metallic inner packaging that completely encloses the cell or battery;

(2) The inner packaging must be surrounded by cushioning material that is non-combustible, electrically non-conductive, and absorbent; and

(3) Each inner packaging must be individually placed in one of the following packagings meeting the applicable requirements of part 178, subparts L, M, P, and Q of this subchapter at the Packing Group I level:

DDR Batteries cannot be transported via aircraft.

Transport & Disposal Challenges

DOT Special Permits

Allows for handling material outside of the Hazardous Materials Regulations, provided a level of security can be met

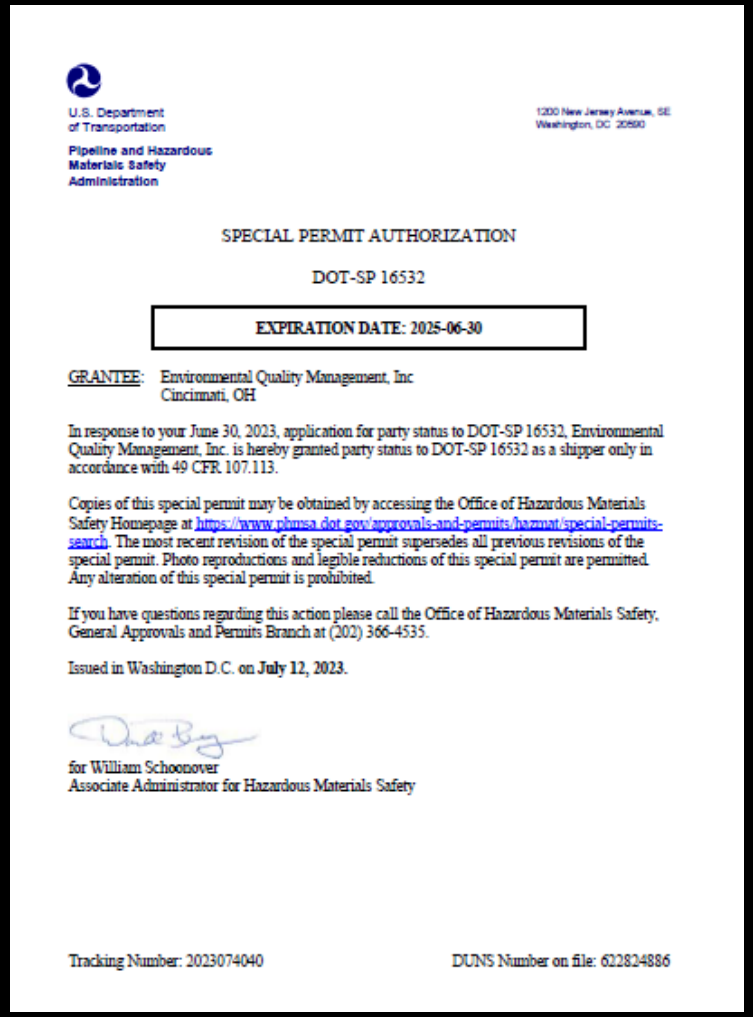
Can be issued to response company, manufacturer, project site

Takes time; submit for approval

Transport & Disposal Challenges

DOT Special Permits

Transport & Disposal Challenges
DOT Special Permits



U.S. Department of Transportation

Pipeline and Hazardous Materials Safety Administration

1200 New Jersey Avenue, SE
Washington, DC 20590

SPECIAL PERMIT AUTHORIZATION

DOT-SP 16532

EXPIRATION DATE: 2025-06-30

GRANTEE: Environmental Quality Management, Inc
Cincinnati, OH

In response to your June 30, 2023, application for party status to DOT-SP 16532, Environmental Quality Management, Inc. is hereby granted party status to DOT-SP 16532 as a shipper only in accordance with 49 CFR 107.113.

Copies of this special permit may be obtained by accessing the Office of Hazardous Materials Safety Homepage at https://www.phmsa.dot.gov/approvals-and-permits/hazmat/special-permits-search. The most recent revision of the special permit supersedes all previous revisions of the special permit. Photo reproductions and legible reductions of this special permit are permitted. Any alteration of this special permit is prohibited.

If you have questions regarding this action please call the Office of Hazardous Materials Safety, General Approvals and Permits Branch at (202) 366-4535.

Issued in Washington D.C. on **July 12, 2023.**

for William Schoonover
Associate Administrator for Hazardous Materials Safety

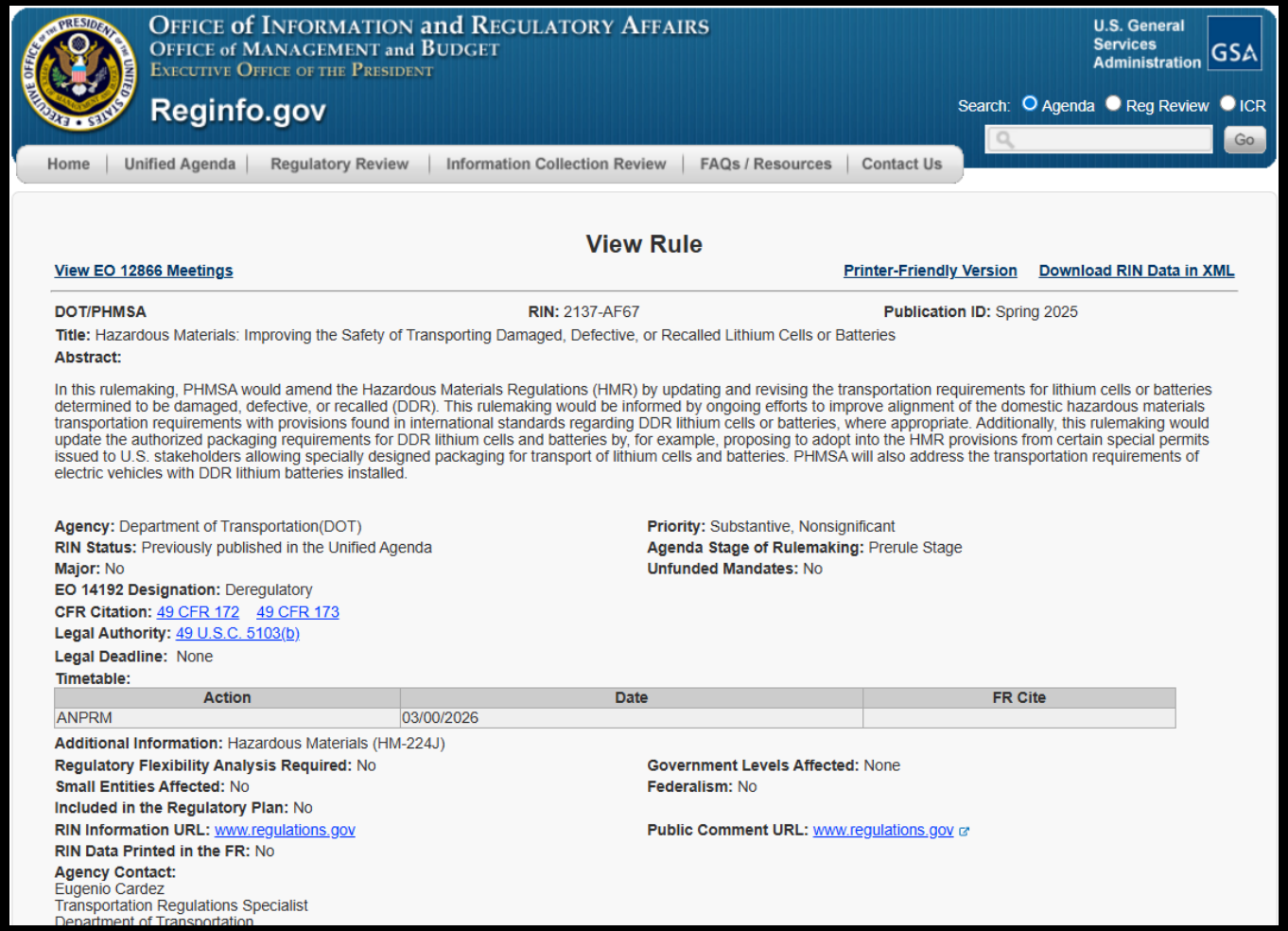
Tracking Number: 2023074040

DUNS Number on file: 622824886

- Safety Controls
- Inner Packaging Requirements
- Outer Packaging Requirements
- Weight Allowance
- Markings
- Labels
- Operational Controls
- Transport Authorized
- Specials Provisions
- Reporting Requirements

Transport & Disposal Challenges
Proposed DOT Regulations for DDR Batteries

- Changes to the Hazardous Materials Regulations?
- Outer packaging labels?
- New classification for DDR batteries?
- Ventilated packaging?



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View Rule

View EO 12866 Meetings | Printer-Friendly Version | Download RIN Data in XML

DOT/PHMSA **RIN:** 2137-AF67 **Publication ID:** Spring 2025

Title: Hazardous Materials: Improving the Safety of Transporting Damaged, Defective, or Recalled Lithium Cells or Batteries

Abstract:

In this rulemaking, PHMSA would amend the Hazardous Materials Regulations (HMR) by updating and revising the transportation requirements for lithium cells or batteries determined to be damaged, defective, or recalled (DDR). This rulemaking would be informed by ongoing efforts to improve alignment of the domestic hazardous materials transportation requirements with provisions found in international standards regarding DDR lithium cells or batteries, where appropriate. Additionally, this rulemaking would update the authorized packaging requirements for DDR lithium cells and batteries by, for example, proposing to adopt into the HMR provisions from certain special permits issued to U.S. stakeholders allowing specially designed packaging for transport of lithium cells and batteries. PHMSA will also address the transportation requirements of electric vehicles with DDR lithium batteries installed.

Agency: Department of Transportation(DOT)
RIN Status: Previously published in the Unified Agenda
Major: No
EO 14192 Designation: Deregulatory
CFR Citation: 49 CFR 172 49 CFR 173
Legal Authority: 49 U.S.C. 5103(b)
Legal Deadline: None

Priority: Substantive, Nonsignificant
Agenda Stage of Rulemaking: Prerule Stage
Unfunded Mandates: No

Timetable:

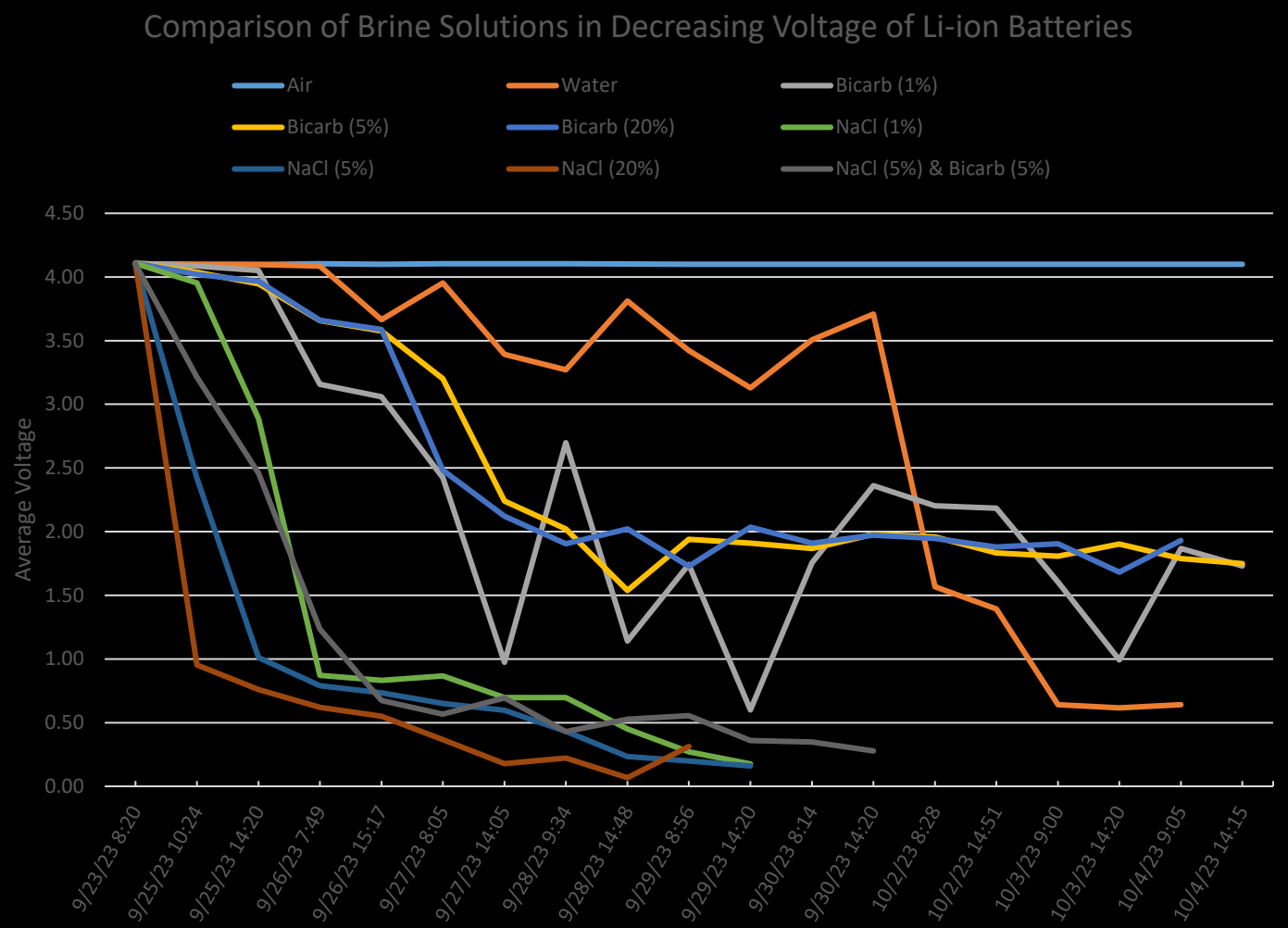
Action	Date	FR Cite
ANPRM	03/00/2026	

Additional Information: Hazardous Materials (HM-224J)
Regulatory Flexibility Analysis Required: No
Small Entities Affected: No
Included in the Regulatory Plan: No
RIN Information URL: www.regulations.gov
RIN Data Printed in the FR: No

Government Levels Affected: None
Federalism: No
Public Comment URL: www.regulations.gov

Agency Contact:
Eugenio Cardez
Transportation Regulations Specialist
Department of Transportation

Battery De-Energizing



- Discharge battery for safety
- Create a salt solution of 5% NaCl
- Allow to soak for 3 days
- Lower voltage
- Release of gases
- Progress dependent on battery construction

Battery De-Energizing

Runoff/Brine Solution

- TCLP results for RCRA metals have been non-detect for disposal
- Studies show other metals may be present in high concentrations
- Could be toxic for aquatic life

Brine solution and runoff water are likely to be non-hazardous but should be disposed of at a POTW if possible.

Table 13
Comparison of contamination of sprinkling and storage water with limit and background levels.

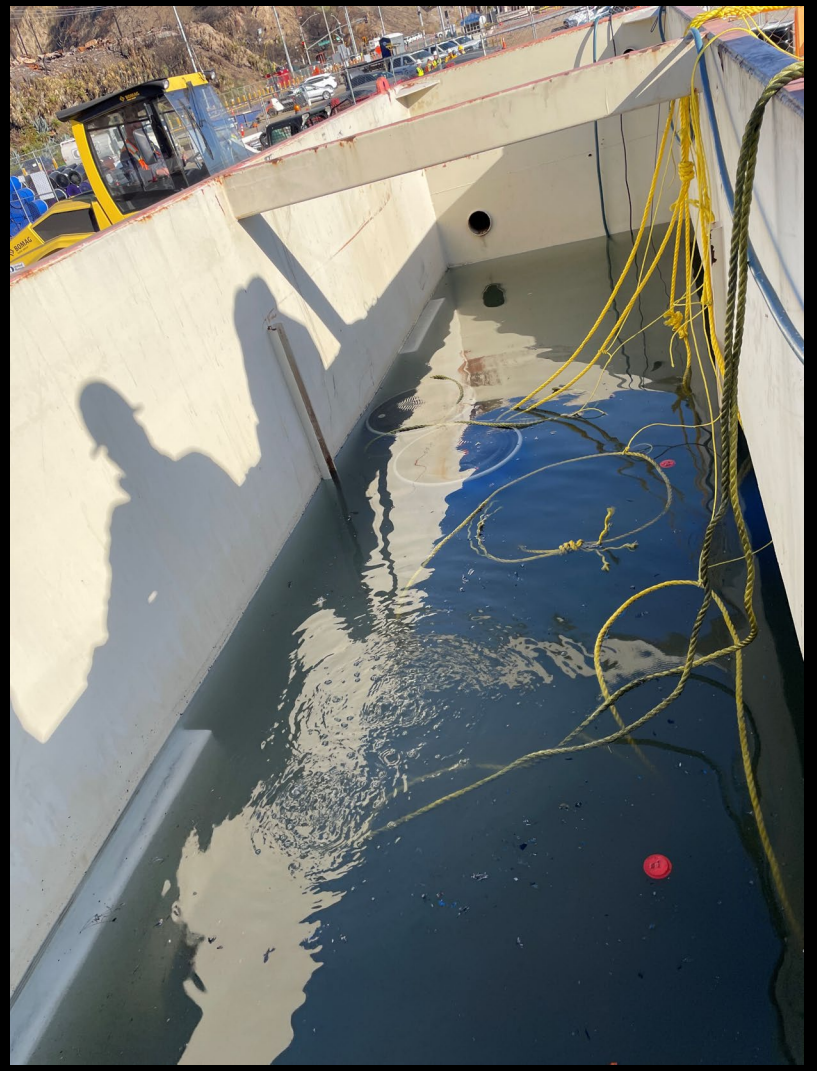
Contaminant/ Parameter	Unit	Sprinkling water	Storage water	Process water	Drinking water limit values [1]	Industrial effluent limit value [2]
pH value	-	8.2	12.3	8	6.8 - 8.2	6.5 - 9.0
Chloride	mg/l	2	22	3	250	n.s.
Sulphate		34	98	2	250	n.s.
Nitrate		2	< 1	< 1	40	n.s.
Phosphate		<1	< 1	< 1	1	n.s.
Fluoride		8	330	< 1	1.5	n.s.
PAH [c]	µg/l	0.001 [a] 0.36 [b]	0.02 [a] 0.02 [b]	0.001 [a] < 0.001 [b]	0.1	n.s.
Benzo[a]pyrene		< 0.001 [a] 0.07 [b]	0.004 [a] 0.01 [b]	< 0.001 [a] < 0.001 [b]	0.01	n.s.
Nickel		36000 [a] 48400 [b]	55000 [a] 181000 [b]	< 700	20	2000
Cobalt		36000 [a] 46000 [b]	50000 [a] 181000 [b]	< 400	n.s. (≤ 70)	500
Manganese		36000 [a] 44000 [b]	53000 [a] 199000 [b]	< 1300	50	n.s.
Lithium		7000 [a] 2200 [b]	1460000 [a] 31000 [b]	< 1300	n.s. (≤ 40)	n.s.

Disposal - Recycling

- End-Point Recycling Facilities offer the best option for disposal
  - Discharge battery (3 days in brine)
  - Grind battery to 0.5” or less pieces
  - Extract metals
  - Dispose of remaining mash

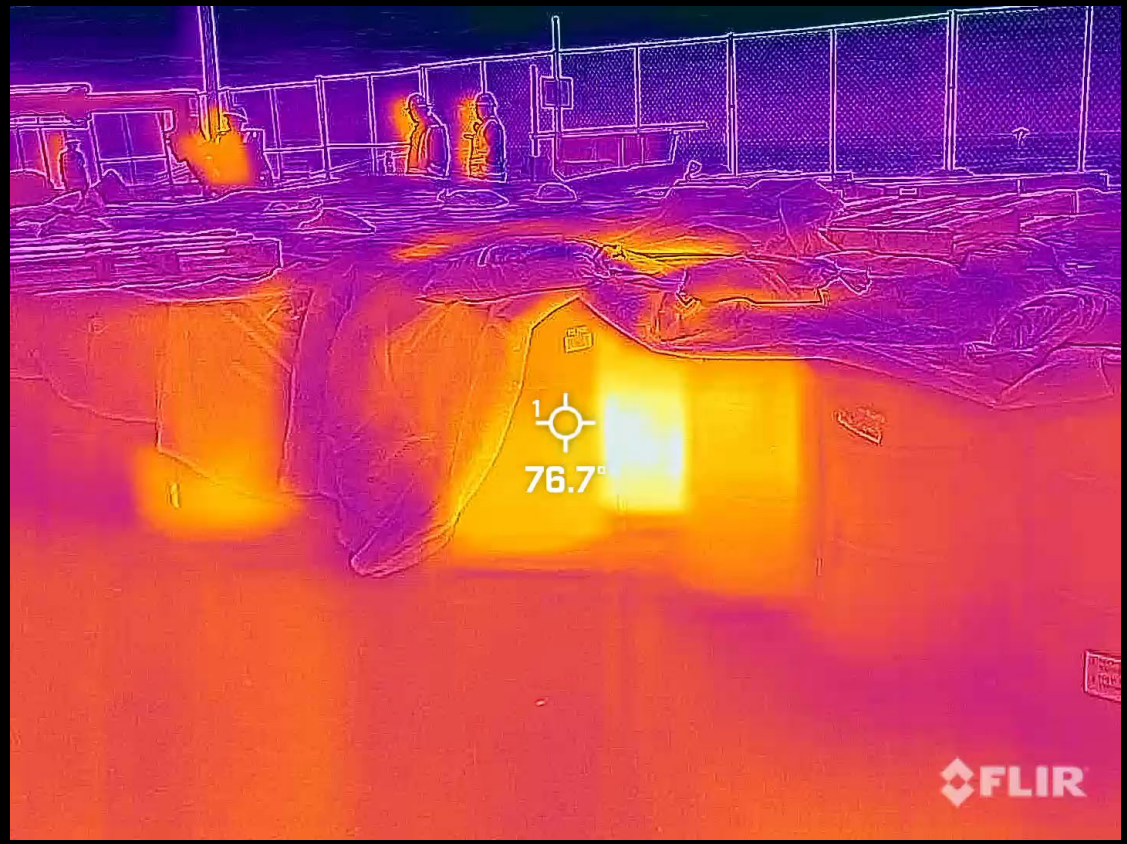
Transportation & Disposal

- Determine final disposition
- Assess state of battery cell condition and charge
  - Increase state of charge is related to risk and reactivity
  - Brine solution can significantly reduce the state of charge.
  - Based upon battery assessment, as necessary brine/de-energize battery cells
- Crush/destroy/de-construct
  - No longer meets the definition of a battery per EPA or a lithium-ion battery per DOT/PHMSA
- Shred



Transportation & Disposal

- Monitor
  - Air readings
  - Heat



Transportation & Disposal

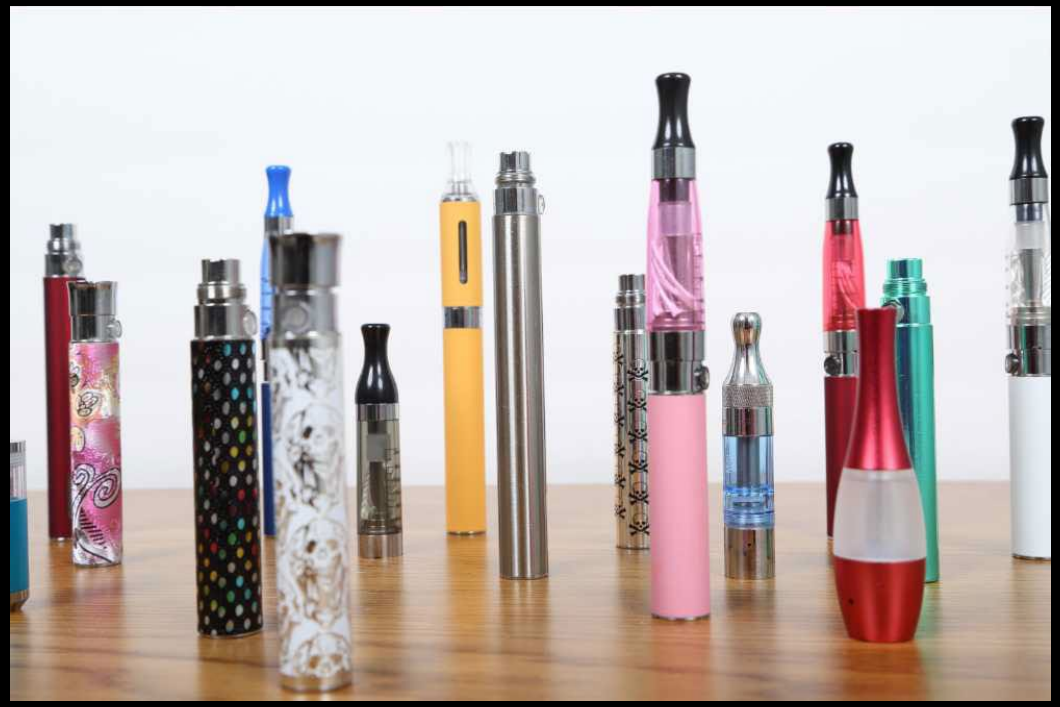
- Package
  - Ensure ventilation
- Label
- Transportation
- Shipping
  - What are the restrictions
  - Where will material be placed

Li-Ion Battery Response Considerations

Module Three: Tactical Considerations

Small Consumer Products
Micro-Mobility Devices
Electric Vehicles
Energy Storage Systems
Accumulators/Recyclers
Stafford Act Responses

Small Consumer Products



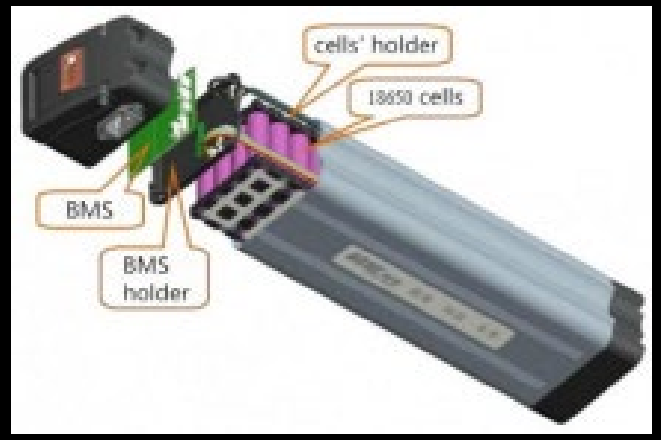




Small Consumer Products
Tactical Considerations

- Life safety
- Property conservation
- Recover batteries
- Appropriate disposal

Micro-Mobility Devices



(i) Electric Unicycle

(ii) Egret (kick electric scooter)

(iii) Electric Scooter

(iv) Three-wheeler Electric Scooter

(v) Electric Mobility Cart

(vi) Electric Bike (bicycle)

(vii) Hoverboard

(viii) Segway

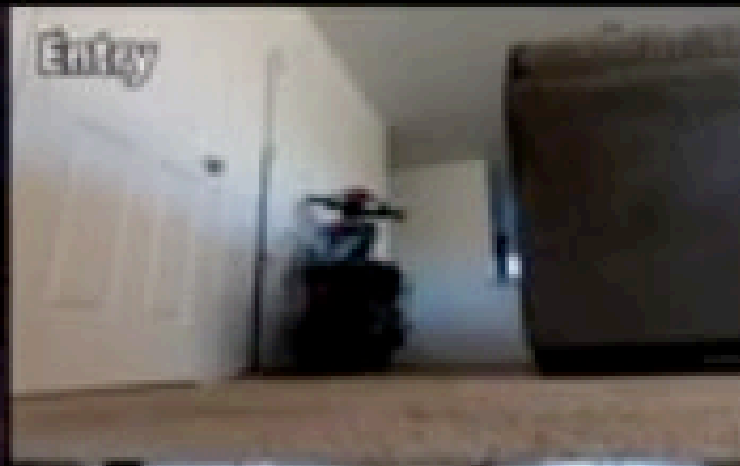
(ix) Electric Caster Board


WORLD NEWS TONIGHT with DAVID MUIR
APRIL 19, 2026
© CITY OF HOLLYWOOD, FLORIDA


4.5K

Intentional
E-Scooter
Overcharge:
Living Room

Overcharge Time:
01:39:27



How Many Gallons per Minute?

- Lithium-Ion batteries do not require Oxygen to burn.
- Smothering also does not work
- Inerting with clean agent may inhibit class A fire but not battery fire, where flaming combustion is suppressed, explosive and toxic gases build-up and don’t burn off
- Cooling to prevent cell propagation may be successful if water can be placed into battery pack
  - **DO NOT** force open the battery pack

Micro Mobility Concerns

Micro Mobility Concerns

Micro Mobility Concerns

"Clustering"

"Farming"

Micro Mobility Concerns

Rapid failure

Overhaul

Toxic atmosphere

Rekindle

Explosive

Micro Mobility Tactical Considerations

- Life safety
  - PPE/SCBA
  - Rescue
  - Evacuate area

- Consider protection of exposures of life, environment, property/superstructure, and commerce.

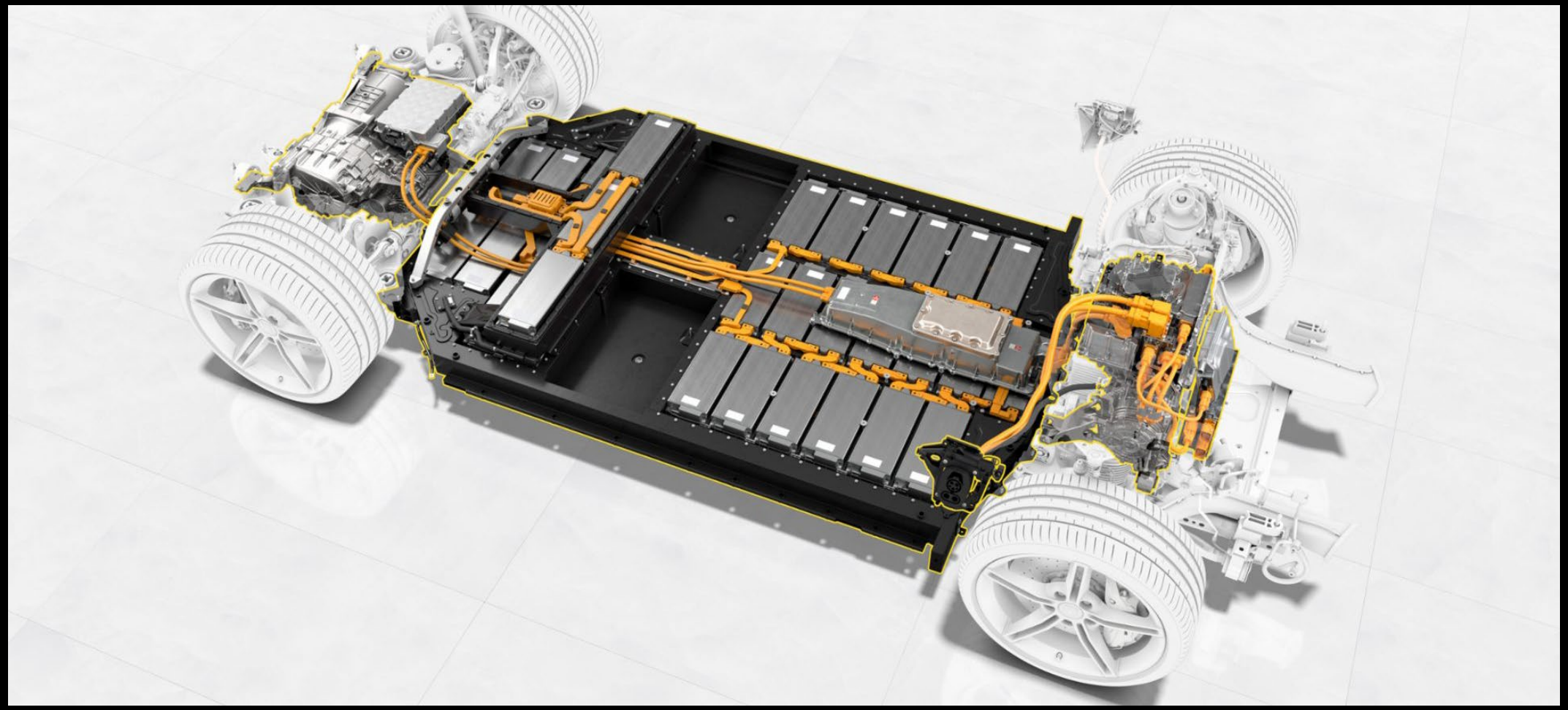
Incident Stabilization

- If outdoors
  - Allow micro mobility to burn to completion
  - Prevent propagation to other devices/battery packs
- If indoors
  - Attack residential fire like normal
  - **During fire attack, uninvolved micro mobility device may ignite behind you!!**

Micro Mobility Tactical Considerations

- Move all lithium-ion battery cells and devices to a safe location, away from firefighting operations, **PRIOR to overhaul**
  - Use shovel with wooden handle
  - Outside is preferred
  - Consider bathroom, bathtub, sink, or metal bucket and fill with water if outdoor not an option
- Wear SCBA during overhaul
- Advise Investigators of possible LIB presence
- Request HazMat to assist with battery stabilization, mitigation, overpacking, and disposal
- Provide protection line during overpacking procedures

Electric Vehicles (EV)



Exponential Increase: Electric Vehicles (EV)

% of EVs Global Auto Sales

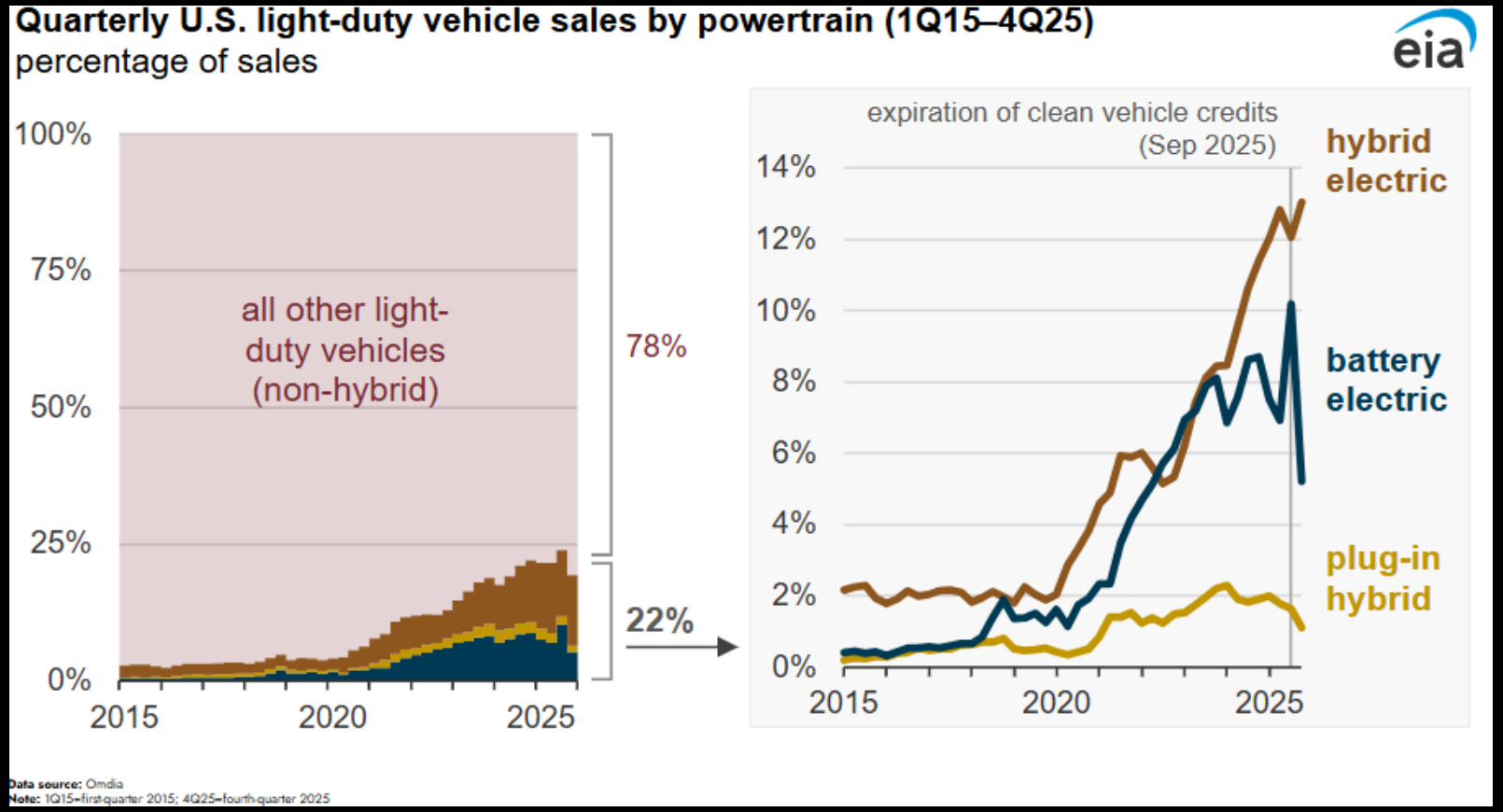
4.7% - 2020

15% - 2025

48% - 2035

California forecasted to be much higher.

By 2035 100% of all vehicle sales in CA must be battery or hydrogen powered



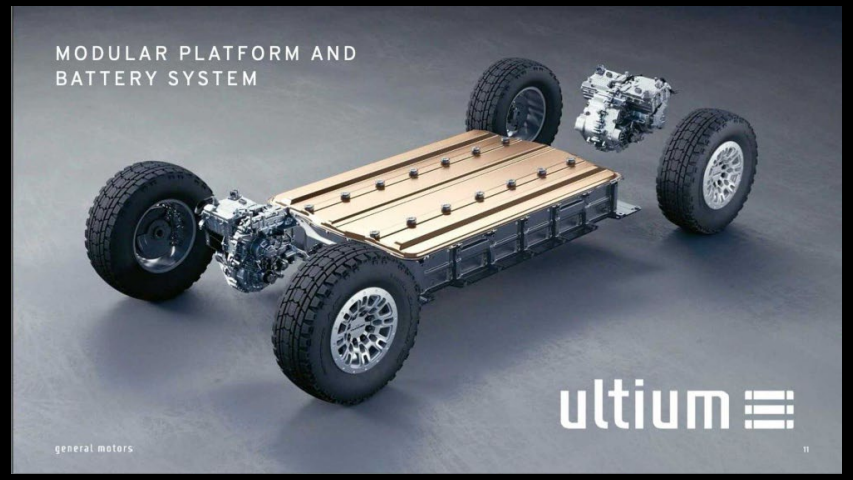
EV Battery Response

To gain an understanding of battery type, important to know:

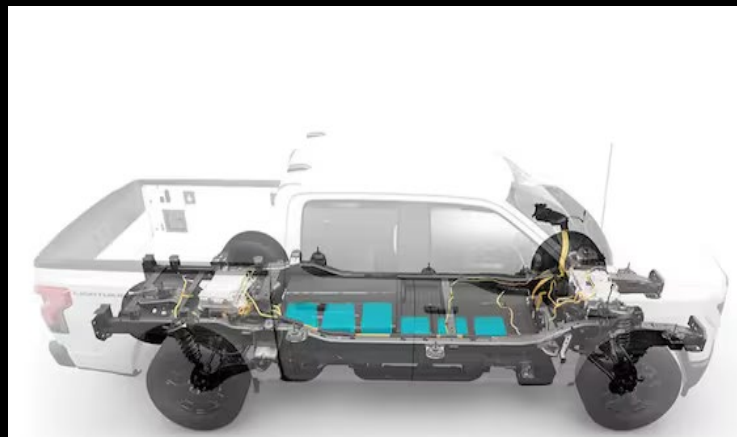
- Make
- Model
- Year
- Option

This is a luxury if available.

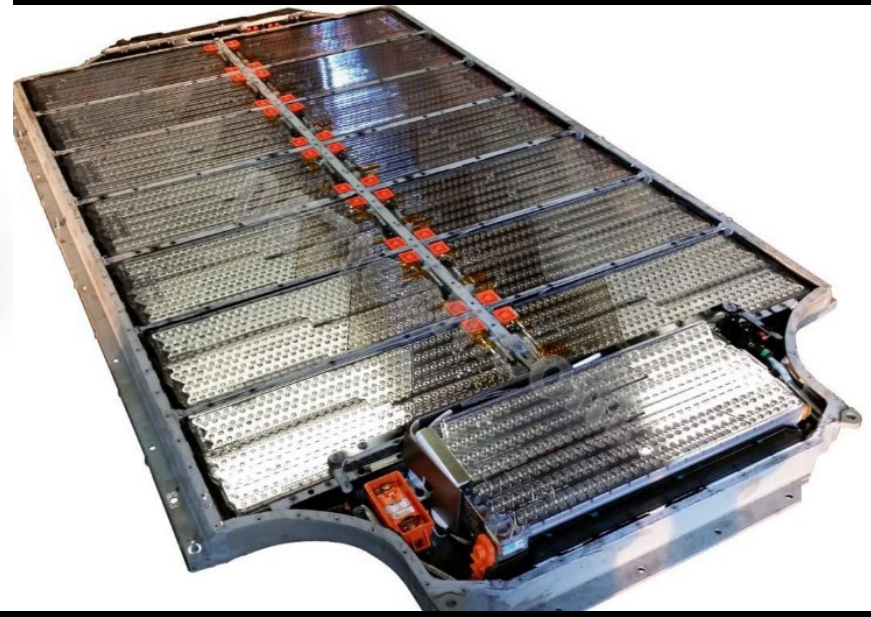
Electric Vehicles (EV) – Battery Packs



GM Battery Pack
Pouch Cells



Ford Lighting Battery Pack
Pouch Cells



Tesla Battery Pack
Cylindrical Cells

EV Battery Response

Different Make = Different Battery

Different Model = Different Battery

Different Year = Different Battery

Different Option = Different Battery

National Highway Transportation Safety Administration

Emergency Response Guides\Tech Ref

EV Battery Response (Tesla)

EV Battery Response (Toyota Prius)

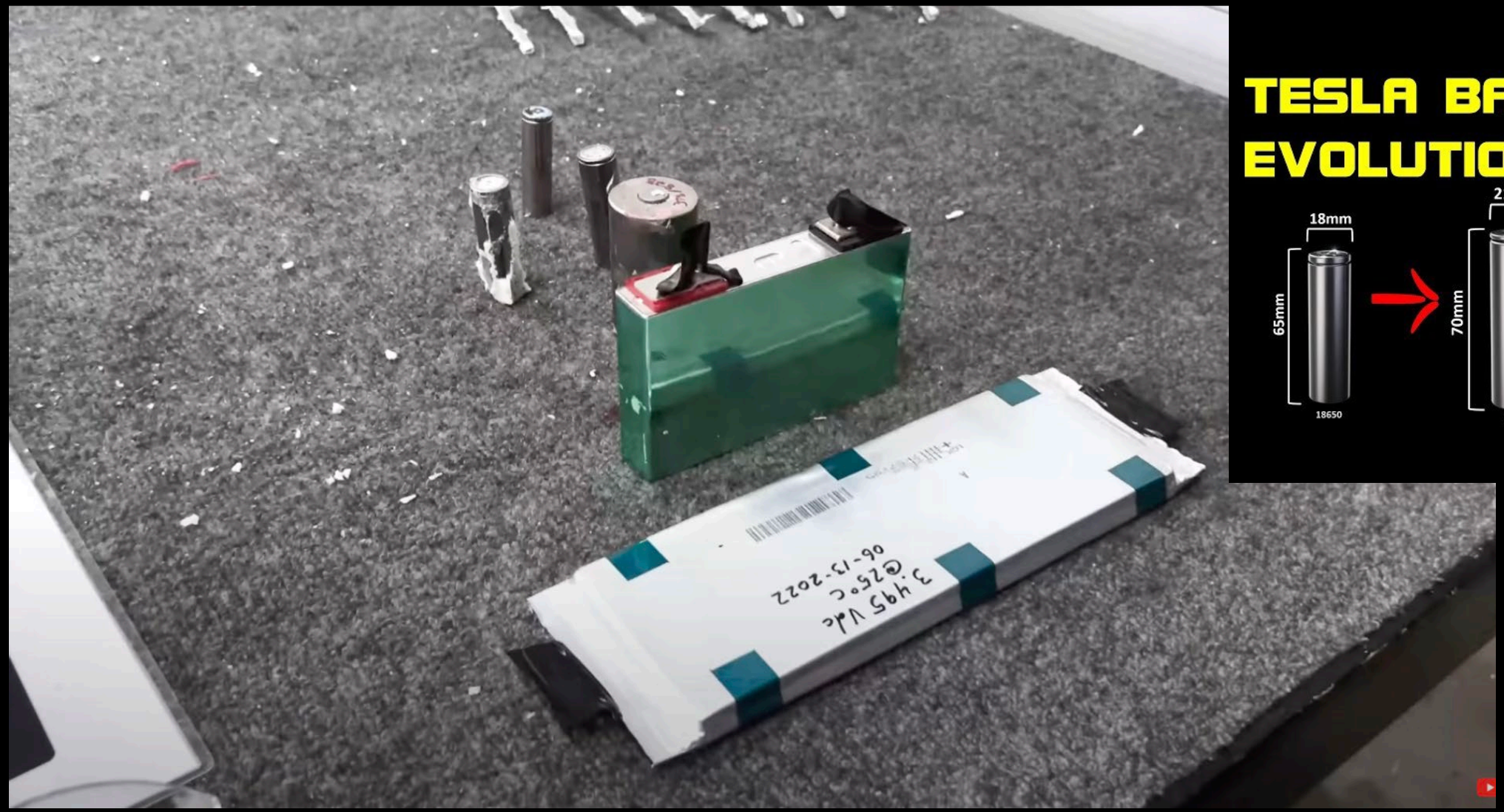
EV Battery Response (Nissan Leaf)

EV Battery Response (Subaru)

EV Battery Response (BMW i3)

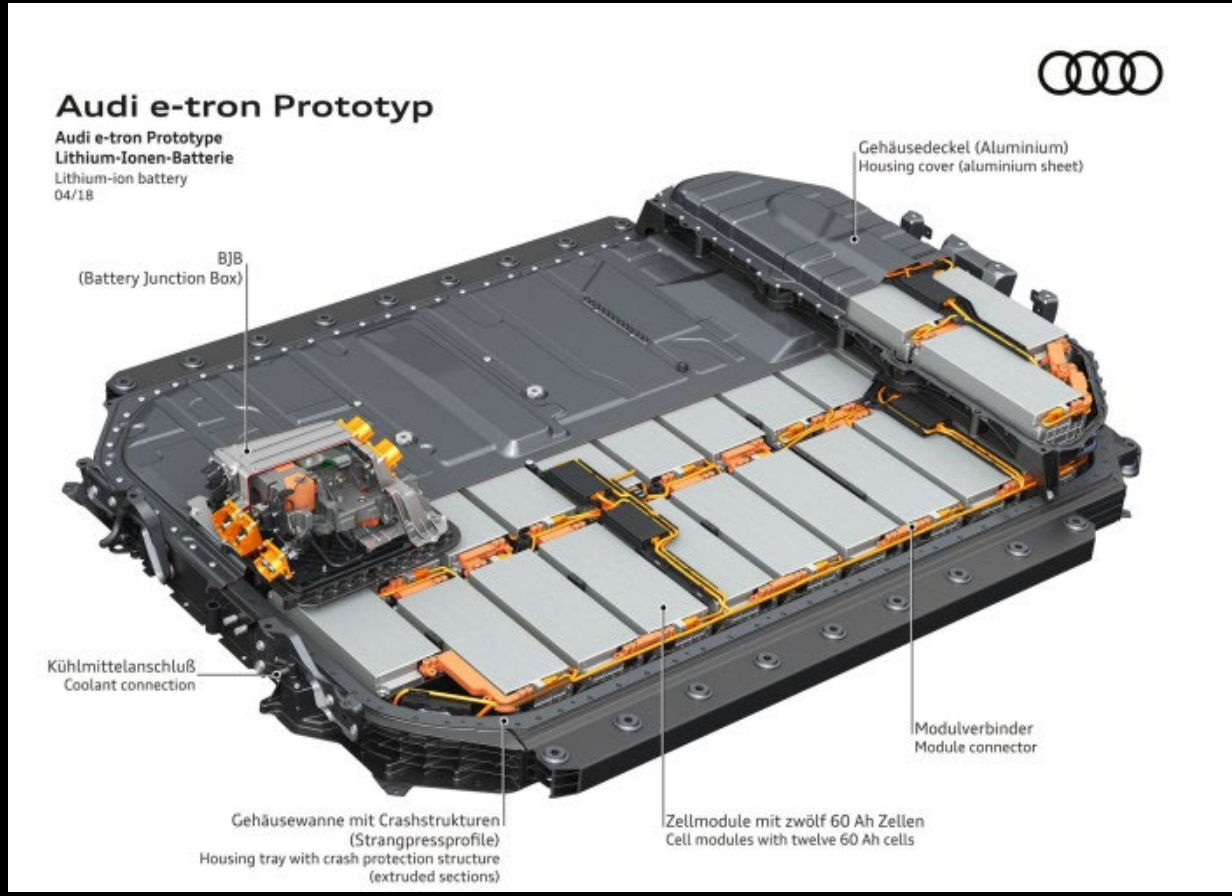
EV Battery Response

Electric Vehicles (EV) – Battery Packs



EV – Offensive Operations

- Water is considered best cooling agent
  - If offensive operation engaged:
    - Water should be applied under the vehicle and up at the batteries.
    - For pouch cell vehicles (i.e., GM), there may be access points near the wheel wells
    - Water application into access points to battery compartment can prevent propagation (manufacturer specific)
- **<u>Delayed thermal propagation ignition or delayed damage ignition of cells within the module or pack is common and cannot be predicted – can happen minutes, hours, days, weeks, months later!!</u>**



Example ERG

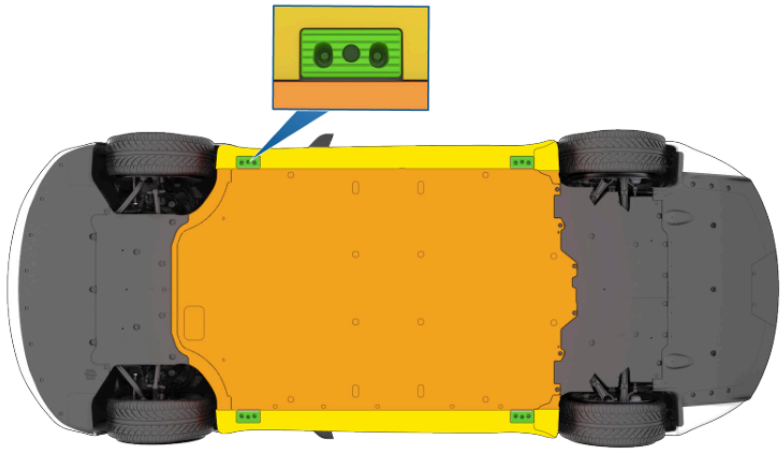
STABILIZATION / LIFTING POINTS

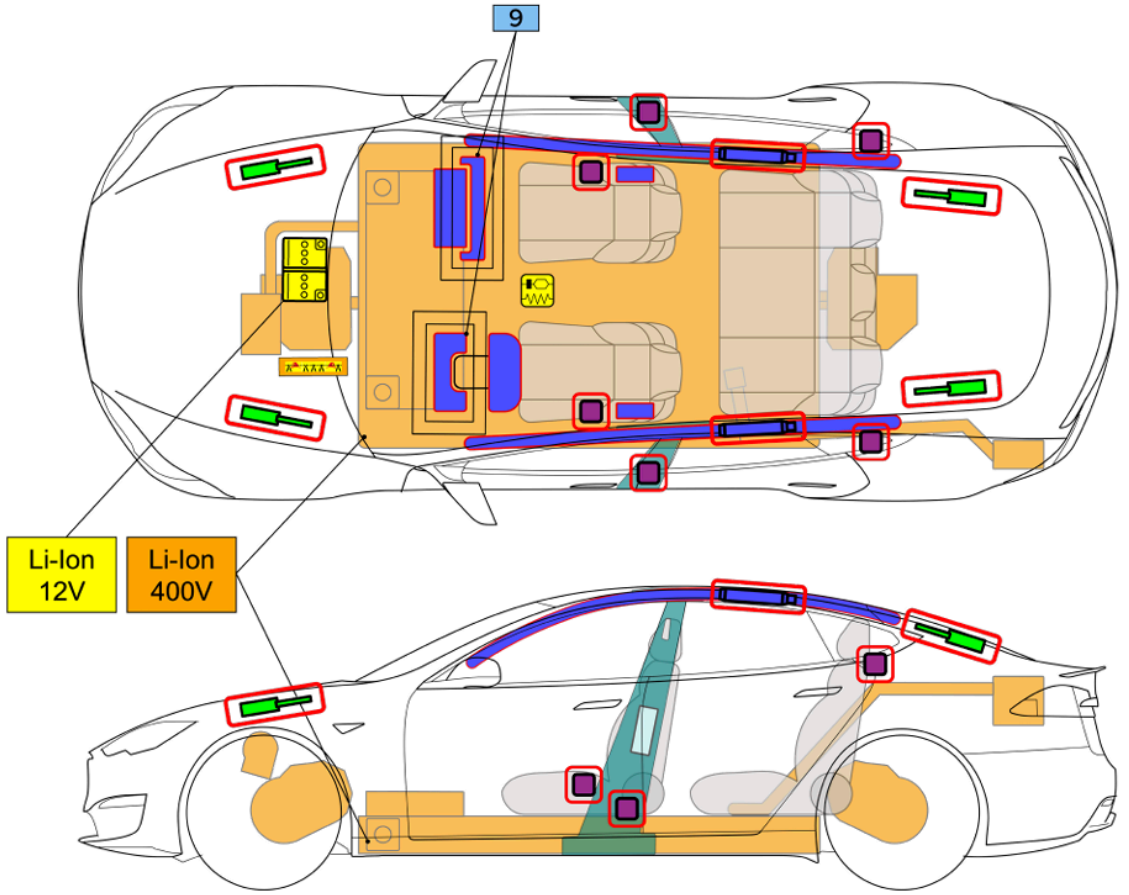
The high voltage battery is located under the floor pan. A large section of the undercarriage houses the high voltage battery. When lifting or stabilizing Model S, only use the designated lift areas, as shown in green.

> **WARNING** Be careful to not damage the battery pack while stabilizing / lifting the vehicle.

> **WARNING** The vehicle should be lifted or manipulated only if first responders are trained and equipped at the technician level per the applicable country's national fire training requirements and are familiar with the vehicle's lifting points. Use caution to ensure you never come into contact with the high voltage battery or other high voltage components while lifting or manipulating the vehicle.

> **WARNING** DO NOT USE THE HIGH VOLTAGE BATTERY TO LIFT OR STABILIZE MODEL S.





	Airbag		Stored gas inflator		Seatbelt preten-sioner		SRS Control Unit		Pedestrian protection active system
	Automatic rollover protection system		Gas strut/ pre-loaded spring		High strength zone		Zone requiring special attention		
	Battery low volt-age		Ultra ca-pacitor, low voltage		Fuel tank		Gas tank		Safety valve
	High voltage battery pack		High volt-age power cable/com-ponent		High voltage discon-nect		Fuse box disabling high voltage system		Ultra capaci-tor, high voltage
	Cable cut								

3 Keys to Success

EV Identification

PROTECT EXPOSURES!

(If possible)

Water

EV Fire Tactical Considerations

Life safety

- PPE
- Rescue / Check for victims
- Chock wheels
- Wind direction
- Evacuate / Shelter-in-Place

Incident Stabilization

- **<u>Attack the fire like a normal vehicle fire.</u>** Foam is NOT recommended
  - Most EV fires do not involve the batteries

- After confirming it is an EV and batteries are involved, if possible, allow the batteries to burn and evacuate the area 330’ in all directions and protect exposures.
- Stay out of smoke, toxic.
- Consider PPV fans to move smoke away from victims and responders.

EV Fire Tactical Considerations

- If extinguishment/cooling is required:
  - Secure a water supply
  - Consider tilting the vehicle to gain access to the underside of the vehicle
    - This will require training prior to placing into operations
    - Lifting points must be referenced
  - Consider directing spray into side vents of battery pack
  - Use a thermal imager to check for continued heating
  - Never cut, crush, puncture, or open a high voltage battery to extinguish it
  - If the cells are visible due to damage, you can direct a hose stream directly on the cell
  - Observe the battery and watch for evidence of thermal runaway

EV Fire Tactical Considerations

- Other considerations
  - Refer to the Emergency Response Guide (ERG) for the specific make and model of the vehicle for guidance on securing power to the lithium-ion battery. https://www.nhtsa.gov/emergency-response-guides
  - Some battery cooling mechanisms are powered by the 12-volt system
- Once the lithium-ion battery has been cooled, stand-by at least 120 minutes and continue monitoring the lithium-ion battery using the thermal imager and observe for any other signs of thermal runaway

EV Fire Tactical Considerations

- Tow Company
  - Make sure it's towed on a flatbed.
    - Regenerative braking sends power to batteries. This may cause a fire with rotational force on wheels
  - Store 50 ft away from all exposures
  - Prepare for rekindle
  - Determine disposal

EV Fire Tactical Considerations

Available Tools

- Fire blanket
- Encapsulant/Suppressants
- Piercing nozzles
- Dunk tanks
- Emergency Plug

EV Fire Tactical Considerations – Inside (underground/garage)


2023-04-11 08:30:46 :0600
AXON BODY 3 X60AC497T

EV Fire Tactical Considerations – Inside (underground/garage/warehouse)

- Garage
  - Approach from a 45° angle to avoid possible door explosion/over pressurization; deflagration-detonation phenomena.
  - If no active fire, be concerned with possible explosive atmosphere
- Warehouse
  - Careful cutting into rollup doors without knowing what's inside

EV Fire Tactical Considerations – Inside (underground/garage/warehouse)

- Underground Parking
  - Consider protection of exposures of life, environment, property/superstructure, and commerce.
  - Toxic atmosphere hazard
  - Explosive atmosphere
  - Allowing vehicle to burn is an option, with significant consequences to the structure
  - Identification of EV will be difficult, if not impossible. Follow your department SOP for underground vehicle fires
  - Perform thorough PPE and personal decontamination procedures

Battery Energy Storage System (BESS)

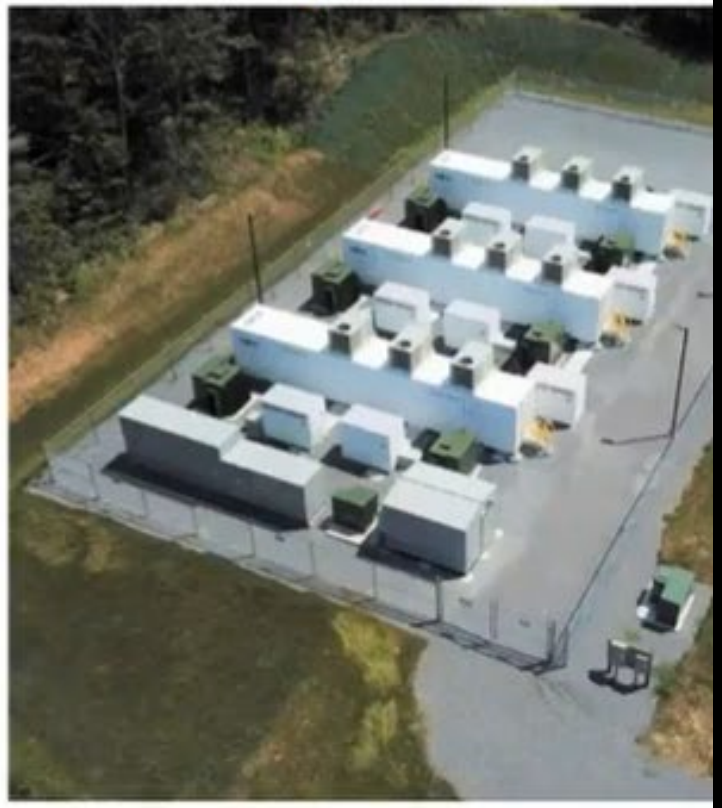
Residential

kWh

Commercial

kWh - MWh

Utility-Scale



MWh - GWh

KEY TAKEAWAYS FROM APS EXPLOSION REP

SEVERAL VALLEY FIREFIGHTERS HURT IN 2019 BLAST

abc 15 ARIZONA

Battery Energy Storage System (BESS)

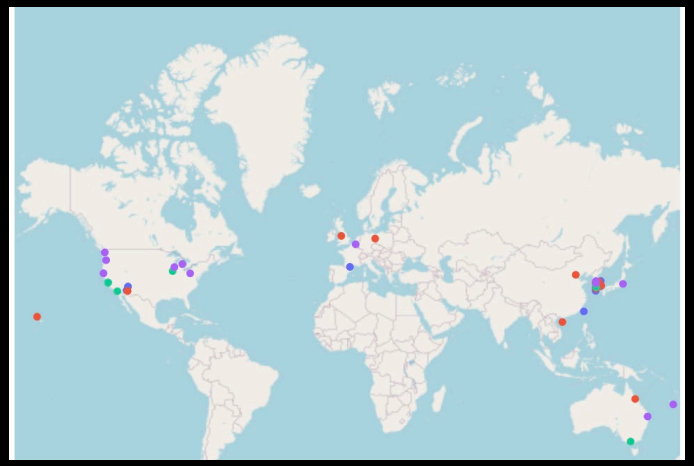
Battery Energy Storage System (BESS)

- Large Systems
- Multiple racks of batteries
- Surprise, AZ – 2019
- Regulations
  - NFPA 855
    - Safety measures
  - UL 9540 & 9540A
    - Testing of system
- Local zoning laws

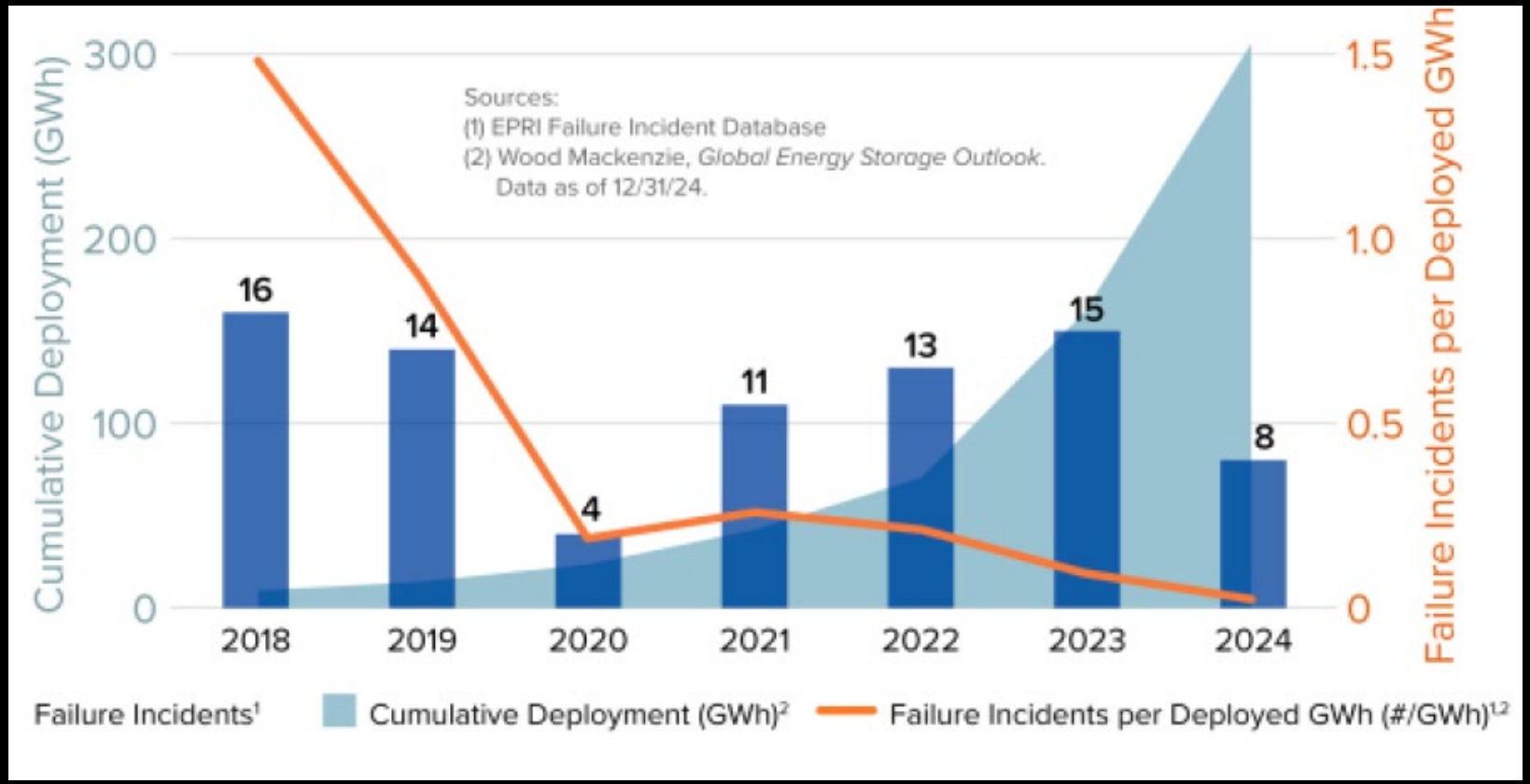
Battery Energy Storage System (BESS)

- Smaller Systems
- Urban locations
- City equipment
- Airports/Hospitals

BESS – Failure Events



- China
  - 2 FF Dead
- Surprise, AZ
  - 8 FF injured
- Chandler, AZ
- Victoria, Australia
- Moss Landing, CA
- Valley Center, CA
- Otay Mesa, San Diego, CA



BESS Failure Tactical Considerations

- Signs of possible BESS Failure
  - Suspicious odor emanating from the BESS
  - Smoke/Gas Cloud
    - Battery thermal runaway fires are preceded by smoke/gas
- If fire, smoke, or suspicious odor is observed, consider:
  - If possible, shut off the unit/system.
  - Evacuate the area of all non-emergency personnel.
  - Do not approach the unit and attempt to gain access.
    - Some BESS safety mechanisms are designed to maintain doors shut, and other have automatic ventilation doors.
  - Contact site emergency contact and/or manufacturer.

BESS Tactical Considerations

If a fire is confirmed:

- Confirm if batteries are involved
- Non-Intervention or Defensive Operations
- Establish water supply.


1.2 GWh in Moss Landing, CA

Life safety

- Stay out of smoke!
- PPE
  - Structural Firefighting Gear and SCBA.
- Rescue
- Evacuate / Shelter-in-Place
  - Use as much "ground truth" as possible to determine distance
  - Use air monitoring devices.

BESS Tactical Considerations

Incident Stabilization

- Let it burn!
  - Applying water to the burning unit will only delay the event.
  - May take multiple operational periods.
  - During periods of module propagation, there may be no sign of fire, but the event can still be active and flare up can still occur.
- Environmental Protection
  - Minimize/contain/redirect runoff if possible
  - Use lowest GPM needed

BESS Tactical Considerations

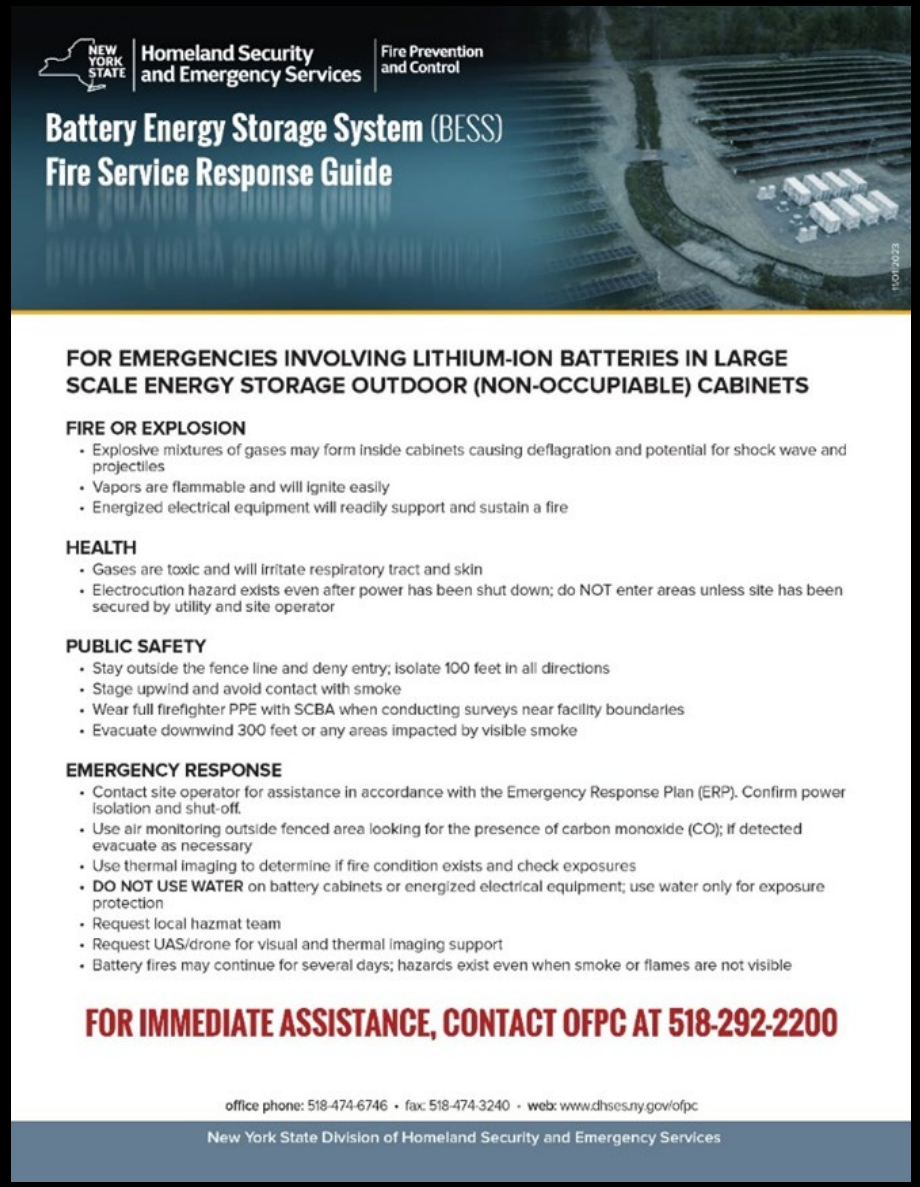
Property Conservation/Environmental/Commerce Conservation

- Allow system safety devices to operate as designed.
- Monitor alarm panel and manually activate any safety devices if appropriate.
- Prevent propagation.
  - Water curtains and unstaffed lines
  - Apply from a distance and upwind if possible.
    - Protect exposed packs
    - Extinguish and protect other infrastructural exposures
    - Use 30-degree fog for water curtains to absorb heat and knock down toxic plume
- Protect other exposures.
  - Neighboring structures
  - Vegetation
- Recovery
  - Allow batteries to cool (this process may take 12-48 hours or longer).
  - Use on-site resources and manufacturer for decommissioning and recovery plans.
- Impacts to Commerce

BESS Tactical Considerations

- Resources to consider
  - BESS Personnel / PRP
  - EPA, State Environmental Agency, HazMat Teams
  - Health Department
  - Gas/Electric
  - Private Contractor

NY State BESS Fire Resources



NEW YORK STATE | Homeland Security and Emergency Services | Fire Prevention and Control

Battery Energy Storage System (BESS) Fire Service Response Guide

FOR EMERGENCIES INVOLVING LITHIUM-ION BATTERIES IN LARGE SCALE ENERGY STORAGE OUTDOOR (NON-OCCUPIABLE) CABINETS

FIRE OR EXPLOSION

- Explosive mixtures of gases may form inside cabinets causing deflagration and potential for shock wave and projectiles
- Vapors are flammable and will ignite easily
- Energized electrical equipment will readily support and sustain a fire

HEALTH

- Gases are toxic and will irritate respiratory tract and skin
- Electrocution hazard exists even after power has been shut down; do NOT enter areas unless site has been secured by utility and site operator

PUBLIC SAFETY

- Stay outside the fence line and deny entry; isolate 100 feet in all directions
- Stage upwind and avoid contact with smoke
- Wear full firefighter PPE with SCBA when conducting surveys near facility boundaries
- Evacuate downwind 300 feet or any areas impacted by visible smoke

EMERGENCY RESPONSE

- Contact site operator for assistance in accordance with the Emergency Response Plan (ERP). Confirm power isolation and shut-off.
- Use air monitoring outside fenced area looking for the presence of carbon monoxide (CO); if detected evacuate as necessary
- Use thermal imaging to determine if fire condition exists and check exposures
- **DO NOT USE WATER** on battery cabinets or energized electrical equipment; use water only for exposure protection
- Request local hazmat team
- Request UAS/drone for visual and thermal imaging support
- Battery fires may continue for several days; hazards exist even when smoke or flames are not visible

FOR IMMEDIATE ASSISTANCE, CONTACT OFPC AT 518-292-2200

office phone: 518-474-6746 • fax: 518-474-3240 • web: www.dhses.ny.gov/ofpc

New York State Division of Homeland Security and Emergency Services

Transportation Related Tactical Considerations

- Are batteries involved?
- Can it be allowed to burn?
- Protect surroundings
- Can it be moved?

Battery Accumulators

- May have large numbers of batteries (thousands to millions)
- Batteries may be ancillary to the business, or may be the business
- No limitations to location or staging

Battery Accumulator Identification

- Currently not necessarily required to report
- May contain many various battery types and chemistries
- Fires may be difficult to extinguish due to large amounts of plastic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Channel10

Damaged Batteries are Unpredictable

Damaged Batteries are Unpredictable


UN3480

Battery Recyclers

Lithium-Ion Battery Case Study:

2025 SoCal Wildfires

Legal Disclaimer

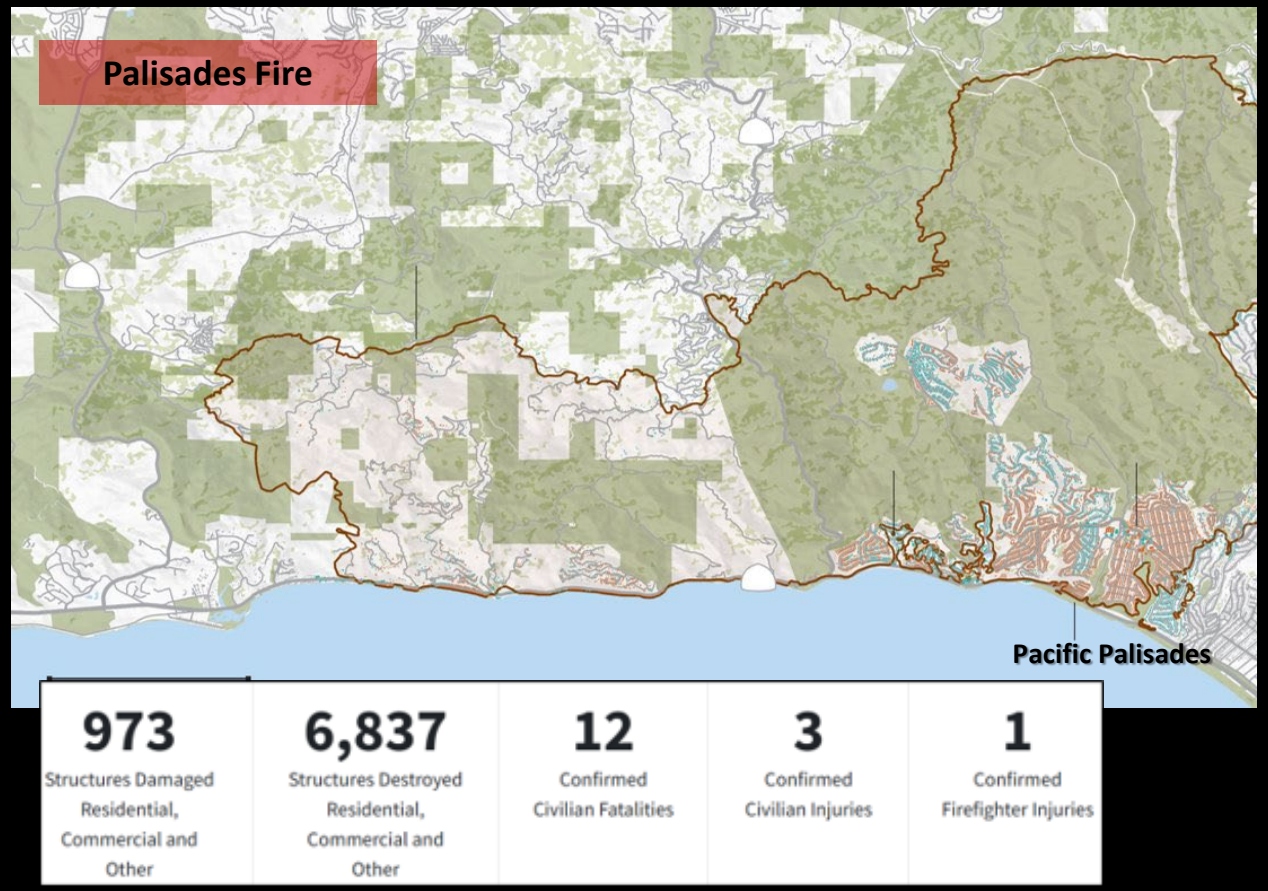
The information provided herein is intended for informational purposes only and should not be construed as legal advice, relied upon nor as establishing a professional or contractual relationship with any participants. The actions carried out by the U.S. Environmental Protection Agency (EPA), its contractors, and support staff during Maui and/or SoCal Wildfire Responses were based solely on the knowledge, data, and information available at the time. It is important to note that, during these responses, the behavior of lithium-ion batteries in wildfire scenarios was not fully understood, and any interpretations or conclusions drawn from subsequent analysis may differ from those applied at the time.

The EPA, its contractors, and support staff acknowledge that lessons learned from past responses, emergent data, and evolving regulatory frameworks may inform future actions and decisions related to disaster response efforts. As such, individuals and entities are advised to consult other relevant sources and experts for current information and guidance regarding environmental safety and emergency response protocols. The EPA and presenters of these Case Studies disclaim any liability for actions taken or decisions made based on the information provided herein.

EPA Mission

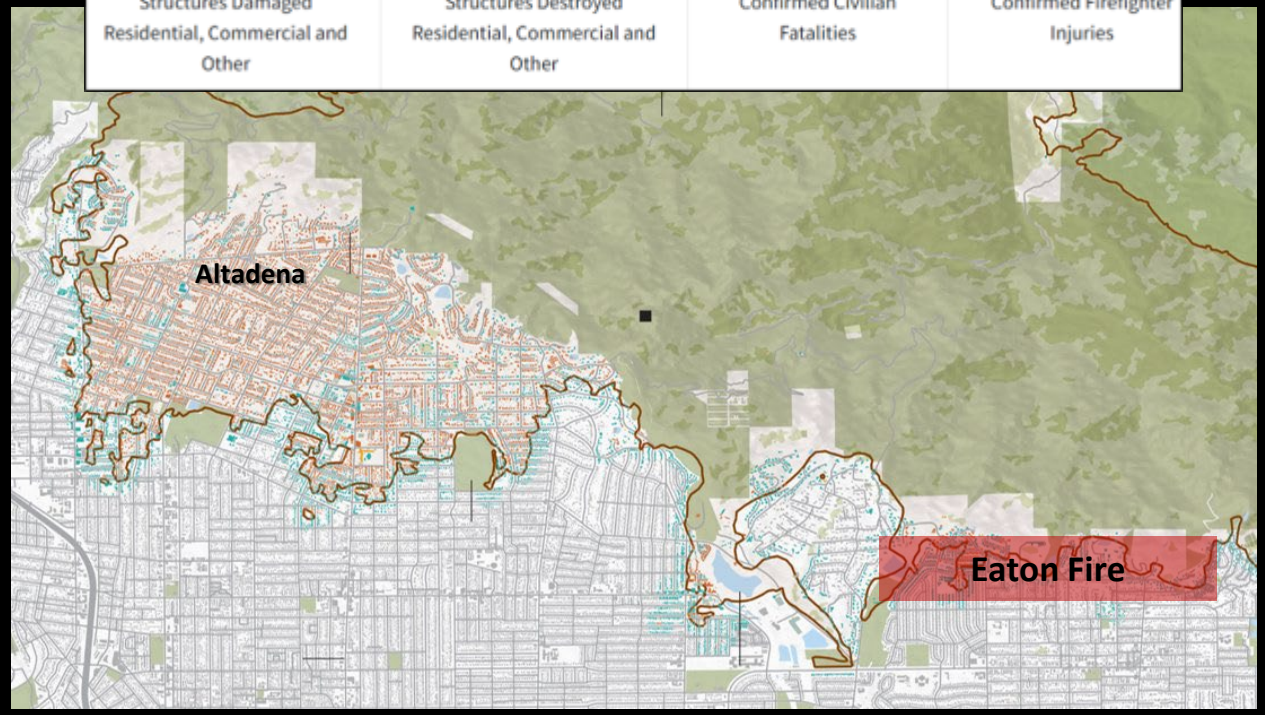
Stafford Act Response

MA: Address Li-Ion Batteries



973	6,837	12	3	1
Structures Damaged Residential, Commercial and Other	Structures Destroyed Residential, Commercial and Other	Confirmed Civilian Fatalities	Confirmed Civilian Injuries	Confirmed Firefighter Injuries

1,074	9,414	17	9
Structures Damaged Residential, Commercial and Other	Structures Destroyed Residential, Commercial and Other	Confirmed Civilian Fatalities	Confirmed Firefighter Injuries



- On January 7, 2025, a fire started in the Pacific Palisades region of Los Angeles.
- Fires quickly spread across multiple areas of the city. More than 57,000 acres of land were devastated (89 square miles).
- Over 200,000 people were evacuated.
- More than 18,000 structures were damaged or destroyed.

Battery Operations Roadmap

- Battery Identification
- Data Management
- Field Operations
  - Electric Vehicles
  - Energy Storage Systems
  - Other Arrays
- Battery Processing
- Battery Termination
- Disposal

Reconnaissance

Los Angeles Wildfires

Lithium-ion batteries burned by wildfires

The U.S. Environmental Protection Agency (EPA) has been assigned by the Federal Emergency Management Agency (FEMA) to remove lithium-ion batteries affected by the Los Angeles County wildfires.

This includes battery:

- recovery
- safe transportation
- processing (de-energizing)
- safe disposal

⚠ Use extreme caution when returning to your property ⚠

Your home may have damaged or destroyed lithium-ion batteries, lithium-ion battery energy storage systems, and electric and hybrid vehicles.

- ✓ **The batteries should be considered extremely dangerous**, even if they look intact.
- ✓ **Lithium-ion batteries can spontaneously re-ignite, explode, and emit toxic gases and particulates even after the fire is out.**

Household Items with Lithium-Ion Batteries:

Other examples:

- Electric/hybrid vehicles
- Electric bikes
- Hoverboards
- Wheelchairs
- Digital cameras
- Home alarms
- Power banks or stations
- Game controllers
- Home energy storage systems
- Personal mobility device
- Scooters
- Drones
- Tablets
- Power tools
- Vaping devices

January 25, 2025 *epa.gov/california-wildfires* *1-833-798-7372*

If you hear a popping, hissing noise, or see smoke or fire:

1. Do not attempt to extinguish or smother the battery.
2. Leave the area immediately.
3. Move upwind at least 330 ft (the length of a football field) and **call 911**.

- **Do not** touch fire-damaged products with lithium-ion batteries – they can ignite.
- **Do not** start, move, tow, or charge a fire-damaged electric/hybrid vehicles (EV, PHEV, HEV). These will be assessed by EPA hazardous material professionals.
- **Do not** use or start a fire-damaged residential energy storage or house battery. These will be assessed by EPA hazardous material professionals.
- **Do not** enter enclosed spaces with lithium-ion battery products.
  - Gasses and vapors from damaged lithium-ion batteries can build up in enclosed spaces (such as a garage, shed, basement, or closet) and may produce an explosive environment.

- **DO** call our hotline if you encounter a lithium-ion battery while re-entering your property and/or are unsure if a lithium-ion battery was damaged.

epa.gov/california-wildfires

For questions about this work or **if you have an electric or hybrid vehicle and/or a battery energy storage system in the burn zone**, call the EPA hotline at:

1-833-R9-USEPA
(1-833-798-7372)

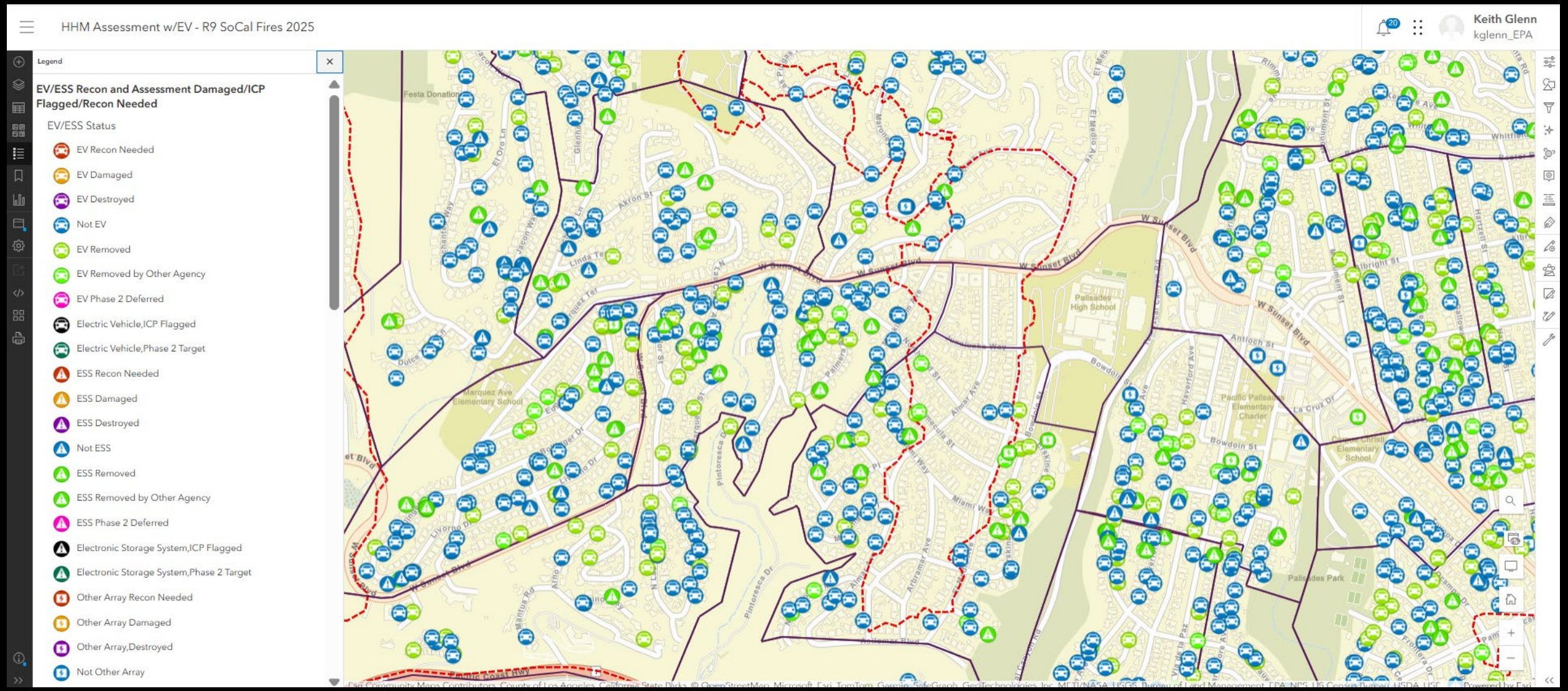
Preliminary ID

- SARCOPS (Search and Rescue)
- CUPA Teams (Certified Unified Program Agency) – LACoFD
- Recon Teams

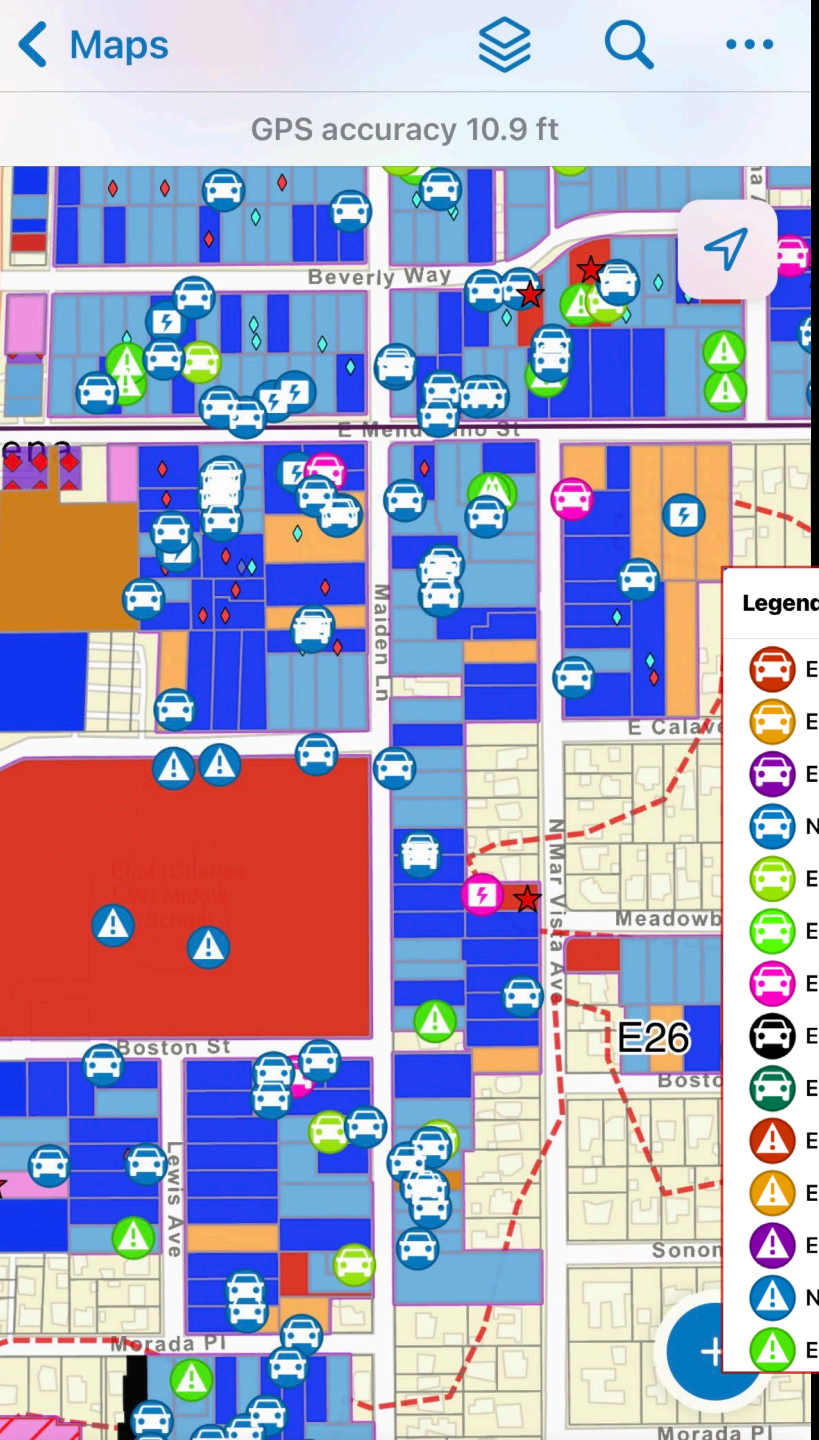
Other Identification Routes

- HHM Referrals
- Local Permits
- EPA Hotline
- Information Requests/SCE – Tesla, Enphase
- Phase II/Army Corps

Reconnaissance



Data Management



- All vehicles identified and loaded into mapping system
- EV/Non-EV
- Make/model/year when identifiable
- Photos
- Safety concerns
- Other notes from recon teams

Battery Recovery Teams

Teams

- EPA OSC
- Technical Contractor (Air monitoring/Data management)
- Equipment Operator
- 5-6 Hazmat Technicians
- Electrician
- (opt.) LACoFD H&S Officer

Equipment

- Mini-excavator
- Water buffalo
- Extrication tools
- Hand tools

H&S

- FR Tyvek, Respirator with combination acid-gas cart., Steel toe/steel shank boots, hard hat, safety glasses
- 75’/330' evac radii

Battery Recovery - EV

Battery Recovery - EV

Battery Recovery - EV

Battery Recovery - EV

Battery Recovery - ESS

Battery Recovery - ESS

Battery Recovery - ESS







Battery Recovery – Partially & Undamaged

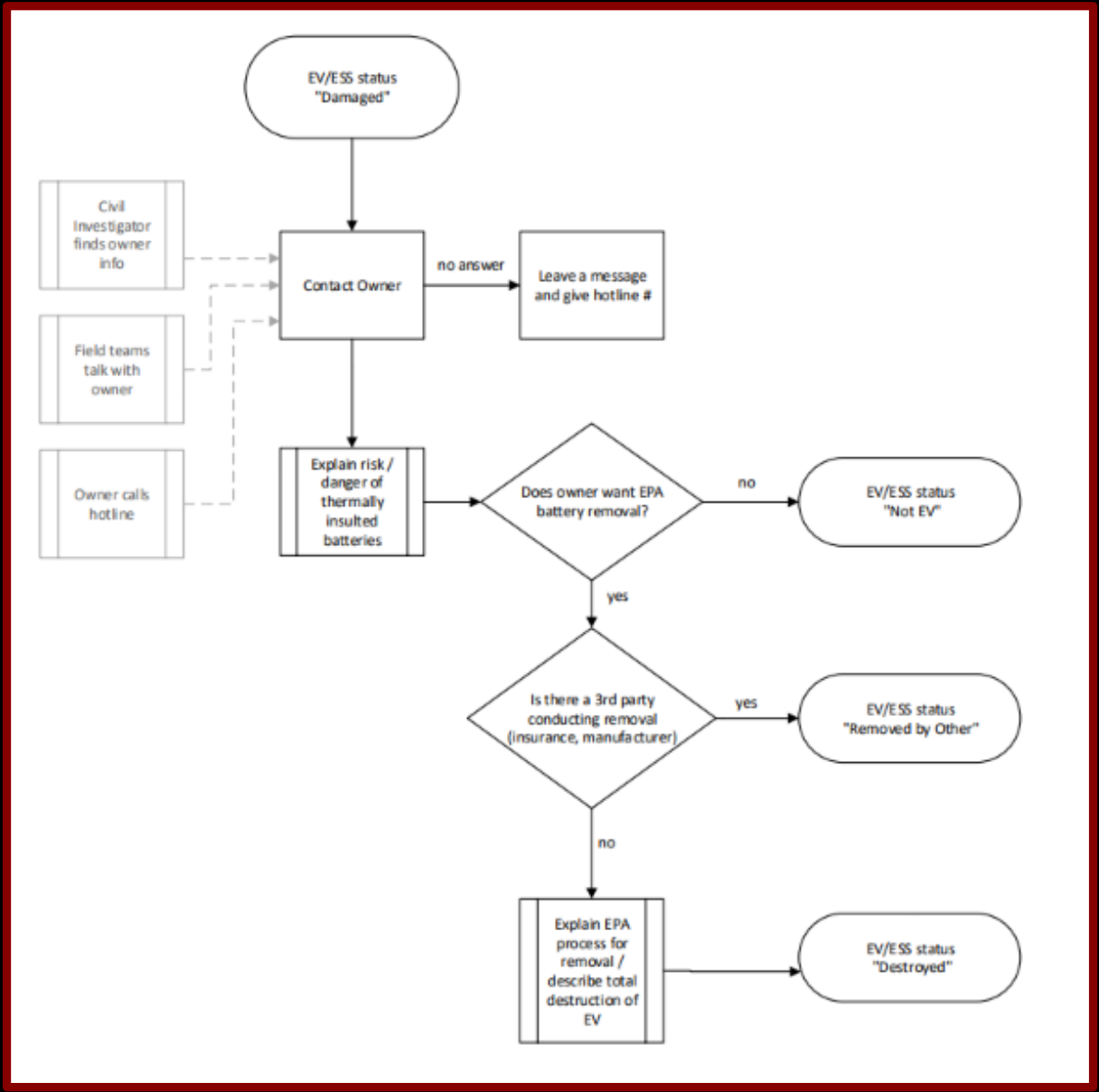
Primary Hazards:

- Thermal Runaway
- Offgassing

60°C (140°F) – Temperature exposure level where we begin to see thermal impact to batteries

EPA developed an adjudication process to work with residents and determine who would be handling units that were only slightly damaged in the fire (EPA, DOT, insurance, other)

Battery Recovery – Partially & Undamaged Adjudication Process

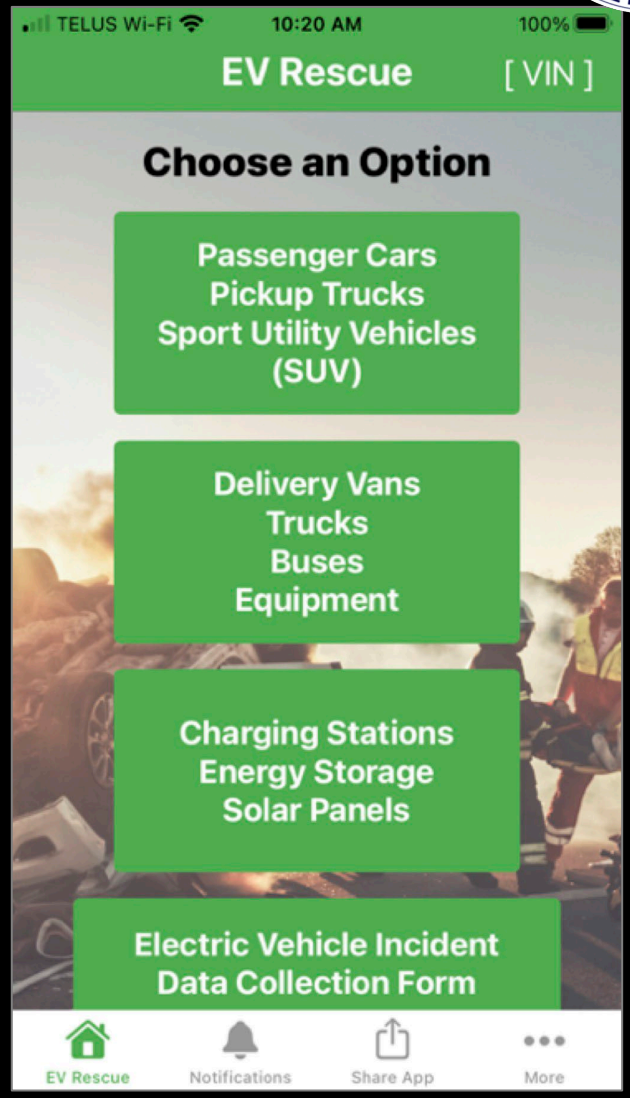


- Use of Civil Investigators
- Work with local authorities
- Contact Owner
- Explain hazards
- Make a determination
- Data Management input / Documentation

Battery Recovery – Partially & Undamaged

Battery Recovery – Partially & Undamaged

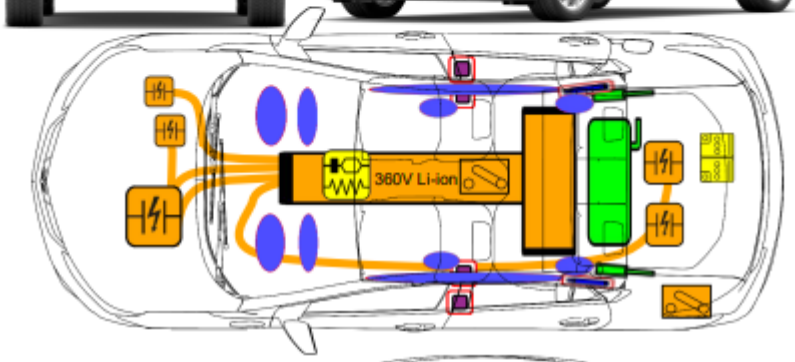
Electric Vehicle Response Resources

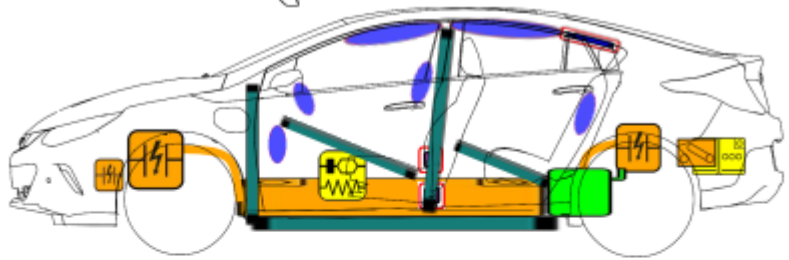


GM

Chevrolet Volt
5 Door Hatchback
2016

First Responder
Rescue Sheet





	Air Bag		Stored Gas Inflator		Seat Belt Pretensioner		SRS Control Unit		
			Gas Strut/ Preloaded Spring		High Strength Zone				
	Battery Low Voltage				Fuel Tank				
	High Voltage Battery Pack		High Voltage Power Cable		High Voltage Disconnect				Ultra Capacitor, High Voltage

RSN - 1G1-201601 (V03)

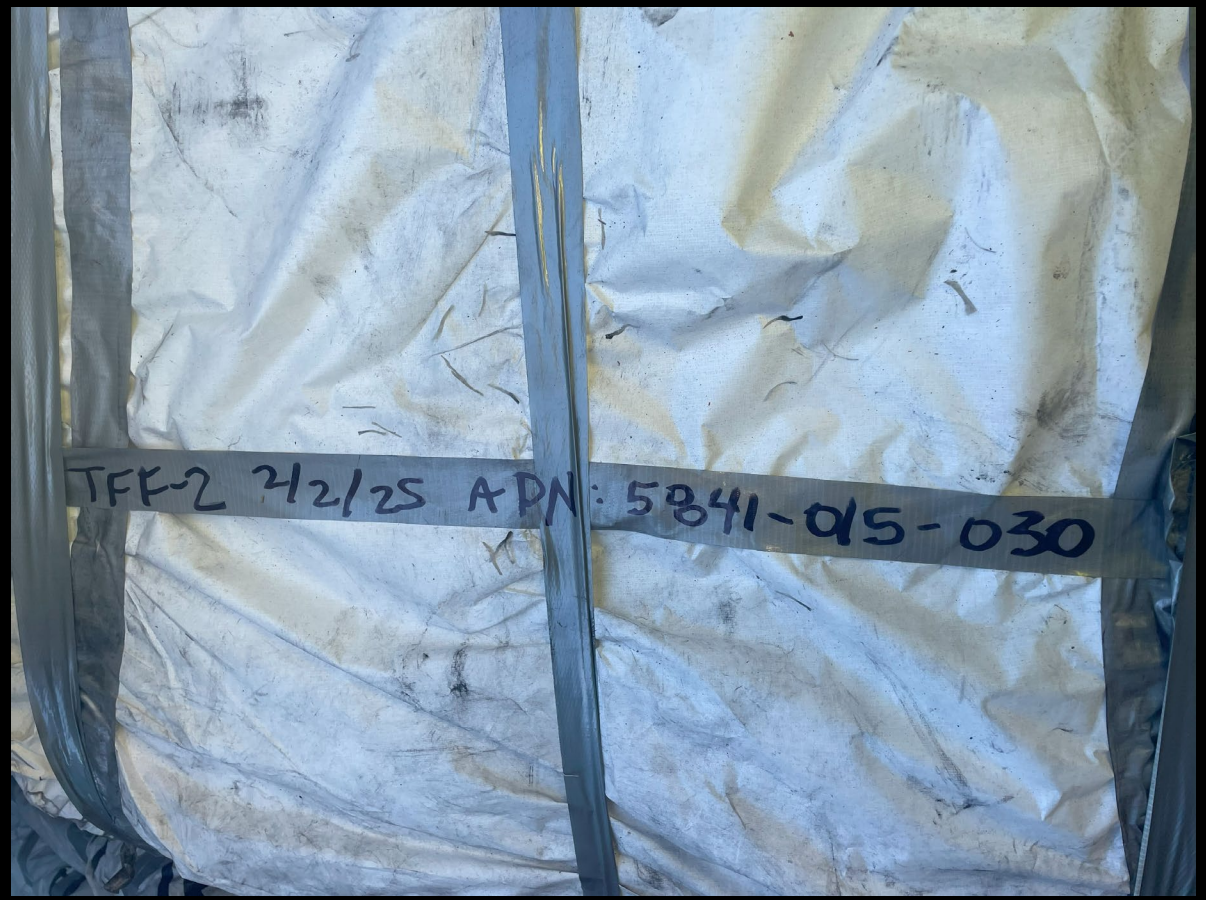
Battery Recovery – Partially & Undamaged

Battery Recovery – Partially & Undamaged

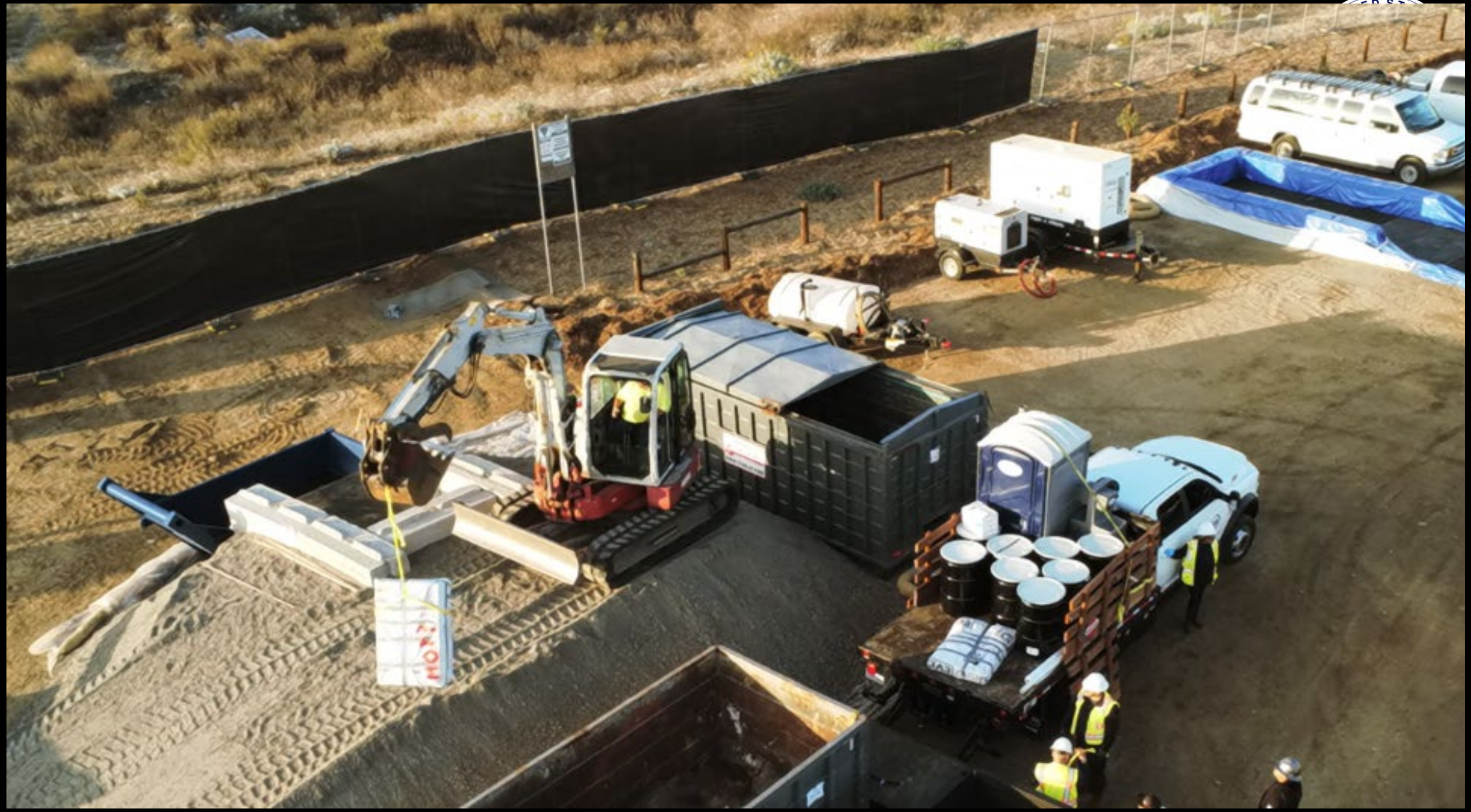
Battery Recovery – Partially & Undamaged

Battery Recovery – Partially & Undamaged

Battery Transport



Staging



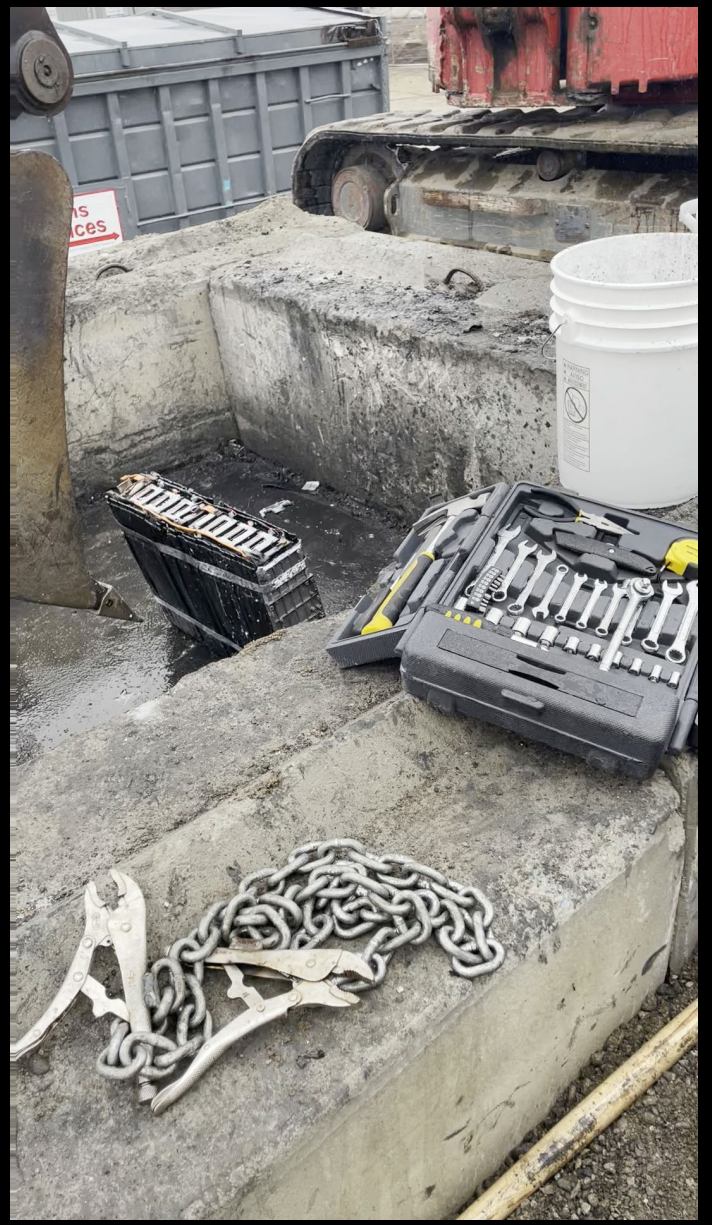
Battery Processing

- Types of Batteries
  - NiMH
  - Lithium Ion
    - Cylindrical
    - Prismatic
    - Pouch
- Processing
  - Brine Bath – Baking Soda and NaCl
  - Smash Pad
  - Vibratory Roller
  - Shredder/Excavator

Battery Processing - Brining

Battery Processing – Smash Pad

Battery Processing – Smash Pad



Battery Processing - Crushing

Battery Processing - Shredding

Battery Processing - Shredding

Final Product

Disposal

Disposal

Processed battery material is no longer considered Hazardous Waste

In Maui – sent via vented cubic yard boxes to a recycling facility

In CA – First attempt at bulk disposal using roll-offs.

- Air monitoring investigation determined that ventilation was necessary for transportation due to H_2 accumulation/LEL.
- Disposal through Clean Harbors to a facility in Utah.

Air Monitoring

Biggest concerns are H_2 gas, HF, and metals. Respirators mandatory during battery processing operations.

- AreaRae
- Dustrak
- SPM Flex (HF – Mineral Acid)
- SPM Flex (HCN)

**H_2 is cross-sensitive with CO, so standard suite of sensors were used and adjusted

Heavy metals – Personnel monitoring.

Statistics

SoCal vs. Maui Battery Processing

Increased quantity of recon/recovery teams & staging areas
Larger staging/processing – frac tanks, equipment, smash pad
More processing capacity
Smaller footprint per staging area
Use of shredders
Better understanding of batteries; lessons learned from Maui
Willingness to expand beyond our knowledge and try new methods

Maui Wildfires

~1,200 properties
~400 targets
~98 vehicles & 150 ESS locations
30 tons (est) batteries processed
90-day timeframe
~3 teams recon/recovery/processing

SoCal Wildfires

~18,000 properties
>5,000 ESS & EV targets
~645 vehicles & 420 ESS locations
500 tons (est)
28-day timeframe
~25 teams recon/recovery/processing

Challenges

- Expedited timeline
- Obtaining personnel and resources
- Training personnel in batteries
- Not in my back yard (NIMBY)
- Topography
- Volume of material
- Separate geographical locations
- Natural disasters (landslides)

The New York Times

The New NIMBY Battle Over the Waste From the L.A. Fires

Federal and state officials say the temporary sites for processing hazardous waste pose no threat, but residents are worried about their air and water.

CALIFORNIA

Heavy mudslides and flooding shut down PCH, sweep vehicle and firefighter into ocean

Li-Ion Battery Response Considerations

Module 4: Health and Safety

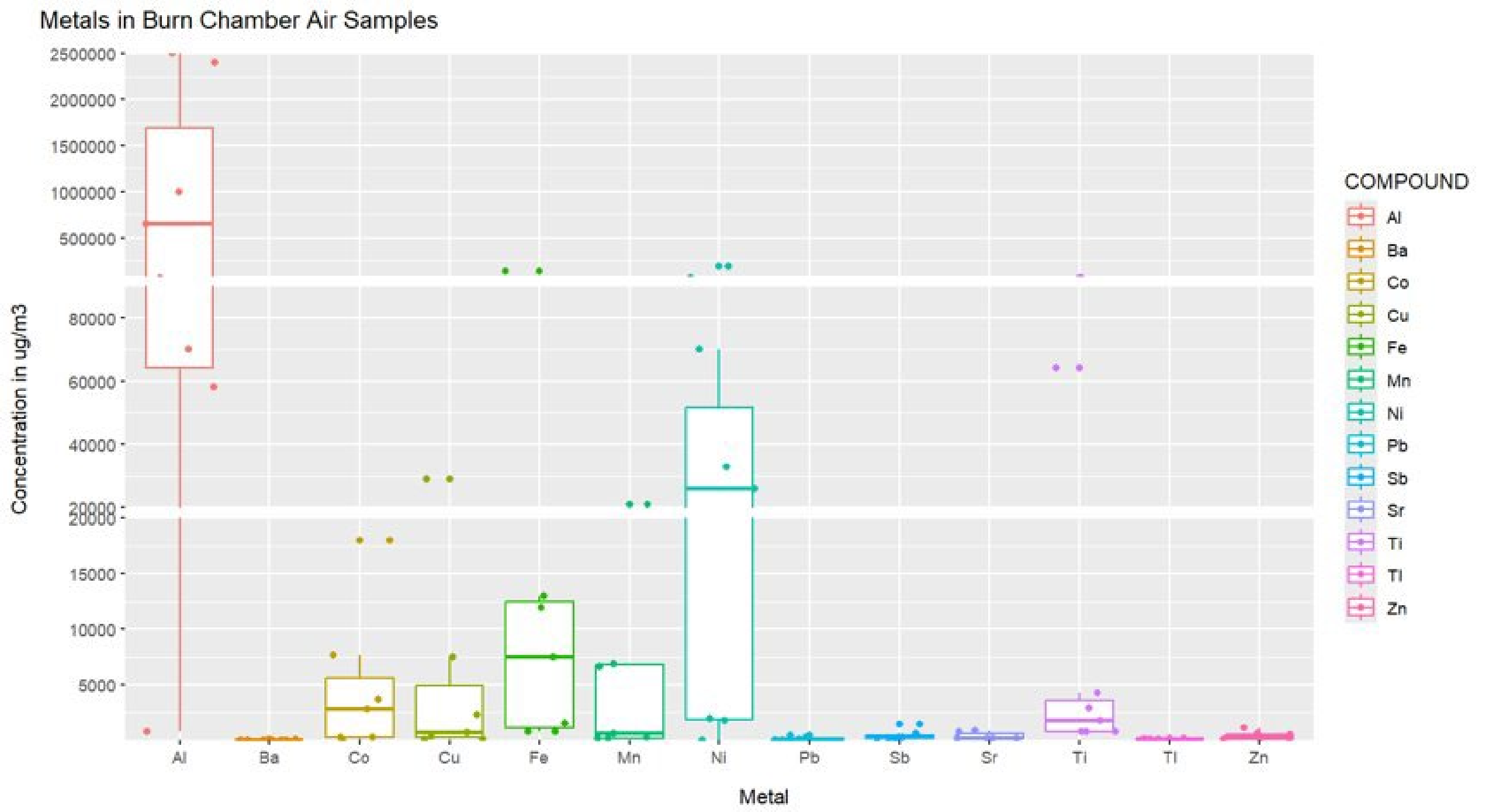
Air Monitoring
What chemicals to look for
Equipment Considerations
Personal Protection

Air Monitoring

Target Compounds for Lithium-Ion Battery Fires

Compounds	Hydrocarbons	Particulates (Metals)
Hydrogen	Methane	Manganese
Hydrogen Fluoride	Ethylene	Copper
Carbon Monoxide	Propylene	Nickel
Sulfur Dioxide	Propane	Cobalt
Hydrogen Cyanide	Ethane	Carbon Black
Hydrogen Chloride	Acetylene	Lithium
Hydrogen Sulfide		Aluminum
Ammonia		Zinc Oxide
Formaldehyde		Cadmium
Phosphoryl Fluoride		Lead
Phosphorus Pentafluoride		Silver
Phosphorus Trifluoride		Antimony
		Tin
Green=visible on PID		Barium
		Iron
		Thallium

Post Maui – San Diego Study


Metals in Burn Chamber Air Samples
Concentration in ug/m3
2500000
2000000
1500000
1000000
500000
80000
60000
40000
20000
15000
10000
5000
Al
Ba
Co
Cu
Fe
Mn
Ni
Pb
Sb
Sr
Ti
Tl
Zn
Metal
COMPOUND
Al
Ba
Co
Cu
Fe
Mn
Ni
Pb
Sb
Sr
Ti
Tl
Zn

Air Monitoring – RAE Sensors

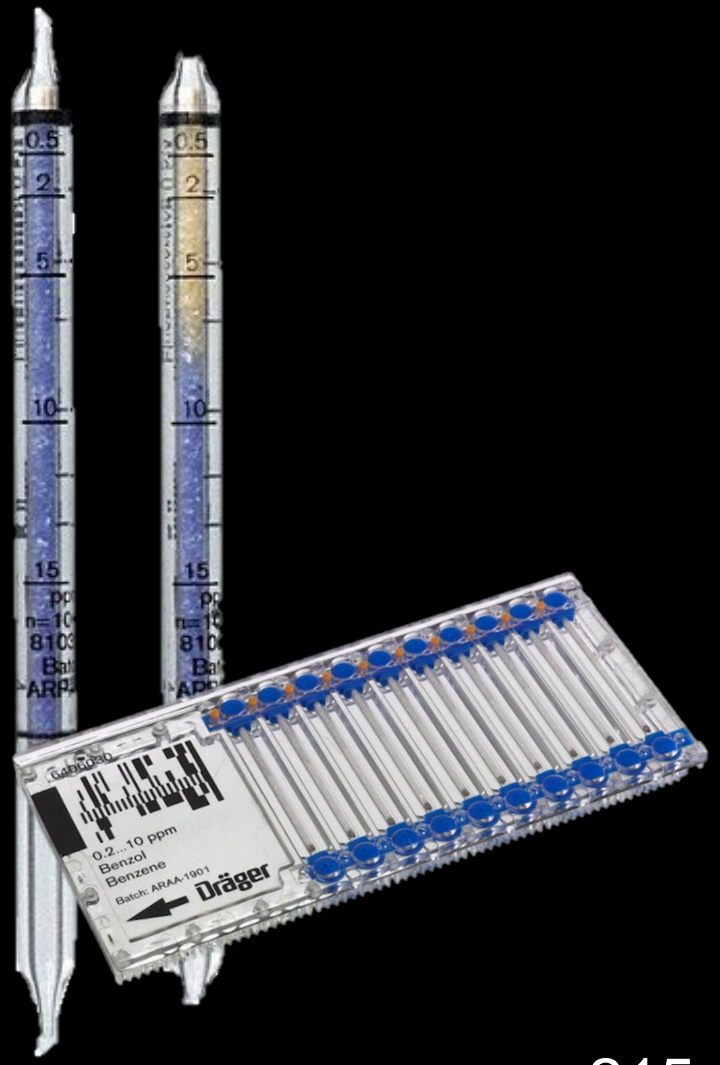
Target Compound	Ionization Potential	RAE Sensor	Detection Range
Carbon Monoxide	14.01 eV	CO	0-500 ppm
Hydrogen Fluoride (AreaRAE Only)	15.98 eV	HF	0.5-10 ppm
Sulfur Dioxide	12.3 eV	SO2	0-20 ppm
Hydrogen	15.43 eV	LEL H2	0-100% (0-30% O2) 0-1000 ppm
Hydrogen Chloride (AreaRAE Only)	12.74 eV	HCl	0-15 ppm

Air Monitoring – SPM Flex

Target Compound	SPM Flex Tape	Detection Range
Hydrogen Fluoride	Mineral Acid	0.4-20 ppm
Sulfur Dioxide	Sulphur Dioxide	0.01-2.5 ppm
Hydrogen Chloride	Mineral Acid	0.2-20 ppm

Air Monitoring – Dräger Tube

Target Compound	Tube Available	CMS Chip Available	Detection Range
Carbon Monoxide	✓	✓	5- 150 ppm, 100-700 ppm
Carbon Dioxide	✓	✓	1-20% Vol.
Hydrofluoric Acid (Hydrogen Fluoride)	✓		0.5-15 ppm, 10-90 ppm
Sulfur Dioxide	✓	✓	≥0.1-3 ppm
Hydrogen	✓		0.2-2%, 0.5-3%
Hydrochloric Acid (Hydrogen Chloride)	✓	✓	0.2-3 ppm, 5-50 ppm

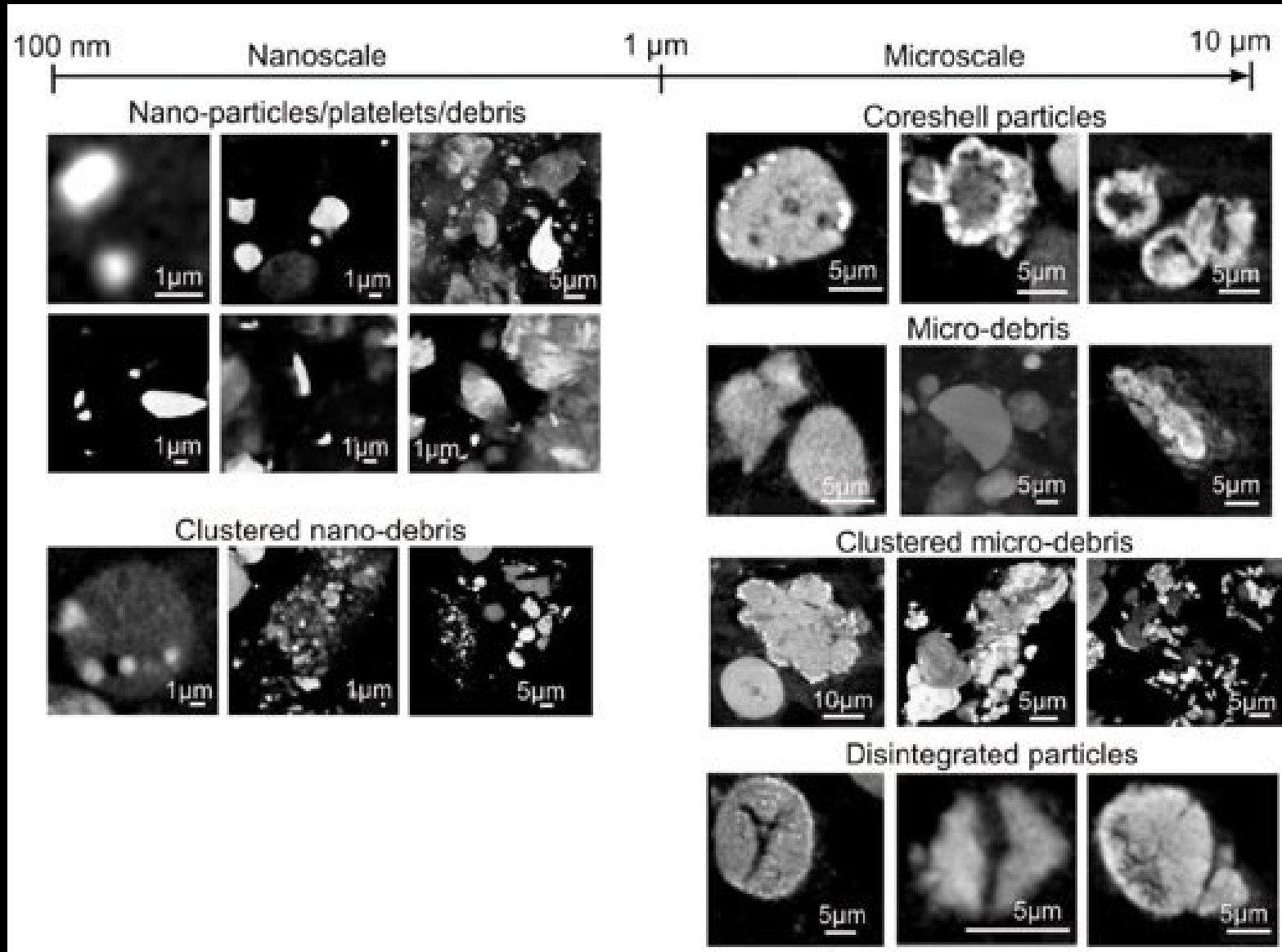


Air Monitoring – DustTrak (Particulates)

- Measurement range: 0.001 to 150 mg/m^3
- Operating temperature range: 32 to 122 ºF
- Method of particle detection: 90º light scattering
- Flow Rate: 3 L/min
- Simultaneously measures different particle diameters by algorithm (PM_{10}, PM_4, $PM_{2.5}$, PM_1 and Total Particulates)

Metals Particulate Size

- National Renewable Energy Lab (NREL) confirms sizes down to nano-particle scale
- 0.1 to 3 μm easily penetrates lungs and impacts respiratory health
- Transition metals contribute to DNA strand breaks, lung inflammation and cancer, asthma, pneumonia, neurological and nervous system effects.



Air Monitoring and Sampling

- **Air Monitoring (Real-time/Near real-time):**
  - Smoke plume modeling (IMAAC: Inter Agency Modeling and Atmospheric Assessment Center, (877) 240-1187), down range monitoring.
  - Particulate/vapor real-time air monitoring (Dust Trak, Multi-RAE, Real-time instruments)
  - Field Portable GC/MS, MS, GAS ID
  - Dust concentration in air calculations (concentration in soil, dust, air)

- **Air Sampling (Not real-time requires laboratory analysis):**
  - Air sampling: pump to cassette for perimeter
  - Air sampling: pump to cassette for personnel
  - Summa Canister or Tedlar bags

PPE Considerations-Initial Emergency Response

- Turnout Gear & SCBA
- Keep protection level during overhaul process
- Decon of turnout gear being evaluated

PPE Considerations-Decon TEEX Study

- 3 tests of 50 NMC batteries in thermal runaway exposing emissions to various materials found in the fire fighting industry
- 6 swatches with bunker gear: outer shell, moisture barrier and thermal liner.
- 4 swatches from cab apparatus material and 2 swatches of SCBA shoulder straps.

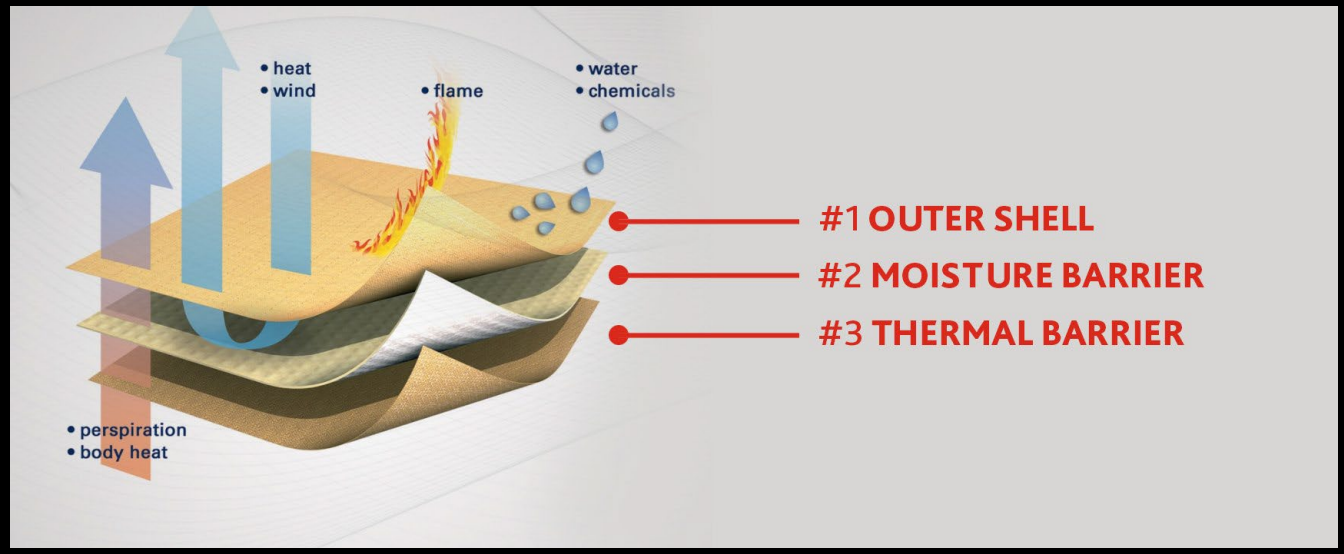


Figure 7

Figure 8

PPE Considerations-Decon TEEX Study Results

- 75 SVOC identified during testing
- Bunker Gear
  - SVOC penetrated to moisture barrier.
  - Water cleaning 21% -91% efficiency.
  - CO2 cleaning showed effective with many compounds undetected.
  - Penetration of metals to vapor barrier was very low. Thermal liner-ND. CO2 cleaning removed over 99% metal contamination. Iron, lead, magnesium most difficult to remove. Copper, cobalt, manganese and nickel remained.
- SCBA Straps
  - Contained highest amount of metal contamination
- TEEX report: https://teex.org/ev-ess-current-practices/

PPE Considerations-Removal

- Modified Level D PPE – FR Coveralls, Thermal Work Gloves, Nitrile Gloves, Eye and Face Protection (safety glasses, splash goggles, face shield, based on specific tasks), Safety Boots
- Modified Level C PPE – FR Coveralls, Thermal Work Gloves, Nitrile Gloves, Full-face Air Purifying Respirator (APR) with appropriate cartridges; typically, the multiple purpose P100, Organic Vapor and Acid Gas cartridges, Safety Boots
- Modified Level B PPE – FR Coveralls, Thermal Work Gloves, Nitrile Gloves, Self-Contained Breathing Apparatus (SCBA) or Supplied Air Respiratory (SAR), Safety Boots

United States Environmental Protection Agency

2023 Maui Wildfires
Damaged Lithium-Ion Battery Management Guide for Electric Vehicles & Mobility Devices

Version: November 27, 2023

1. OBJECTIVE

The handling of damaged lithium-ion batteries inherently presents significant hazards to response personnel. This Guide, along with complementary Standard Operating Procedures, has been established as a set of general guidelines for the proper handling of lithium-ion batteries to protect all response personnel. The purpose of this procedure is to outline the minimum requirements for safe handling, transportation, and the disposal process considerations for fire damaged lithium-ion batteries through a process of hazard identification and exposure control practices resulting in risk mitigation (Hazard x Exposure = Risk). This Guide is geared towards the following categories of lithium-ion batteries: Battery Energy Storage Systems (BESS), electric and hybrid vehicles (EVs), micromobility devices (e-bikes and scooters), and small batteries (vaping devices, power tools, computers, cell phones, etc.).

2. HAZARDS

Thermally insulted, burned or partially damaged lithium-ion batteries are susceptible to thermal runaway. This chemical reaction produces self-sustaining high temperatures that can result in the release of toxic and flammable/explosive vapors with the potential for fire (Figure 1). In addition to combustion products, the vapor produced during thermal runaway and fire can include the following hazardous and toxic and flammable/explosive vapors.:

- Hydrogen (30%-50%)
- Carbon monoxide (CO)
- Hydrogen fluoride (HF)
- Hydrogen chloride (HCl)
- Hydrogen cyanide (HCN)
- Phosphoryl fluoride (POF_3)
- Organic solvent droplets
- Ethane, methane, and other hydrocarbons

Figure 1: Diagram depicting a cascading thermal runaway event.

Burned or damaged batteries are unpredictable and cannot be considered fully discharged or free of hazards. Reignition from propagation or thermal insult to other cells within a battery is common and can occur 30 to 90 days from an initial thermal runaway event. During transportation, extreme temperatures and mechanical damage (such as puncturing or jostling) can trigger additional thermal runaway events. Batteries, groups of cells, or individual cells that have suffered significant fire damage may be present as a mass of melted or consumed material that

SOPs & JHAs

STANDARD OPERATING PROCEDURE 402:

REMOVAL OF LITHIUM-ION AND NICKEL METAL HYDRIDE BATTERIES FROM ELECTRIC VEHICLES

2025 SOCAL WILDFIRE RESPONSE
February 1, 2025

1. OBJECTIVE

This standard operating procedure (SOP) describes a set of general guidelines for the removal of batteries from hybrid and electric vehicles (EVs) impacted by the 2025 Southern California Wildfire Response. This SOP also includes safety procedures for the removal and transportation of extracted batteries. The objective is to extract lithium-ion (Li-ion), nickel metal hydride, (NiMH) and other batteries used in EVs and transport them to a secure area where they may be stored and prepared for recycling or disposal. The handling of damaged Li-ion and NiMH batteries from thermally insulted and fire damaged vehicles presents significant hazards to response personnel and should be handled with extreme care. The EV Battery Removal Team generally consists of the following: Federal On-Scene Coordinator (OSC), START personnel, certified electrician, battery subject matter expert, heavy equipment operator, and 2-3 support team members (air monitoring, water hose operation, supply handler). The EV Battery Removal Team is part of the broader EV Task Force.

The purpose of this SOP is to outline field techniques for the safe removal and transportation of fire damaged Li-ion and NiMH batteries identified in the field. This SOP is geared towards the following sources of Li-ion and NiMH batteries: EVs, limited mobility devices, golf carts, all- terrain vehicles, scooters, bikes, mopeds, and larger transportation vessels.

2. SUMMARY OF METHOD

Removal and transportation of extracted batteries is done by a team of trained hazmat responders familiar with vehicle manufacturers, models, and mechanical and battery technology. Personnel from the Emergency Response and Removal Services (ERRS) contract will be responsible for the physical removal of the batteries and Superfund Technical Analytical Response Team (START) personnel will be responsible for the documentation of activities in field logbooks and electronic field collection and mapping software. Additional contractors will be responsible for electrical and temperature checks.

3. HEALTH AND SAFETY

Qualified personnel should have completed adequate training to enter a disaster area, including HAZWOPER, OSHA, site-specific safety, and cultural training, if necessary. Numerous chemical and physical hazards are present during vehicle battery recovery. Chemical hazards include acid gases, occasional lead-acid, and heavy metals. Physical hazards include heavy lifting of tools, sharp metal, risk of fire or explosion from thermal runaway of a battery, heat stress, ash and chemical exposure, and dehydration. Level C PPE will be used for this operation: half-face or full-face respirator utilizing acid gas/P100 dual cartridge, flame retardant clothing (FRC)[1], cut resistant or shock resistant gloves (as appropriate), hard hat, protective boots and safety glasses. A Job Hazard Analysis (JHA) has been generated by the Safety Officer for inclusion in the Health and Safety Plan, which is housed on the 2023 Maui Wildfires Teams page, Section 1.6 Safety Officer, managed by the US Environmental Protection Agency (EPA).

[1] Flame Retardant Clothing: The implications of using disposable vs reusable FRC should be considered in the health and safety plan and field procedures. Appropriate decontamination or disposal of FRC should be implemented in the field prior to entering vehicles so ash and other contaminants do not contaminant vehicles.

JHA – Battery Energy Storage Systems

2023 Maui Wildfires

U.S. Environmental Protection Agency, Region 9

Emergency Response Section

JOB HAZARD ANALYSIS #7: Power Walls / Lithium Batteries

JHA		
JHA #: 007	**Name of Task:** Power Walls / Lithium Batteries	**Location:** 2023 Maui Wildfires
Task Description: Managing power walls and lithium batteries		**Task Duration:** Daily

Physical Hazards

Hazard	Source	Control Measures	Exposure Potential H	M	L	Unk	N/A
Stored Energy (Electricity) / Fire and Explosion	1. Electric/Power supply lines 2. Power walls (Tesla and other brands or homemade versions) 3. Lithium batteries	1. Ensure all electrical power has been shut off/disconnected from the power wall: a. Licensed/certified electrician to verify power status. 2. Ensure no backfeeding to the power wall (i.e., solar panels or any other device that could potentially be feeding energy to or drawing energy from power wall). 3. Isolate the energy storage system (i.e., power wall) after verification that all energy to the system has been shut off or disconnected. 4. Prepare power wall for transportation: • Partially burned, Partially insulted, intact, but suspected insulted power walls: - Use SCBA for respiratory protection along with Flame-Resistant (FR) clothing. Completely charred or Completely charred and bulged power walls: – Use organic vapor/acid gas filters along with Flame-Resistant (FR) clothing. • Wrap powerwall in fireblankets (e.g., Bridgehill). • If any reaction occurs during handling, immediately drop the power wall and vacate the area to a safey place. • Place in transport vehicle and secure in place using straps or other equipment. • Ensure fire extinguisher and pressurized water sprayers are available during transport. 5. Transport power wall to secure staging area for further processing: • Coordinate with local fire department prior to transport. • If reaction occurs during transport, park vehicle immediately in a location with minimal fire risk (to the extent possible); call fire department (dial 911) immediately for assistance.					
		• Maintain fire readiness (fire extinguishers and pressurized water sparyers to cool container during transport in the event of reaction/fire situation).					
Chemical Exposure	By-product of fires involving lithium batteries	See Chemical Hazards section below					

Biological Hazards

Hazard	Source	Control Measures	Exposure Potential H	M	L	Unk	N/A
COVID-19 Exposure	Unknown	Follow COVID-19 protocols					

Chemical & Radiological Hazards

Hazard	Source	Control Measures	Exposure Potential H	M	L	Unk	N/A
Hydrogen Fluoride	By-product of fires involving lithium batteries	1. Partially burned, Partially insulted, intact, but suspected insulted power walls: - SCBA required for respiratory protection while handling power walls. – Completely charred or Completely charred and bulged power walls: organic gas/acid gas filters required for respiratory protection. 2. FR clothing required for potential fires. 3. In the event a reaction occurs during handling, immediately drop the power wall and vacate the area to safety. 4. Notify the fire department (dial 911).					

PPE

Level A	Level B	Level C	Level D Mod	Level D
	Partially burned, Partially insulted, intact, but suspected insulted power walls -(SCBA for respiratory protection combined with FR clothing)	Completely charred or Completely charred and bulged power walls: (Organic gas/acid gas filters required for respiratory protection combined with FR clothing.)		

Other

None

JHA – EV Battery Removal & Transport

2023 Maui Wildfires
U.S. Environmental Protection Agency, Region 9
Emergency Response Section

JOB HAZARD ANALYSIS #8: EV Battery Removal and Transport

JHA		
JHA #: 008	**Name of Task:** EV Batteries	**Location:** 2023 Maui Wildfires
Task Description: Managing EV batteries		**Task Duration:** Daily

Physical Hazards – EV Battery Removal

Hazard	Source	Control Measures	Exposure Potential H	M	L	Unk	N/A
Overhead Hazards	Burned out structure debris	Situational awareness. Hard hat					
Trip Hazards	Burned out structure debris	Situational awareness, test footing prior to stepping on unknown area					
Electrocution	Energized power lines. Charged EV battery.	Assume all electric lines and appliances are energized. Evaluate EV battery prior to handling.					
Traffic	Vehicles traveling in work areas	Situational Awareness. High visibility vests					
Fall Hazard	Open septic field or tree root burnout	Situational Awareness. Mark deep fall hazards with caution tape and orange spray paint					
Falling Trees	Burned out trees	Situational Awareness. Observe Arborist markings trees. Avoid hazardous tree fall zones. Cease work with wind speeds of 20mph.					
Puncture Risk	Sharp objects in debris	Situational Awareness. Leather work gloves.					
Heavy Equipment	Crush zones during vehicle rotation	Situational Awareness. Spotter usage.					
Pinch Points	Cutting metal/Jaws of life	Situational Awareness. Use leather work gloves.					
Heat Stress	Working in protective suits	Follow Work/Rest schedules. Stay Hydrated					
Lifting Injuries	Lift heavy batteries and equipment	Use propped lifting techniques. Use two man lift for heavy objects Do not carry heavy objects far distances					

Physical Hazards – EV Batteries

Hazard	Source	Control Measures	Exposure Potential H	M	L	Unk	N/A
Stored Energy (Electricity) / Fire and Explosion	1. Electric/Power supply lines 2. EV high-voltage and low-voltage batteries	1. Ensure all electrical power has been shut off/disconnected from EV vehicle: a. Licensed/certified electrician to verify power status. 2. Ensure no backfeeding to the EV vehicle (i.e., solar panels or any other device that could potentially be feeding energy to or drawing energy from EV vehicle). 3. Isolate the energy storage system (i.e., EV battery) after verification that all energy to the vehicle has been shut off or disconnected. 4. Remove EV battery from vehicle using methods identified in the SOP; methods may include rotating vehicle (on side or completely flipped over) using heavy equipment, cutting metal using "Jaws of Life", removing bolts or other metal fasteners (see physical hazards above). 5. Prepare EV battery for transportation: • Active thermal event or poorly ventilated area - SCBA required for respiratory protection along with Flame-Resistant (FR) clothing OR Standard EV battery removal - organic gas/acid gas filters required for respiratory protection along with Flame-Resistant (FR) clothing. • Wrap EV battery in fireblankets (e.g., Bridgehill) or place loose material in drum with bung off. • If any reaction occurs during handling, immediately drop the EV battery and vacate the area to a safey place (upwind). • Place in transport vehicle and secure in place using straps or other equipment. • Ensure fire extinguisher and pressurized water sprayers are available during transport. 6. Transport EV battery to secure staging area for further processing: • Notify local fire department if thermal or other event occurs that requires a response. • If reaction occurs during transport, park vehicle immediately in a location with minimal fire risk (to the extent possible); call fire department (dial 911) immediately for assistance. • Maintain fire readiness (fire extinguishers and pressurized water sparyers to cool container during transport in the event of reaction/fire situation).					
Chemical Exposure	By-product of fires involving lithium batteries	See Chemical Hazards section below					

Biological Hazards

Hazard	Source	Control Measures	Exposure Potential H	M	L	Unk	N/A
COVID-19 Exposure	Unknown	Follow COVID-19 protocols					

Chemical & Radiological Hazards

Hazard	Source	Control Measures	Exposure Potential H	M	L	Unk	N/A
Alkaline Ash and Battery	Remnants of burned out	Personal Data Ram worn by perimeter personnel. MultiRae monitoring by screening team. P100 respirators on EV					
Materials	structures and battery materials	battery removal crew					
Asbestos	Remnants of burned out structures	Personal Data Ram worn by perimeter personnel. MultiRae monitoring by screening team. P100 respirators on EV battery removal crew					
Flamable and Combustable gases	Batteries	Well ventilated area. P100 respirators and proper eye protection (i.e., goggles). If ventilation concerns, switch to SCBA.					
Acid gases	Batteries	P-100 respirators, acid-proof gloves					
Lead acid	Batteries	Tyvek suites, acid-proof gloves					
Hydrogen Fluoride	By-product of fires involving lithium batteries	1. Active thermal event or poorly ventilated area - SCBA required for respiratory protection OR Standard EV battery removal - organic gas/acid gas filters required for respiratory protection. 2. FR clothing required for potential fires. 3. In the event a reaction occurs during handling, immediately drop the EV battery and vacate the area to safety. 4. Notify the fire department (dial 911).					

PPE

Level A	Level B	Level C	Level D Mod	Level D
	Active thermal event or poorly ventillated area. (SCBA for respiratory protection combined with FR clothing)	Completely charred or completely charred and bulged EV battery: (Organic gas/acid gas filters required for respiratory protection combined with FR clothing.)		

Other

None

NOTES:
From draft SOP on EV Reconnisance – Hazards and required PPE are listed as:
Many hazards exist when performing reconnaissance of burned vehicles. Some of these hazards include sharp edges, broken glass, puncture hazards, structurally unsafe walls, beams, and roofs, high voltage hazards, toxic dust, compromised trees, heat/cold stress, and many more. The recommended PPE for this task is: long sleeve pants and shirts, hardhat, safety toe boots with steel shank, cut resistant gloves, eye protection, high visibility vests, and a dust mask or respirator. Higher level PPE such as Tyvek and boot covers is recommended when conditions require entry into ash footprints.

From draft SOP on EV Battery Removal – Hazards and required PPE are listed as: Numerous chemical and physical hazards are present during vehicle battery recovery. Chemical hazards include acid gases and occasional lead-acid. Physical hazards are heavy lifting of responder tools, sharp metal, fire, heat, ash and dehydration. The PPE level utilized is Level C with half-face respirator utilizing acid gas/P100 dual cartridge, flame retardant clothing (FRC), cut resistant gloves, hard hat and safety glasses. Tyvek suits are only utilized during lead acid battery removal.

Li-Ion Battery Response Considerations

Module 5: Additional Considerations

Opportunities for Concern

- Energy and political initiatives
- Increase in micro-mobility devices
- Increase in EVs
- Use of energy storage systems
- Battery farming
- Weather pattern changes
- Points of disposal/recycling
- Education
- Challenges at local response level

Multi-Agency Involvement

Education
- Trainings
- Outreach
- TTX

Large Disasters/Stafford Act
- Floods
- Fires
- Terrorism to network

Sites
- Battery recycler
- Independent modifier/entrepreneur
- Repair shop
- BESS network
- Vape shop
- Transportation sector
- Battery farmer
- Accumulator
- Illegal dumping
- Ocean vessels

Gaining Ground

Research/Understanding

- Knowledge through trial
- Education from experts
- Research by regulatory agencies
- Outreach from manufacturers

Multi-Agency sharing and partnerships

Rule making & alterations

EPA National LIBTF

- Guidance
- Trainings
- Fact sheets
- Research

Li-Ion Battery Response Considerations

Conclusion / Final Thoughts

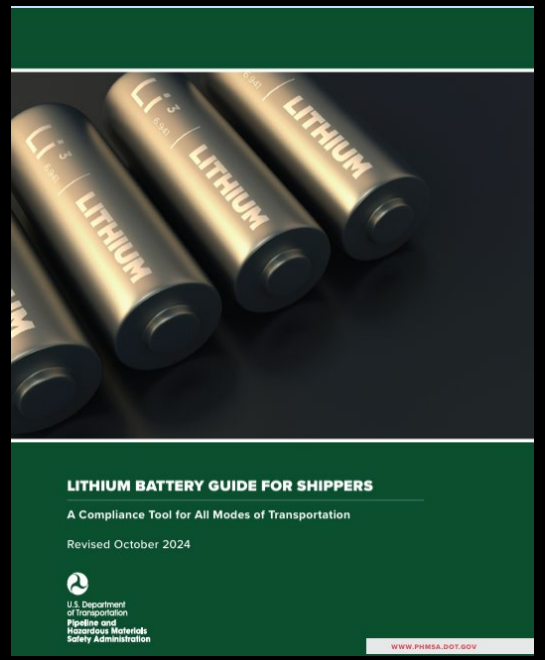
Resources

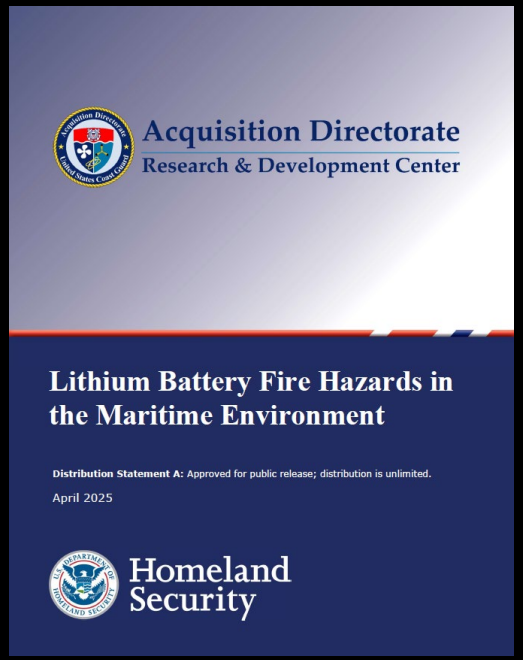
response.epa.gov/R2LIBResources

response.epa.gov/R4LithiumIonBatteryOutreach

phmsa.dot.gov/lithiumbatteries

EPA LIB Guidance Document





Questions?

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