Argonne NATIONAL LABORATORY

Presentation 901

END-OF-LIFE CONSIDERATIONS FOR STATIONARY ENERGY STORAGE SYSTEMS

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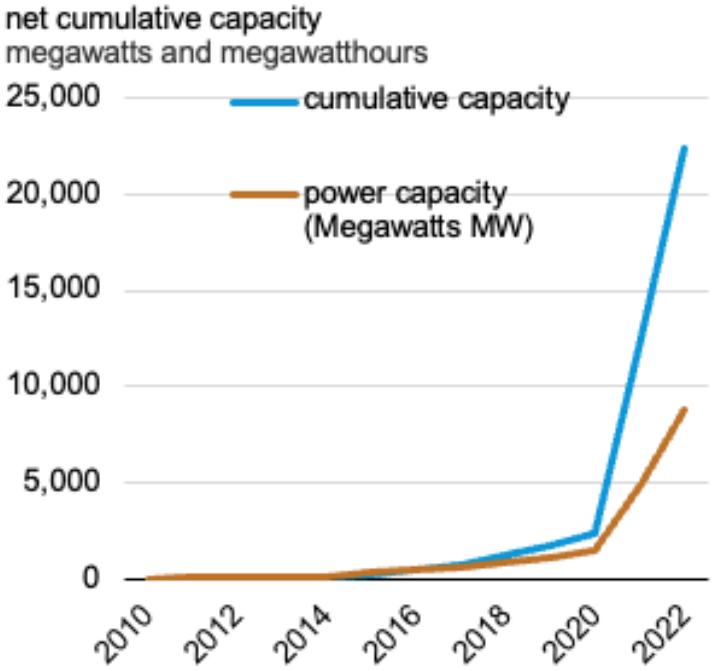
Project Overview

Purpose:

- Improving understanding of end-of-life (EOL) management of battery energy storage systems (BESSs) and enabling knowledge sharing with stakeholders
- Raising the importance of EOL consideration during the planning stage
  - Cost
  - Environmental impacts

Benefit:

- Improved cost and environmental impacts over the life cycle of BESSs
- Better decision making
- More awareness

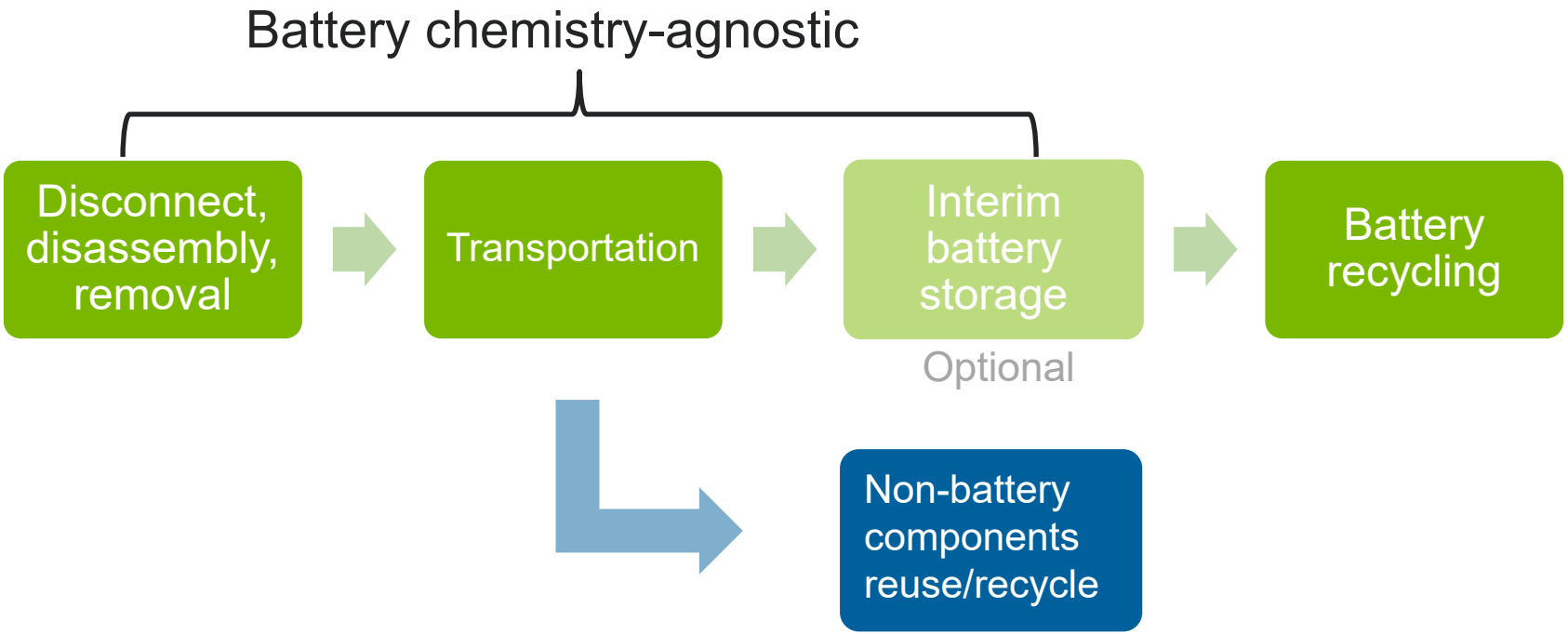


Source: EIA 2023

Current Status of BESS EOL Management

- Currently, a decommissioning plan is generally required as part of the permit application for a new BESS project.
- The stakeholder who builds the BESS (e.g., a BESS developer, a utility company, a municipality) will be held responsible for decommissioning and recycling the system at EOL.
- In some jurisdictions, a decommissioning bond may be set upfront to ensure that EOL management will not be affected if the BESS builder ceases to exist.
- Most of the BESS owners/operators still do not have a good understanding of what EOL management entails and the associated costs.
- The majority of BESSs use lithium-ion batteries (LIBs) based on $LiFePO_4$ (LFP) chemistry.

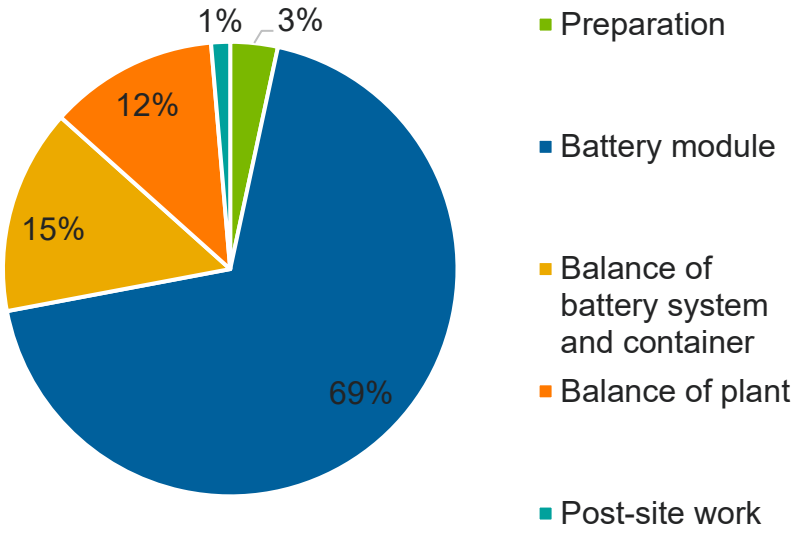
What does BESS EOL management entail?



How much does BESS EOL management cost?

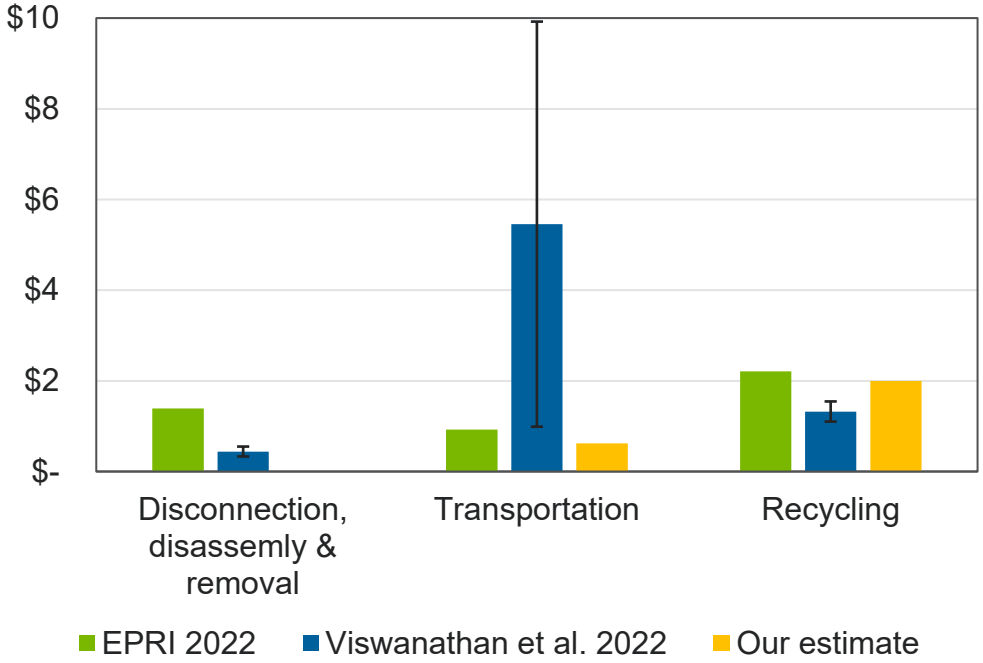
Management of batteries dominates overall BESS EOL cost; Recycling dominates battery EOL cost.

BESS EOL Cost Breakdown ($59/kWh)



Source: EPRI 2022

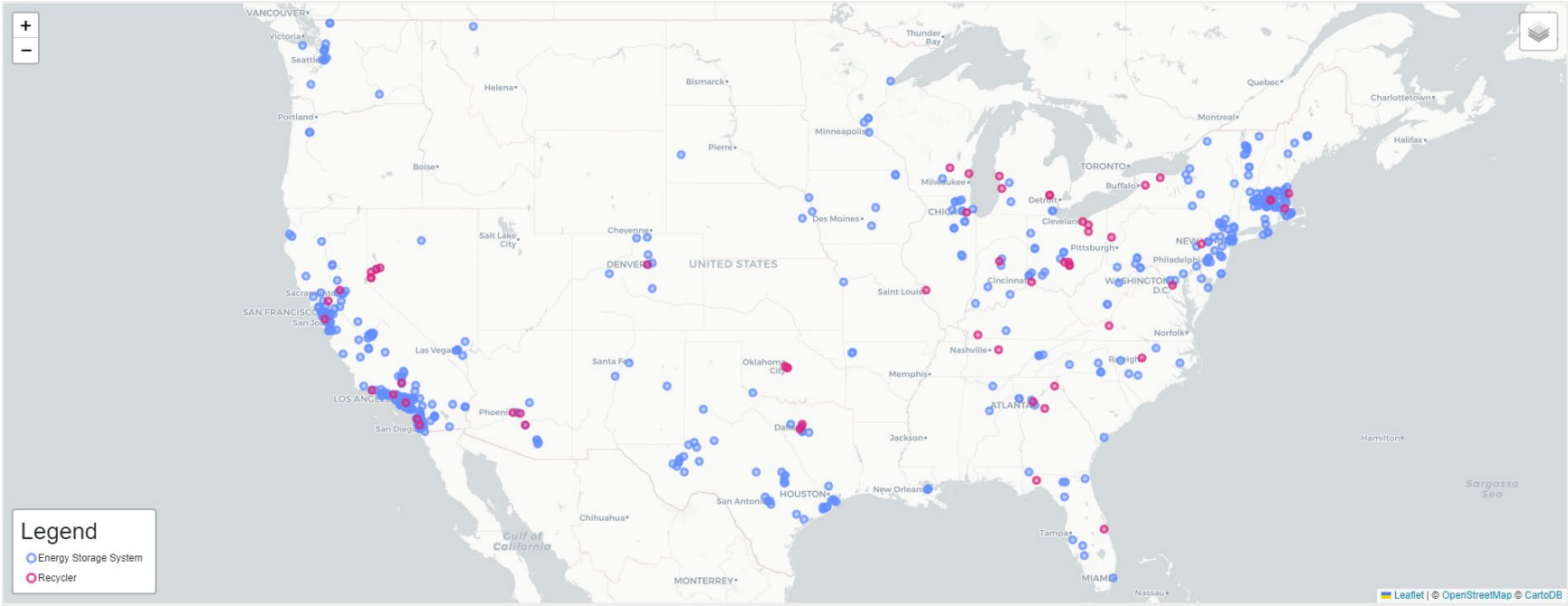
Battery EOL Costs Comparison ($/kg battery)



EPRI assumed a transportation distance of 2,000 miles, while we assumed 138 miles; EPRI assumed NMC battery chemistry, while Viswanathan *et al.* and we assumed LFP.

Battery Transportation Cost

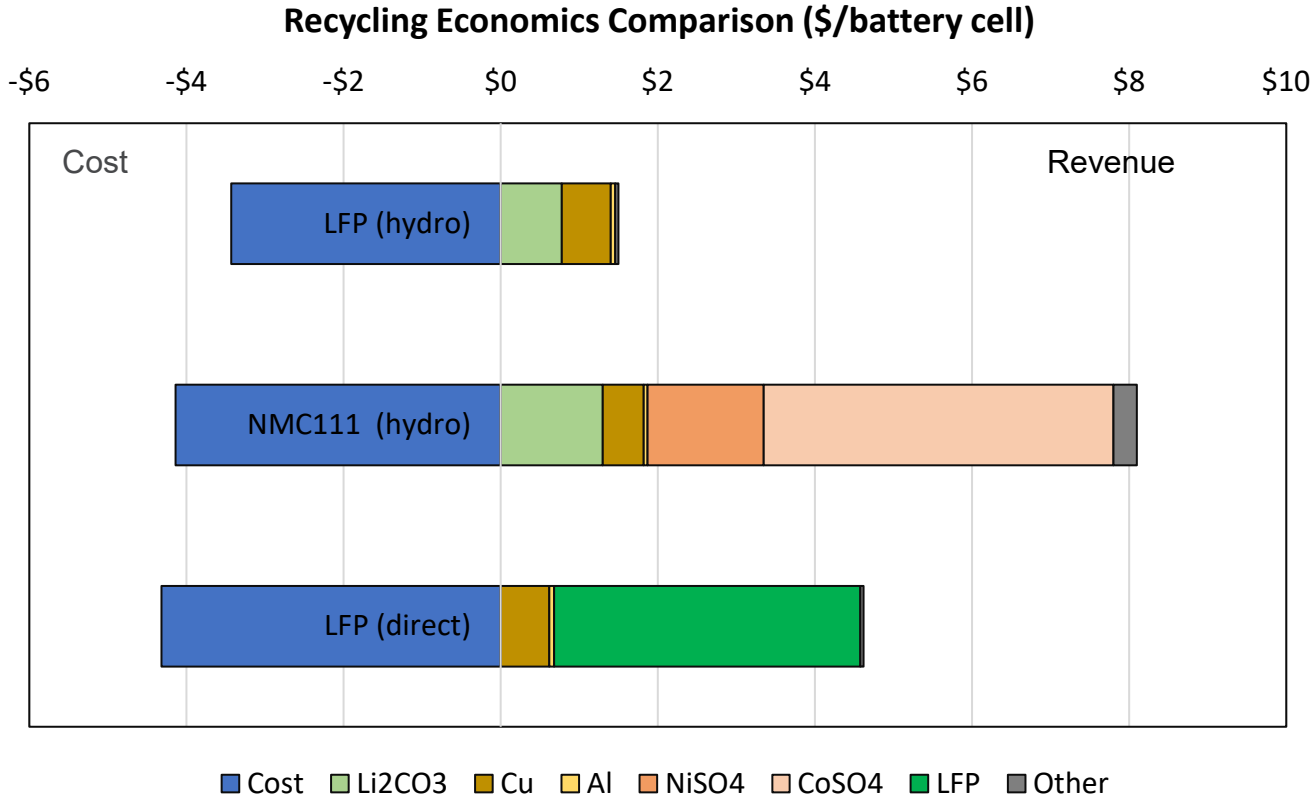
Depends on regulation and transportation distance.



- LIBs are regulated by the Department of Transportation as Class 9 hazardous material and have additional requirements for packaging, labeling, and handling.
- The average distance between existing BESS projects and their nearest recycling locations is 138 miles.

Battery Recycling Cost

Depends on battery composition and recycling technology.



- Results represent costs and revenues at a U.S. recycling plant that processes 10,000 metric tons of battery cells per year.
- The difference between the cost and total revenue could be the recycling cost borne by the BESS owner/operator.
- Results based on EverBatt 2023.

What about reuse? What about other BESS components?

- Utility companies always recycle batteries from decommissioned BESSs since they do not want any liability associated with reuse/repurposing.
- Other BESS owners/operators could consider reuse/repurposing, but at present the volume of reusable/repurposable batteries is too small for them to make a business case.
- Some BESS components (e.g., transformers) have a much longer lifespan than batteries and can thus be reused. Alternatively, a BESS developer may design the system to last 25-35 years and replace the batteries when they begin to fail.
- In addition to BESS components, the balance of plant (e.g., all metals in structural parts and concrete in foundation) is also recycled at EOL.

Knowledge Gaps

Decommissioning

- For existing BESSs without a decommissioning plan, information needed for disconnection, disassembly, and removal may be unavailable.
- Decommissioning cost is highly variable and could be hard to estimate.

Recycling

- Information on battery chemistry is not always available.
- Viable recycling technologies and recyclable materials for non-LIBs are still not well understood.

Summary and Future Work

- We assessed the current state of knowledge regarding BESS EOL management and summarized our findings in a report.
- We identified major cost contributors to BESS EOL management cost as well as key factors that could affect these costs.
- We identified remaining knowledge gaps and started collecting additional information through interviews with stakeholders and an online survey to bridge the gaps and inform model development.
- We developed a tool that can estimate transportation distances and costs for BESSs.
- In FY24, we will develop EverBESS to help estimate cost and environmental impacts of EOL management for BESSs based on LIBs and communicate our findings to stakeholders.

Acknowledgements

- Dr. Imre Gyuk, Office of Electricity
- Field project manager: Patrick Balducci
- Project team: Qiang Dai, Jakob Elias, Jeff Spangenberger

Thank You!

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References and Nomenclature

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Nomenclature

- EPRI: Electric Power Research Institute
- Hydro: hydrometallurgical
- NMC: lithium nickel manganese cobalt oxide
- NMC111: $LiNi_{1/3}Mn_{1/3}Co_{1/3}O_2$