DOE OE ENERGY STORAGE PEER REVIEW & ANNUAL MEETING, 2026
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EVERBESS: END-OF-LIFE CONSIDERATIONS FOR STATIONARY ENERGY STORAGE SYSTEMS

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Project Overview

- **Goal:** Provide BESS stakeholders with a model to estimate costs associated with end-of-life management
- **Current Practice:** Not many examples; One-off projects; Little information on standards and best practices
- **Why ANL:** Extensive experience with TEA modeling especially in the battery recycling space; Developed and maintain the lithium-ion battery recycling model named EverBatt
- **Innovation:** Provide a clean, easy-to-use model interface with easy-to-interpret results in a framework that allows for a high degree of customizability and simple integration
- **Duration: FY22-present**
- **Impact:** BESS owners will be more prepared for their financial responsibilities and will be better equipped to plan for their system's EOL management
- **Vertical/Investment Area:**
  - Analytics
  - Materials and Systems Innovation
- **Alignment:** Provide decision-making tools for stakeholders to evaluate BESS EOL and better understand LCOS while securing supply chains for energy infrastructure and increasing energy affordability and resilience in the U.S.

Project Motivation

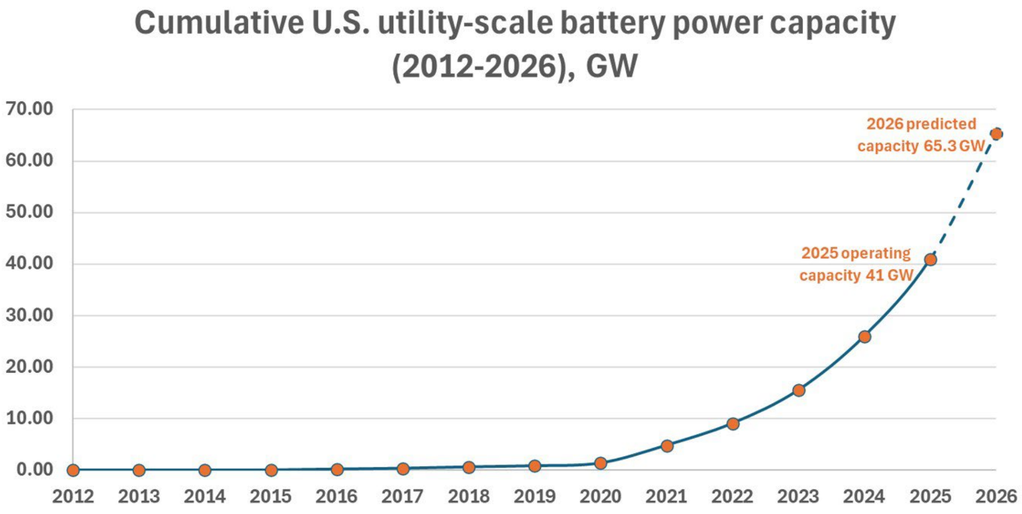
Motivation:

- Rapid increase in BESS deployment necessitates better understanding of EOL management at planning stage.
- The AI boom will further drive up BESS deployment and may pose additional challenges to supply chain and EOL.

Impacts:

- Improved critical resource utilization
- Informed decision making and planning for circularity of critical materials
- Cost and supply chain benefits

U.S. battery storage added a record 15GW capacity in 2025



Data source: U.S. Energy Information Administration, *Preliminary Monthly Electric Generator Inventory*

Problem: Status Quo In BESS EOL Management

How things stand…

- **BESS owners** (BESS developer, utility company, etc.) are responsible for decommissioning plans.
- Decommissioning plans (and allocated funds/bonds) are generally **required for a permit application.**
- Most BESS owners/operators do not have a good understanding of **EOL management** processes and their costs.
- **Thus, more clarity on component fates at EOL and the associated costs is desired.**

BESS EOL Overview

Generally, three steps happen at EOL

Decommissioning

- De-energizing
- Disconnection, removal, and packaging of modules
- Removal of all other system components
- Cleanup of site (including restoration if needed)

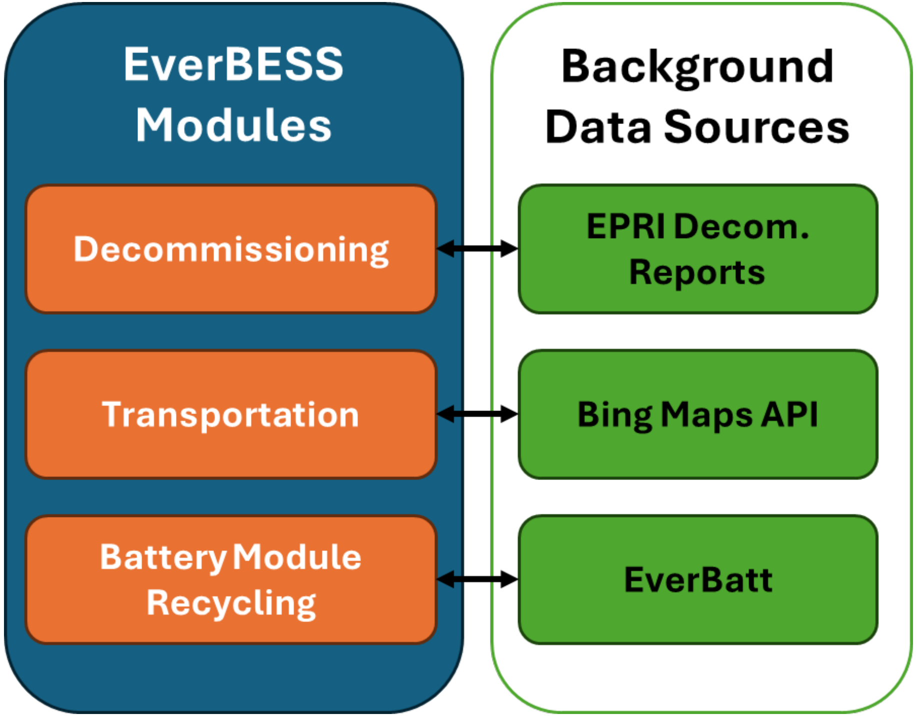
Transportation

- Transport of modules to a capable recycler
- Transport of other system components to a reseller/scrap yard
- Storage may be involved
- Hazmat requirements may apply

Recycling

- Dismantling of battery modules
- Removal of refrigerants from system components
- Removal of modifications from container/enclosure
- Recovery of valuable materials

Approach: EverBESS Framework



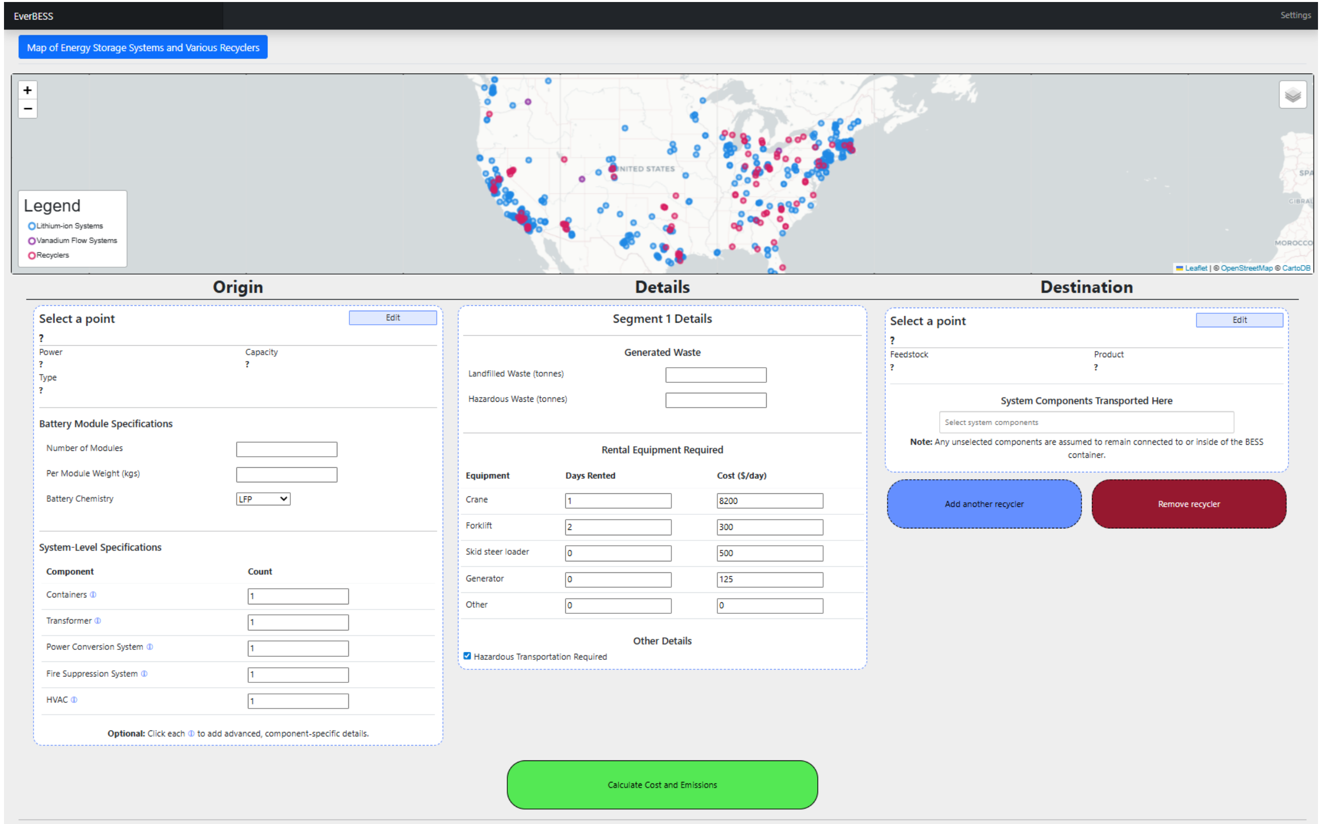
- EPRI provides estimates for the labor required to decommission each BESS component.
- Driving distance between the BESS and recycler sites is calculated via Bing Maps API.
- EverBatt model examines the cost and environmental impacts of battery recycling processes.

Currently EverBESS includes Li-ion and vanadium flow redox batteries and is being expanded to include Na-ion batteries.

Approach: EverBESS Model

What is it?

- Web application
- Built on FastAPI
- Open to the public



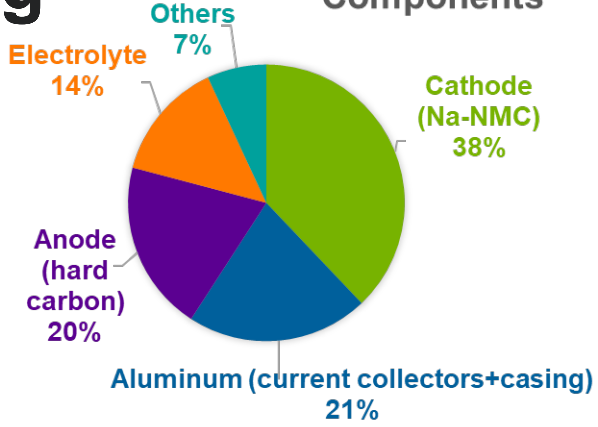
Available at: https://everbess.egs.anl.gov

Results: Na-ion Battery Recycling

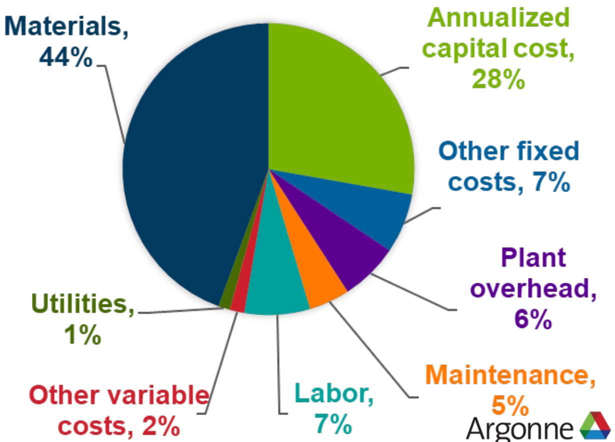
Conducted analysis for Na-NMC chemistry

- Commercially the most developed sodium-ion battery chemistry
- Hydrometallurgical recycling process developed by industry
- Preliminary analysis results:
  - Total cost of recycling at plant: $6.19/kg cell processed
  - Potential revenue: $4.39/kg of cell processed, from recovered Ni, Co, Mn, and aluminum
- Hard carbon anode and electrolyte solvent & salt can be substantial revenue streams if recovered

Mass% of Components



Cost Breakdown



Na-NMC: sodium nickel manganese cobalt oxide

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Results: User Interface Improvement

Background Data

Note: Since EverBESS uses background data that is down to the state level at times, you must select a BESS and a recycler destination of the 'Modules' component before background data is displayed.

Decommissioning

Labor Rates

Electrical Engineers

Data Source: BLS OEWS

Rate ($/hour)

71.34

HVAC Mechanics and Installers

Data Source: BLS OEWS

Rate ($/hour)

35.8

Waste Handling Fees

Transportation

Recycling

Use Defaults Confirm

Waste Handling Fees

Landfill tipping fee

Data Source: EREF 2024 Analysis of MSW Landfill Tipping Fees

Tipping Fee ($/U.S. ton)

83.76

Hazardous waste handling fee

Data Source: Industry quotes

Tipping Fee ($/tonnes)

1077

Transport Costs

Hazardous transportation

Data Source: ATRI Operational Cost of Trucking 2024

Cost ($/mile)

2.303

Non-hazardous transportation

Data Source: ATRI Operational Cost of Trucking 2024

Cost ($/mile)

2.11

Labor Rates

Chemical Plant and System Operators

Data Source: BLS OEWS Database

Rate ($/hour)

31.45

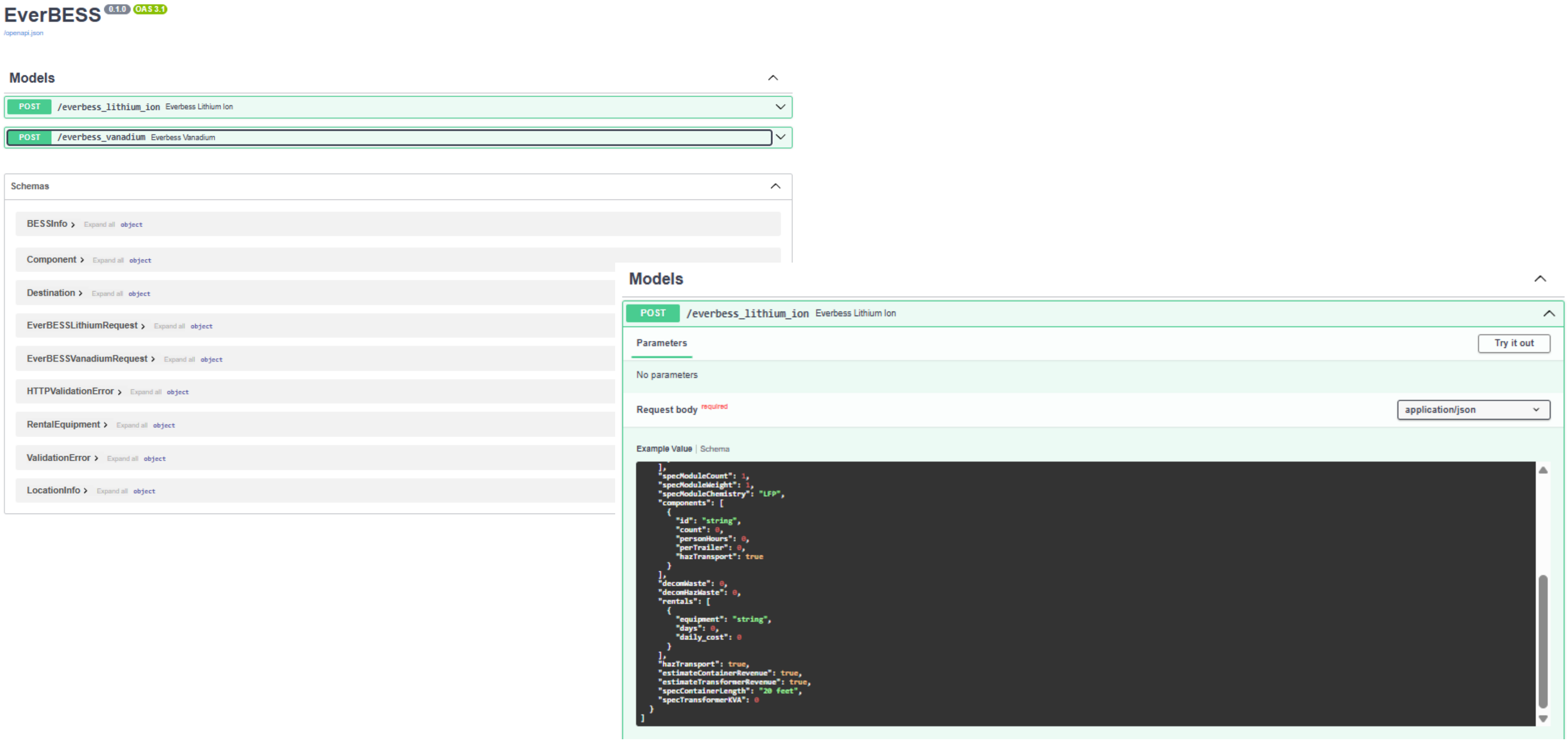
Input Materials

Material Costs

Output Materials

Material Revenues

Results: API Development and Enabling AI



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https://everbess.egs.anl.gov/docs

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Future Work

- EverBESS development and expansion
  - Na-ion battery expansion to include more chemistries
  - Vanadium redox flow battery to include electrolyte refurbishing
  - Assess EOL value of auxiliary BESS components (other than batteries)
  - Model validation
  - API development
- Comparative study of Li-ion, vanadium, and Na-ion BESS EOL management
- Continue industry and stakeholder outreach to increase awareness of BESS EOL cost and promote responsible EOL management

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THANK YOU

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