



State of Lithium-Ion Battery Recycling

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Todd Coy
KBI
tcoy@kinsbursky.com
949-310-0807



Introduction



- ❑ Established 1923 – Incorporated 1958
- ❑ Only fully Part B Permitted TSDf – Anaheim, CA for battery recycling.
- ❑ 4.7 acres
- ❑ Permitted capacity 6MM pounds of batteries per month. Specializing in industrial application large format lead acid batteries
- ❑ Precious Metal recycling from Automotive Catalyst
- ❑ Accepts and manages all battery chemistries
- ❑ Consolidates lithium-ion batteries for affiliated companies

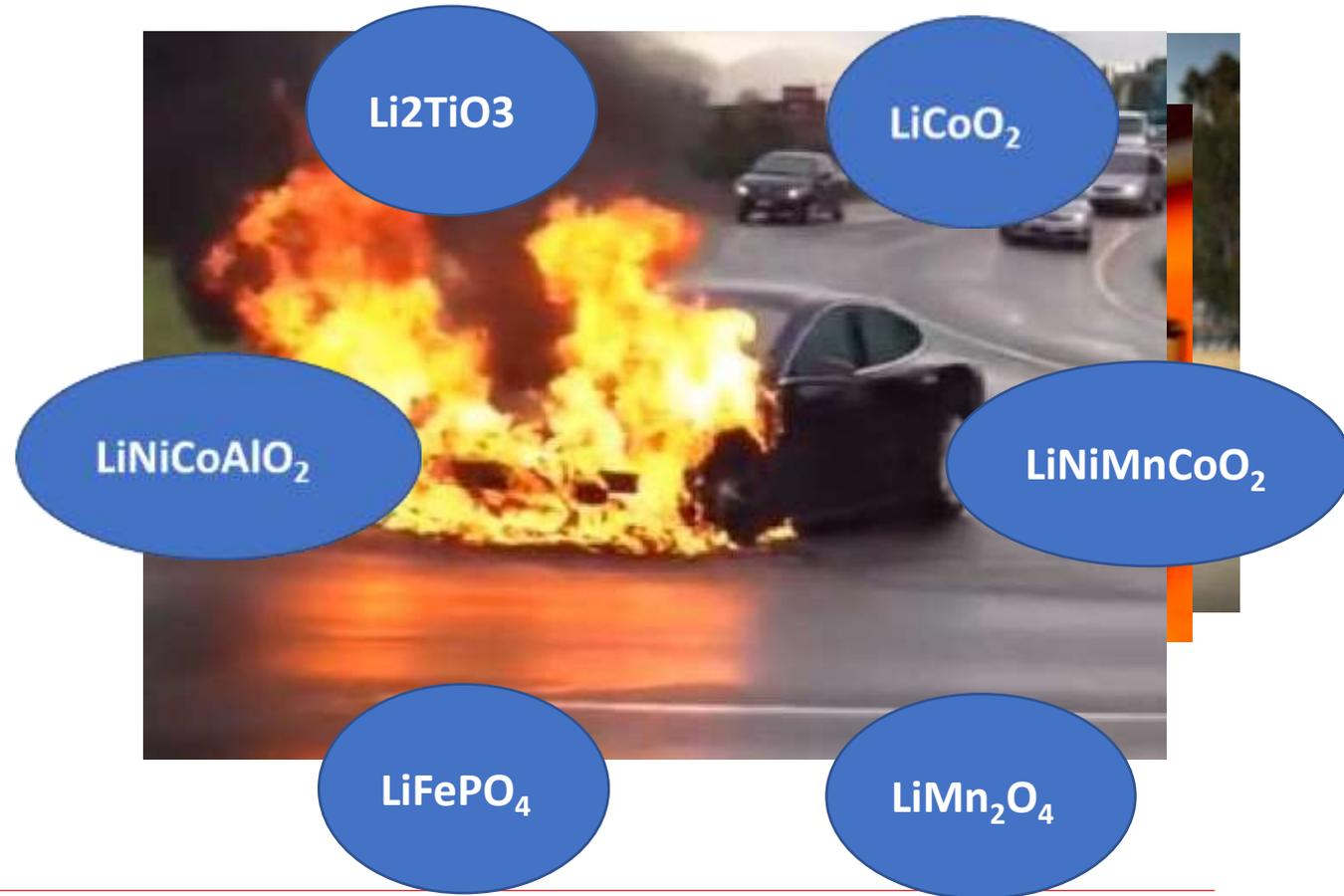
Introduction



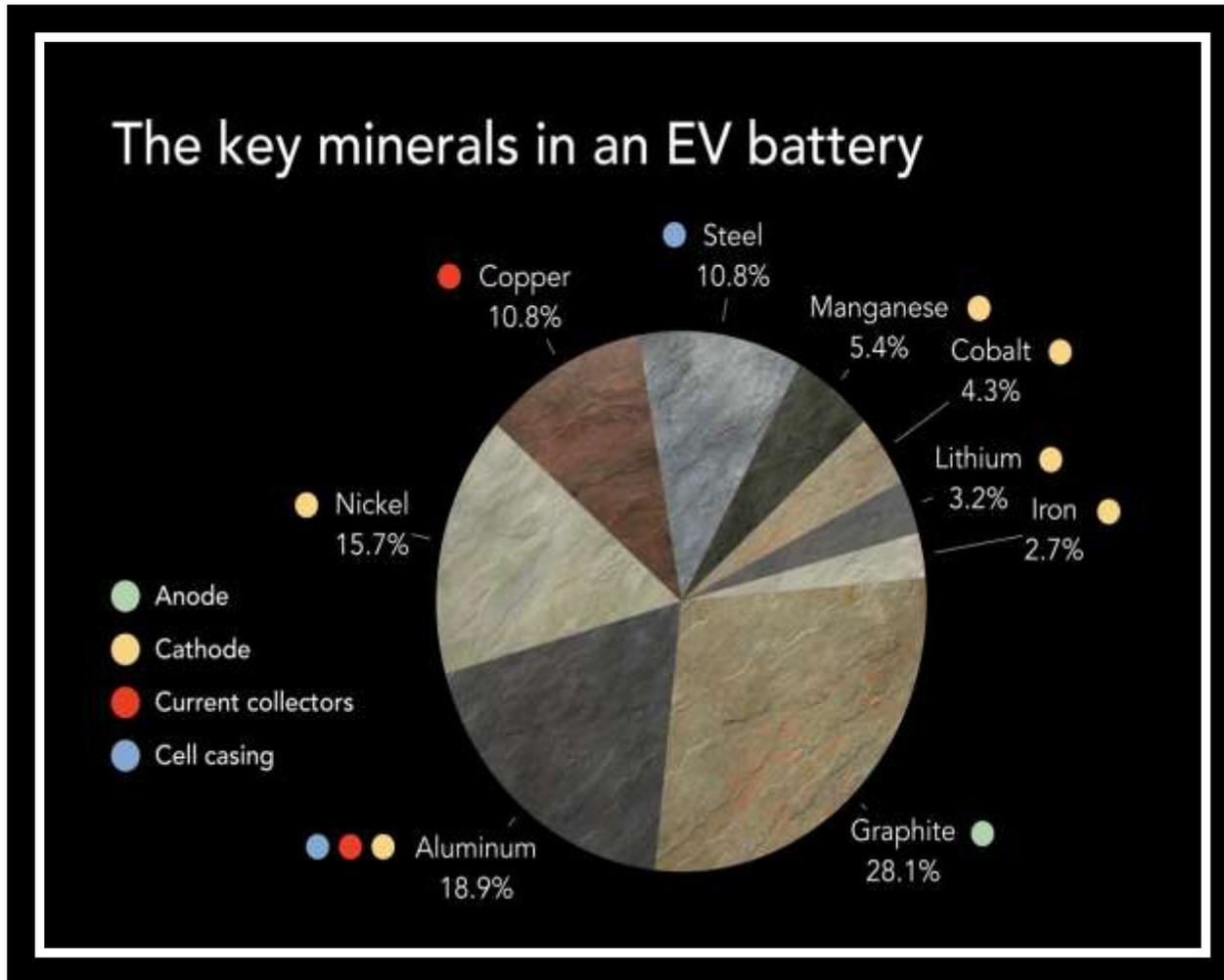
- ❑ Leading Lithium-Ion Battery recycler in North America
- ❑ Recycling facilities in Trail, B.C, Canada and Lancaster Ohio – Expansion planned for AZ and SC.
- ❑ Ohio – Part B permitted facility
- ❑ Canada – Part B equivalent through Canadian Ministry of Environment
- ❑ Canadian Operation ISO 18000 and R2 Certified
- ❑ Awarded 9.5M from DOE in 2009 – ground up construction of facility in Ohio.
- ❑ Awarded 85M from DOE in 2022 to expand recycling capacity in Ohio.

New Batteries, New Perceptions, New Problems.

- ❑ Lithium-ion battery recycling is now sexy
 - ❑ Sleekly dressed up
 - ❑ Wrapped in something cool
 - ❑ Mysterious
 - ❑ What's your chemistry?
 - ❑ Some say could be dangerous

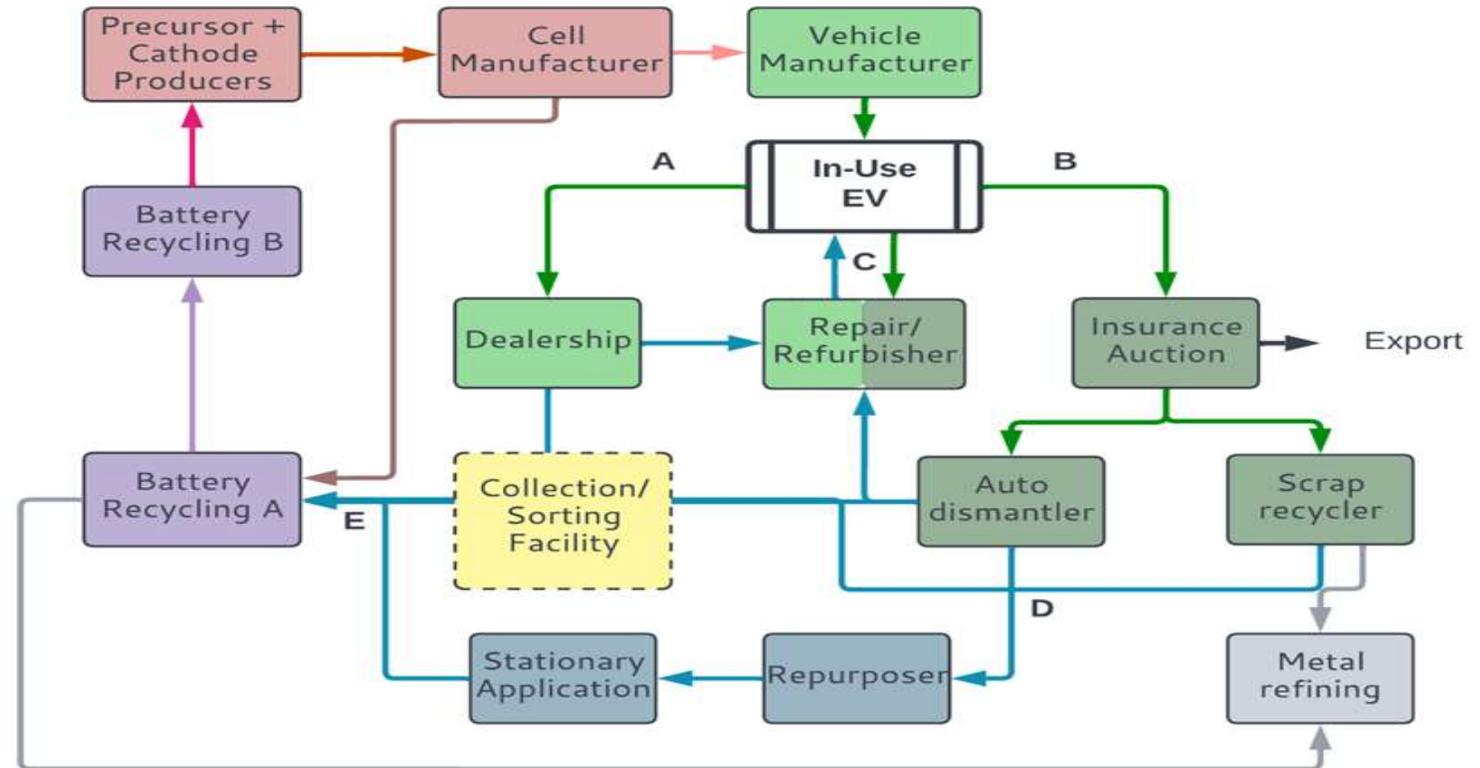


What is happening With Battery Recycling



Industry is transforming at a rapid pace

- Federal funding: IIJA
- Approximately 550 billion dollars (Electrification, Infrastructure)
- 18.6 Billion in EV related programs.



Margaret Slattery¹, Jessica Dunn¹, Alissa Kendall^{1,2}

1. Energy and Efficiency Institute,
University of California Davis, 1605
Tilia St #100, Davis, CA 95616,
USA

2. Department of Civil and
Environmental Engineering,
University of California Davis, 1
Shields Avenue Davis, CA 95616,
USA

Flows

- ➔ Vehicle
- ➔ Pack or module
- ➔ “Black mass” (Co, Ni, Mn, C, Li powder)
- ➔ Metal sulfates (CoSO₄, NiSO₄, MnSO₄)
- ➔ Cathode active material
- ➔ Cell
- ➔ Production scrap
- ➔ Other metals (e.g., Al, Cu)

Stakeholder/Facility Type

- OEM network
- Independent vehicle network
- Repurposing
- Collection and logistics
- Downstream processing
- Upstream production
- Other metals

CURRENT RECYCLING AND FUTURE PLANNED

2023

Lithium Ion Battery Recycling

Total Announced U.S.

128,000 tons

Current U.S. Black Mass Capacity

25 - 35,000

Name	Location	Capacity (Announced)	Closed Loop Planned
Cirba Solutions	Canada	5,000	No
Cirba Solutions	Ohio	4000	Yes
Cirba Solutions	Arizona	12000	No
LiCycle	Canada	35,000 (BM)	Yes
LiCycle	New York	5,000	No
LiCycle	Arizona	10,000	No
LiCycle	Alabama	10,000	No
ABTC	Nevada	20,000	Yes/Mining Lithium
Redwood Materials	Nevada	10 GWh	Yes
Ascend Elements	Georgia	30,000	Yes
Lithion	Canada	7500	Yes
Princeton	Texas	500	Pilot Facility
Ace Green	Texas	Unk	Unk
Ecobat	Texas	30,000	Unk
TOTAL		134,000	

CURRENT RECYCLING AND FUTURE PLANNED

2023

Lithium Ion Battery Recycling

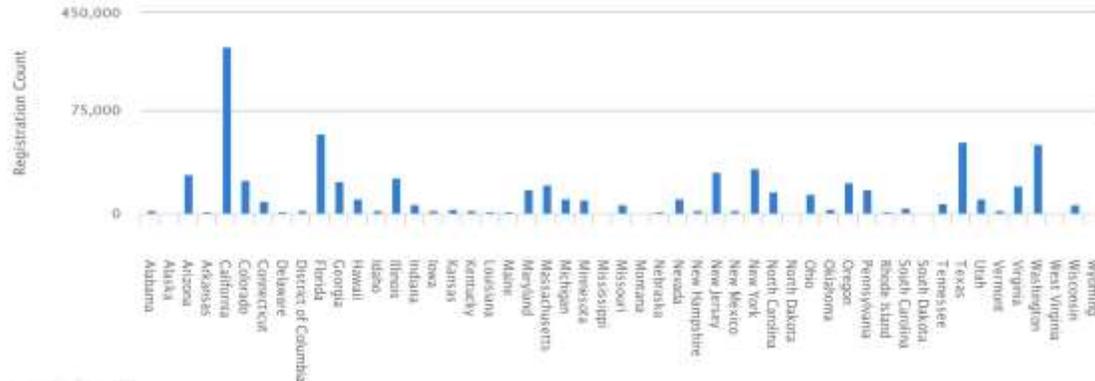
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Cirba Solutions	Arizona	12000	No
LiCycle	Canada	35,000 (BM)	Yes
LiCycle	New York	5,000	No
LiCycle	Arizona	10,000	No
LiCycle	Alabama	10,000	No
ABTC	Nevada	20,000	Yes/Mining Lithium
Redwood Materials	Nevada	10 GWh	Yes
Ascend Elements	Georgia	30,000	Yes
Lithion	Canada	7500	Yes
Princeton	Texas	500	Pilot Facility
Ace Green	Texas	Unk	Unk
Ecobat	Texas	30,000	Unk

- In May 2022, ACE Green Recycling, Inc. (ACE) announced plans to build and operate four new lithium-ion battery recycling facilities with an annual capacity of over 10,000 tons in Thailand and India.
- In November 2022, Attero Recycling Pvt. Ltd. (India), a recycler of electronic waste and lithium-ion batteries, announced investing USD 81.0 million (INR 600 crores) in setting up a Li-ion battery recycling factory with a recycling capacity of 19,500 MT in Telangana (India).
- In October 2021, Contemporary Amperex Technology Co., Limited (CATL, China) announced a USD 5 billion facility to recycle Lithium-ion batteries. The facility will be a joint venture with EV manufacturers due to the rising need for battery recycling backed by growing EV adoption globally.
- Fortum – Finland – 3,000 tons but expanding
- Brunp – China (CATL)
- Sungeel – Korea (Samsung SDI)
- Nippon Recycling – Japan

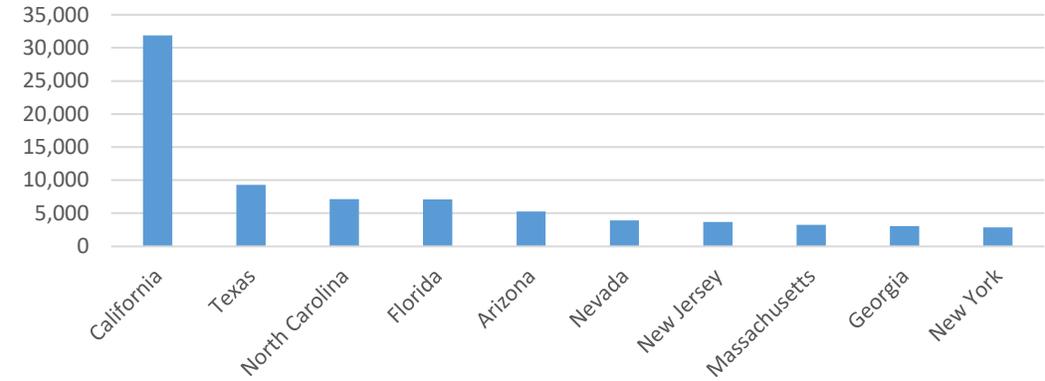
California Comparison

Electric Vehicle Registrations by State

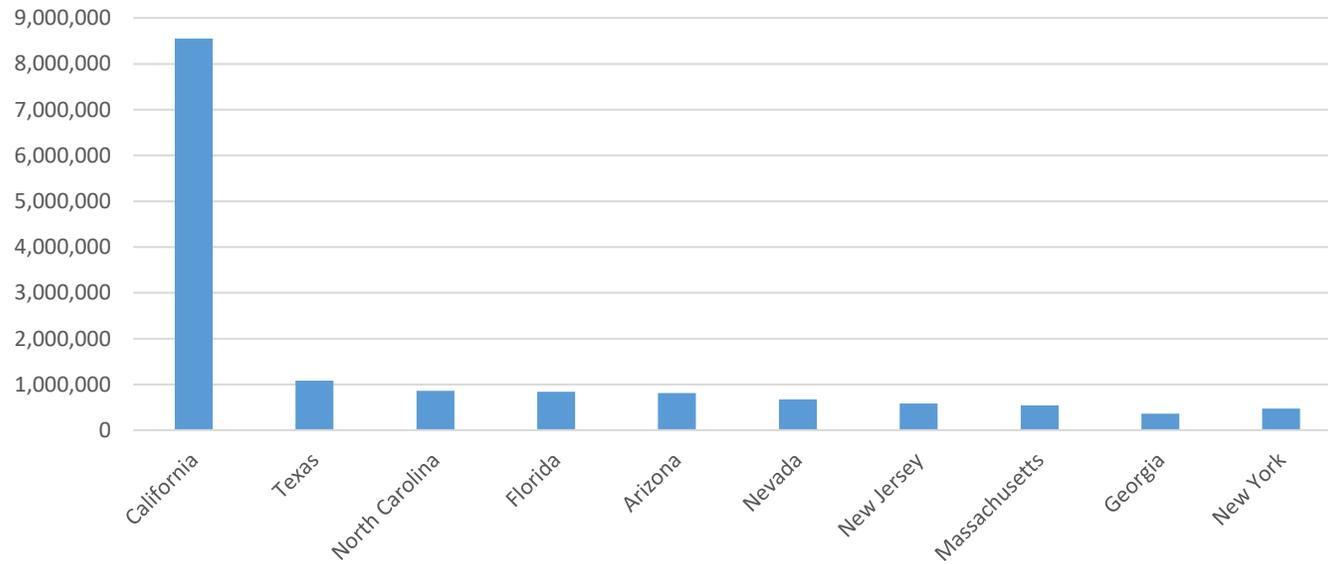


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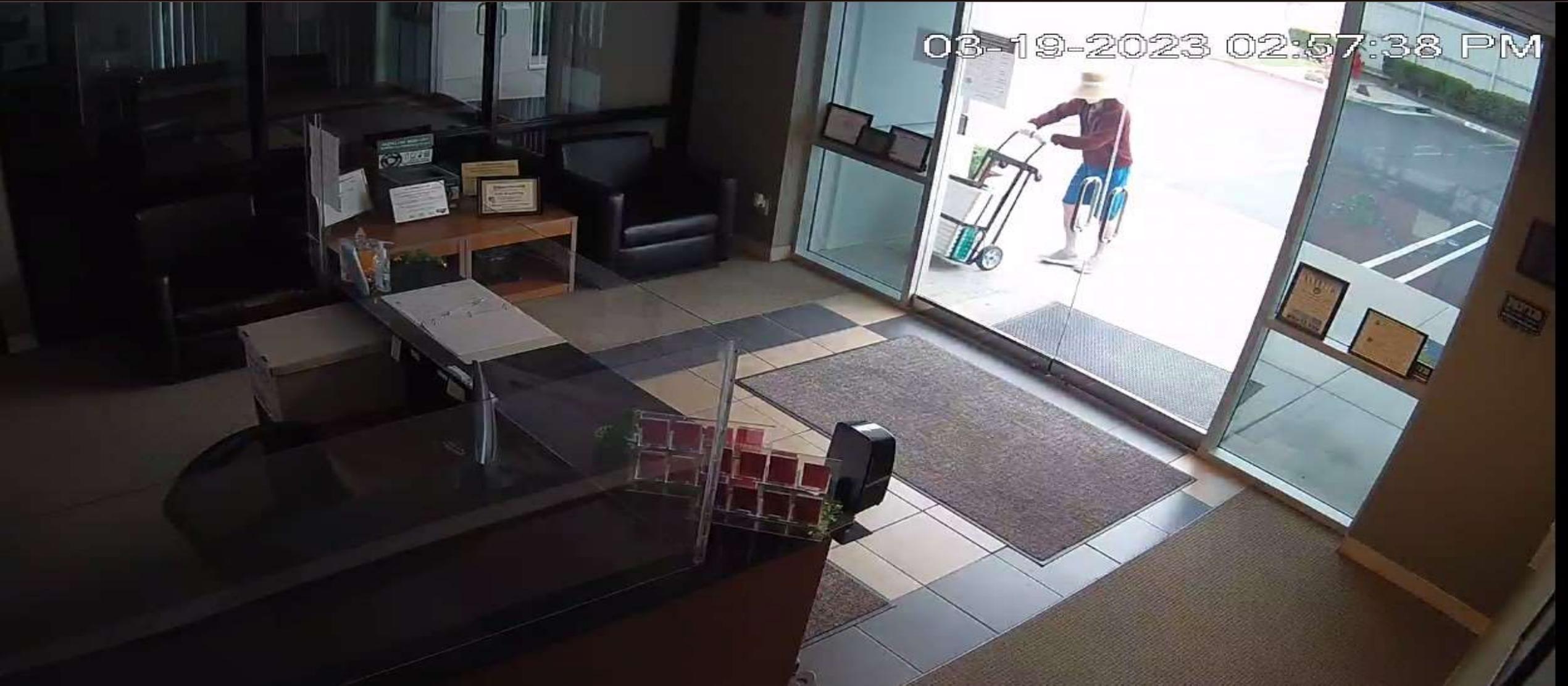
Cumulative Solar Capacity (Megawatts)



Equivalent Number of Homes Supplied by Solar Energy



What is Happening with Lithium Ion Battery Recycling in California ?



What is happening With Lithium Ion Battery Recycling in California ?

In 2018, California Assembly Bill 2832 required the convening of the Lithium-Ion Battery Recycling Advisory Group whose mandate includes submission of policy recommendations to the Legislature to ensure “...that as close to 100% as possible of lithium-ion batteries in the state are reused or recycled at end-of-life”(Dahle, 2018).

The Advisory group submitted their final report in April of 2022 to the California Legislature. Report was nonbinding recommendations.

What is happening With Lithium Ion Battery Recycling in California ?

In 2022, California Senate Bill 1215 passed – Covered battery embedded products – requires retailer take back.

In 2022 California Assembly Bill 2440 was passed – Battery Collection and Recycling.

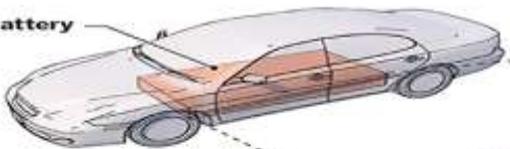
Senate Bill 615 is currently being drafted via Battery Committee working with Senator Ben Allen. This is an EV battery bill.

In part looking at EU framework (Battery Directive) and advisory panel recommendations to frame legislation.

New life for spent cells

Scientists are working to ensure the electric vehicle (EV) batteries being sold today can be recycled in 2030 and beyond, when thousands of batteries will reach the end of their lives every day. EV batteries come in many designs, but generally share these components.

EV battery



Heavy batteries give EVs a low center of gravity.

EV battery pack

Inside the pack, electrical components manage the charge and stability of dozens of modules.

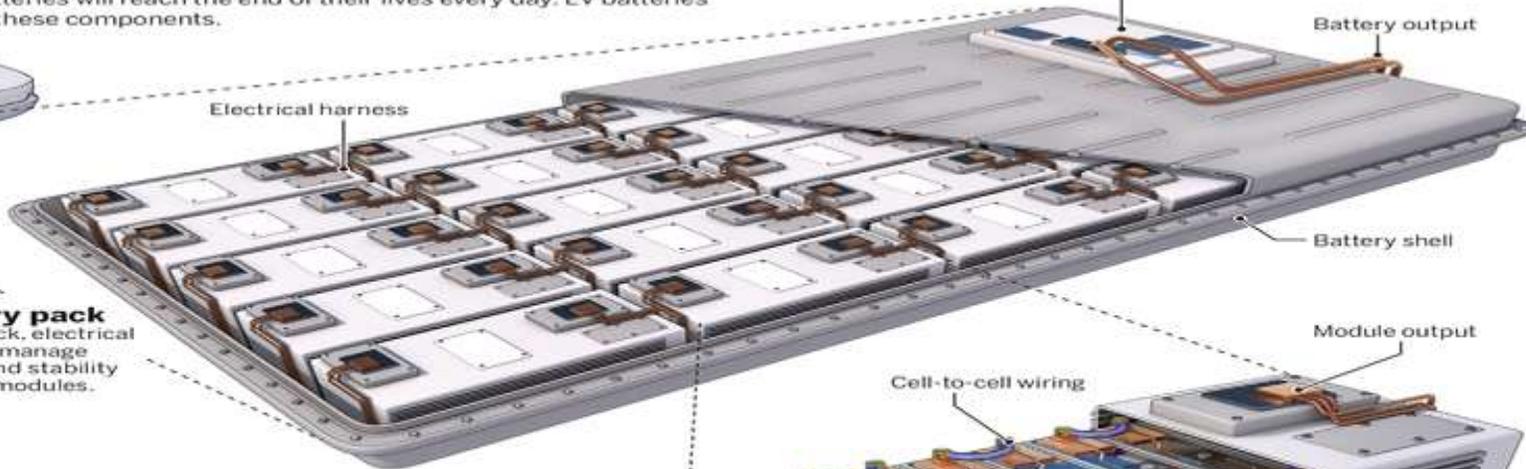
Mining



Refining



Electrical harness



Battery charge controller

Battery output

Battery shell

Module output

Cell-to-cell wiring

Module

Each module houses many battery cells.

Module case

Terminal

Cell

EV batteries can have hundreds or even thousands of cells. Designs vary, and include rectangular prismatic cells (below, right) and cylindrical cells (below, left).

Prismatic cell

Cell case

Cell components

Each cell houses the essential components of a battery. They release and store electricity as lithium atoms move between electrodes.

Aluminum current collector

Copper current collector

The circles of recycling

Pyrometallurgy burns spent batteries into a slag, and hydrometallurgy dissolves them in acids. Both aim to extract cathode materials. The ideal is direct recycling, which would recover the cathode intact. But for recycling to be viable it must be cost competitive with mined materials.

Cylindrical cell

A tough steel casing makes these cells difficult to open. Often durable glue combines thousands of cells into packs.



Cathode

The cathode typically holds the most valuable recyclable material, made up of many metals.

Anode

Negative electrodes are composed of graphite, carbon, or silicon-based components.

Electrolyte and separator

Lithium travels through a separator sheet soaked in electrolyte.

Battery manufacture

Battery use

Landfill

Second uses

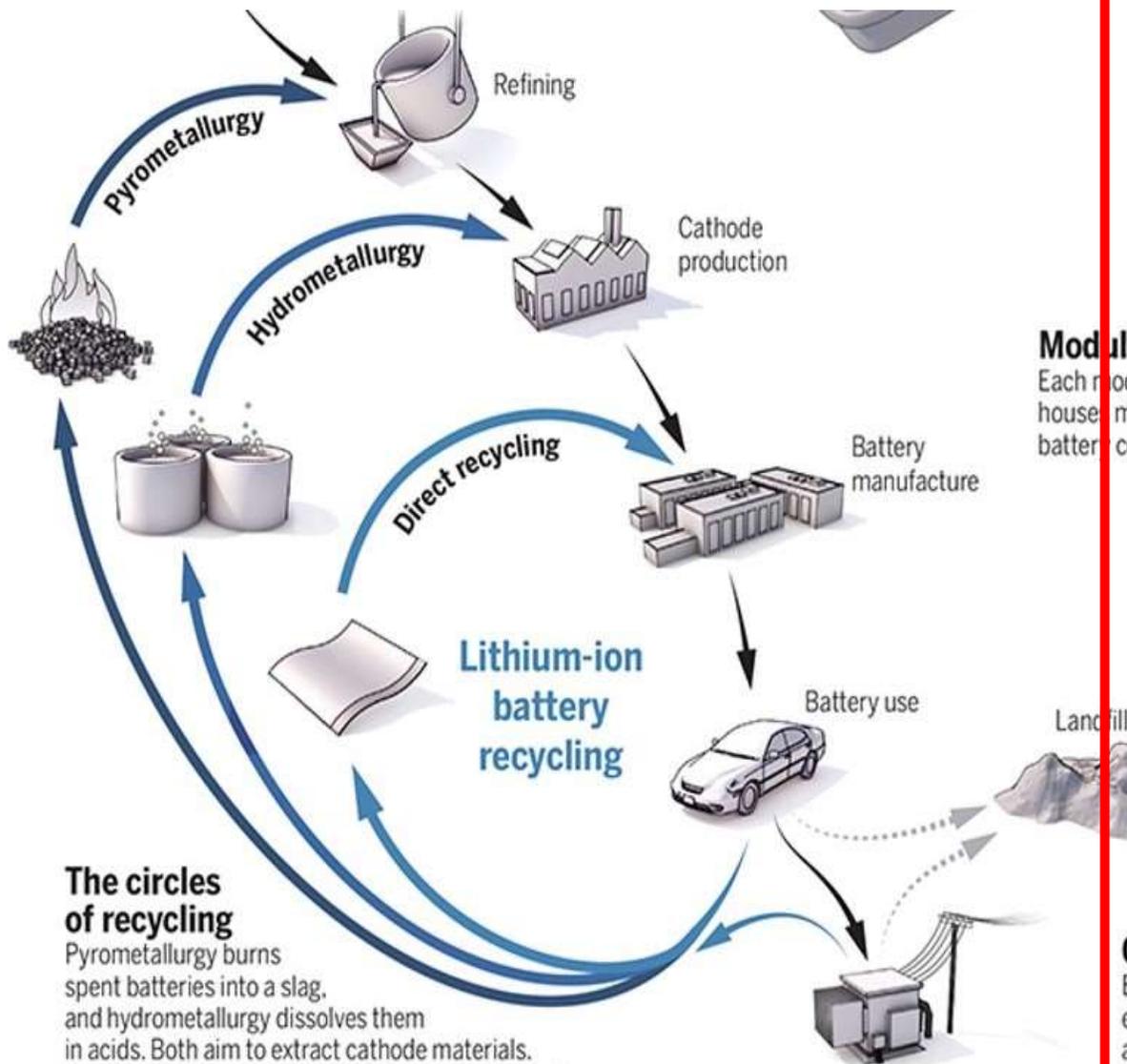
Cathode production

Pyrometallurgy

Hydrometallurgy

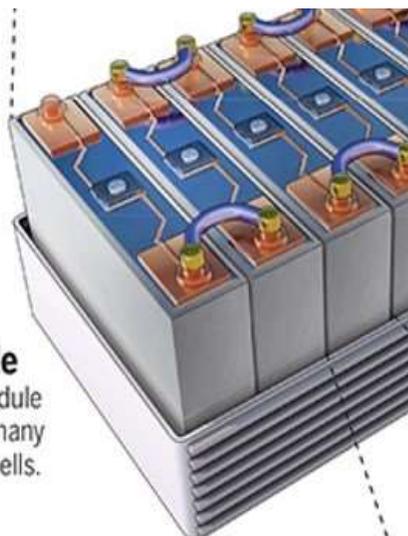
Direct recycling

Lithium-ion battery recycling



The circles of recycling

Pyrometallurgy burns spent batteries into a slag, and hydrometallurgy dissolves them in acids. Both aim to extract cathode materials.



Module
Each module houses many battery cells.

Cell
EV batteries can have hundreds or even thousands of cells. Designs vary, and include rectangular prismatic cells (below, right) and cylindrical cells (below, left).

Cell components

Each cell houses the essential components of a battery. They release and store electricity as lithium

Activities described in this infographic are considered hazardous waste treatment In California and would require a Part B Hazardous Waste Treatment Permit.

Path to Recycling – Regulatory Compliance

Brief Regulatory Overview – Packaging requirements can be found 49 CFR 173.185

- All batteries must be protected from short circuit when being offered for transportation.
- Covering Terminals, taping, or other means.
- There are specific packaging unique to the type and size of the batteries when being offered for transportation
- Batteries being sent for recycling or disposal have some reduced packaging requirements.
- Damaged batteries have unique packaging requirements

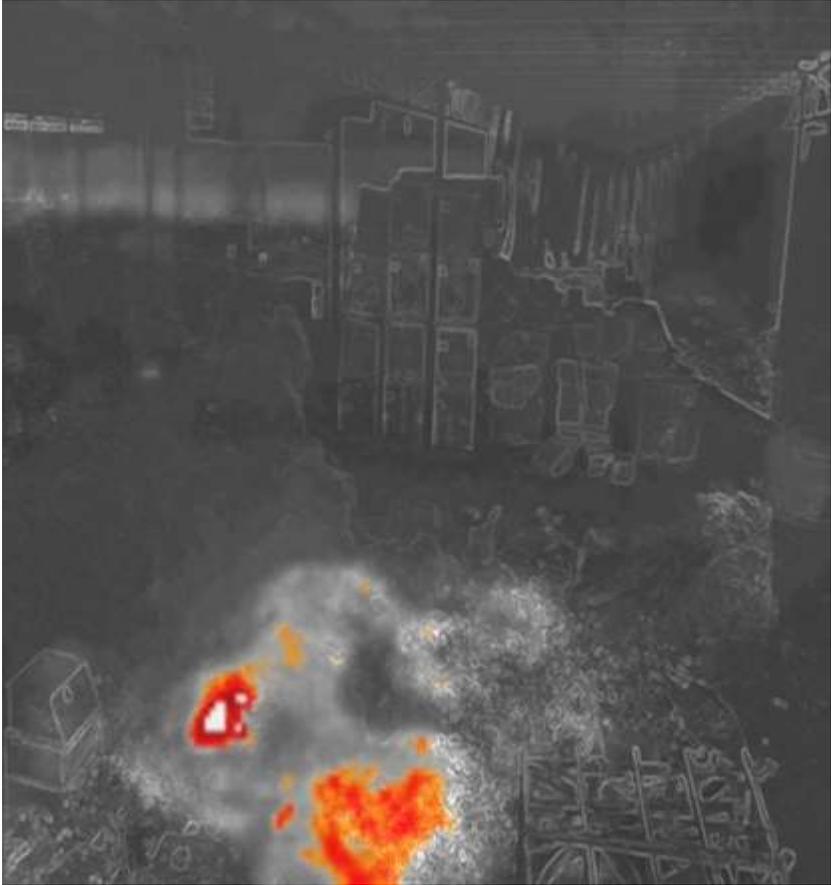
In Conclusion

- ❑ Globally, battery recycling (lithium – ion) has advanced more in the past 5 years than in the past 20.
- ❑ Li-ion / black mass has become commoditized in the market and is traded internationally.
- ❑ Demand/Capacity is predicated on continued EV/ESS proliferation and commodity markets.
- ❑ Energy systems will continue to evolve, and material sciences may disrupt future battery recycling ecosystem.
- ❑ R&D needs to be directed towards other systems (FeP04)
- ❑ Recycling is still expanding – will there be a consolidation/contraction?

In Conclusion

- ❑ Multiple states developing extended producer responsibility legislation for batteries. A national framework is needed for consistency and efficiencies
- ❑ In addition to recycling, which is a national security issue with respect to the recovery of critical minerals and reducing dependence on imports. Additionally, there is significant attention is being given to public safety with respect to battery “thermal events”
- ❑ March 21st, industry hosted a congressional briefing on battery “events” and public safety.

Morris III



EOL (End of Life) Battery Management



EOL (End of Life) Battery Management



EOL (End of Life) Battery Management



EOL (End of Life) Battery Management



California SB615 Electric vehicle traction batteries. "Requires all electric vehicle traction batteries, as defined, sold with motor vehicles in the state to be recovered and reused, repurposed, remanufactured, or recycled at the end of their useful life in a motor vehicle or any other application. Would also require a vehicle manufacturer, dealer, automobile dismantler, automotive repair dealer, and nonvehicle secondary user to be responsible for ensuring the responsible end-of-life management of an electric vehicle traction battery once it is removed from a vehicle or other application to which the electric vehicle traction battery has been used."

9 States are currently looking to pass legislation on managing EOL batteries.
Illinois SB1333 Lithium-Ion Battery Disposal Provides that a lithium-ion battery may not be disposed of in a mixed recycling waste bin. Requires the Environmental Protection Agency to encourage local authorities to use separate curbside recycling collection bins for the disposal of lithium-ion batteries. Provides that hazardous materials include lithium-ion batteries for purposes of specified provisions of the Act.

Most Bills have a Producer responsibility component.
HB1374 Electric Vehicle Recycling Act. Creates the Electric Vehicle Recycling Act. Provides that, within 60 days after the Act's effective date, manufacturers of electric vehicles that contain hazardous components and batteries must begin to implement a collection program that facilitates the removal of hazardous components and batteries from motor vehicles prior to the sale of such vehicles, including repaired, used, or surplus vehicles, or the vehicles processed for recycling and to collect and properly manage hazardous components and batteries in accordance with the Environmental Protection Act. Provides that, within 90 days after the Act's effective date, manufacturers of vehicles that contain hazardous components and batteries that cannot be reused and are deemed to be hazardous, must submit to the Environmental Protection Agency an implementation plan that describes how the collection program will be carried out for the duration of the program. Effective immediately.

Most have calls for a "Stewardship Organization" to be formed to manage the collection and recycling programs.
Massachusetts SD.347 Resolve establishing a commission on electric vehicle battery recycling The secretary of energy and environmental affairs shall convene an Electric Vehicle Battery Recycling Commission to review and advise the general court on policies pertaining to the recovery and recycling of electric vehicle batteries in the commonwealth.
SD.101 An Act Relative to Lithium-Ion Batteries Establishes the Lithium-Ion Vehicle Battery Advisory Group within the executive office of energy and environmental affairs to review, and advise the legislature on policies pertaining to the recovery and recycling of lithium-ion vehicle batteries sold within motor vehicles in the commonwealth.

New Jersey S1414 Requires DEP to establish licensing program for persons engaged in dismantling of electric batteries for disposal or recycling purposes. Requires DEP to establish a licensure system for persons who engage in the dismantling of electric vehicle batteries in the State. The licensure program would require that any person engaged in electric vehicle battery dismantling services have training and education in several subject areas.

A4803 An Act concerning cautionary signage at electric vehicle battery facilities and supplementing Title 13 of the Revised Statutes. Requires electric vehicle battery facilities to affix sign developed and produced by DEP to all facility entrances as notification that electric vehicle batteries are on-site.

S3256 An Act to support the repurposing, remanufacturing, and recycling of electric vehicle batteries, supplementing Title 13 of the Revised Statutes. Establishes "Electric Vehicle Battery Repurposing Fund" to support repurposing, remanufacturing, and recycling of electric vehicle batteries; dedicates amounts based on certain sales of electronic vehicles.

S3372 Establishes "Electric Vehicle Battery Recycling Task Force" to study ways to safely store, reuse, recycle, and dispose of used EV batteries. Establishes "Electric Vehicle Battery Recycling Task Force" to study ways to safely store, reuse, recycle, and dispose of used electric vehicle batteries.

S3373 Requires manufacturers of EVs to establish and implement EV battery management plans. Requires manufacturers of electric vehicles to establish and implement electric vehicle battery management plans.
A4922 An Act concerning the labeling and tracking of electric vehicle batteries and supplementing Title 13 of the Revised Statutes. Requires manufacturers of electric vehicles to label electric vehicle batteries; establishes electric vehicle battery tracking database; establishes guidelines for safe disassembly of electric vehicle batteries.

New York S157 Prohibits the sale of second-use lithium-ion batteries. Prohibits the sale of second-use lithium-ion batteries intended for use in a bicycle with electric assist, an electric scooter or a limited use motorcycle; provides penalties for violations.
Int. 663 Powered Mobility Devices Prohibits the sale, lease, or rental of powered mobility devices, such as e-bikes and electric scooters, and storage batteries for these devices, that fail to meet two UL standards.
Int. No. 752 (NY City Bill) Prohibiting the sale and assembly of second-use lithium-ion batteries. This bill would prohibit the sale of second-use lithium-ion batteries that have been assembled or reconditioned using cells removed from used batteries. A person who violated the proposed local law would be subject to a civil penalty. The civil penalty would range from \$200 for a first violation to \$1,000 for each subsequent violation within two years. It would also prohibit the assembly of such batteries.
Int. No. 846 (NY City Bill) Requiring the department of sanitation to develop a plan for ensuring proper disposal of rechargeable batteries used for powered mobility devices. Requires the Department of Sanitation to develop a plan for promoting the proper disposal of rechargeable batteries used for powered mobility devices, such as motorized bicycles and scooters.

S154 Relates to the manufacture, distribution and sale of lithium-ion batteries Prohibits the manufacture, distribution or sale certain lithium-ion batteries; provides penalties for violations.
S643 Relates to rechargeable battery recycling Amends existing rechargeable battery law and would require that reports of battery recycling activity submitted by retailers under current law include the weight of rechargeable batteries received for recycling within the city with a population of one million or more.

S1106 Requires lithium batteries of less than one inch in diameter and products containing such batteries to be labeled with warnings related thereto. Requires lithium batteries of less than 1 inch in diameter and products containing such batteries to be labeled with warnings that swallowing such batteries has been known to cause death.

S4939 Establishes a product stewardship program for primary batteries. Relates to establishing a product stewardship program for primary batteries.
A5677 Relates to the sale, lease, rental, and storage of e-bikes and electric mobility devices. Relates to the sale, lease, rental, and storage of e-bikes and electric mobility devices; requires certification testing for compliance with certain safety standards; authorizes the office of fire prevention and control to promulgate rules and regulations to enhance safety standards.

Oregon SB 64 Relating to battery disposal; declaring an emergency. Requires Department of Environmental Quality to study disposal of electric vehicle batteries and batteries used to store energy in wind or solar renewable energy facilities. Directs department to submit findings to interim committees of Legislative Assembly related to environment not later than January 15, 2024. Declares emergency, effective on passage.
SB 444 Relating to recycling innovation. Directs Department of Environmental Quality to establish Recycling Innovators Grant Program to support the development of innovative and demonstrable solutions to complex recycling issues by eligible entities. This includes electric motor vehicle components and batteries.

September 15, 2024. **HB 2769** Relating to electric vehicle batteries. Requires Department of Environmental Quality to study disposal of electric vehicle batteries. Directs department to submit findings to interim committees of Legislative Assembly related to environment not later than September 15, 2024.

HB 3220 Relating to electronics recycling; prescribing an effective date. Modifies provisions of electronics recycling program. Expands definition of covered electronic device. Establishes criteria for electronics producer responsibility programs. Repeals requirement that Department of Environmental Quality establish state contractor program. Repeals requirement that department make certain calculations used in administration of program. Directs Environmental Quality Commission to establish fee calculated to cover costs to department of carrying out program. Establishes that changes to program become operative on January 1, 2026. Provides transition provisions.

Vermont H.67 An act relating to household products containing hazardous substances This bill would require that manufacturers of household products containing a hazardous substance participate in a stewardship organization and implement a plan to collect household products containing a hazardous substance free of charge to the public.

Washington S5144 Providing for responsible environmental management of batteries. An Act relating to providing for responsible environmental management of batteries; amending RCW 43.21B.110 and 43.21B.300; adding a new section to chapter 82.04 RCW; adding a new chapter to Title 70A RCW; and prescribing penalties.

Washington DC S9596 Battery and Electronic Stewardship Amendment Act of 2022 To amend the Sustainable Solid Waste Management Amendment Act of 2014 to clarify that the battery producer responsibility law applies only to primary batteries and rechargeable batteries, to require the battery stewardship organization to develop strategies for collecting batteries in areas and communities with waste management challenges related to environmental justice, to establish timelines and procedures for the Department of Energy and Environments consideration of amendments to battery stewardship plans, etc.

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THANK YOU.

