HOW CAN BATTERIES FROM ELECTRIC VEHICLES GET RECYCLED?

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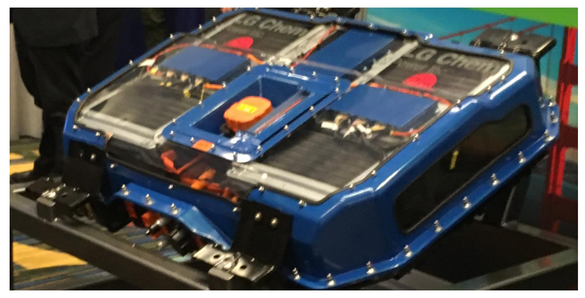
Abstract

There is a need to develop technology to enable a resource-efficient and economically feasible recycling system for lithium-ion batteries and thus assure the future supply of the component materials. Lithium-ion batteries are complex products, and designs and materials are still evolving, which makes planning for future recovery more challenging. Several processes for recycling are proposed or operating, and each has advantages and disadvantages. Since none of the existing processes is ideal, research areas are suggested that could enable development of improved recycling methods. The most promising research area is separation technologies.



Chevy Bolt battery pack.

Material Concerns

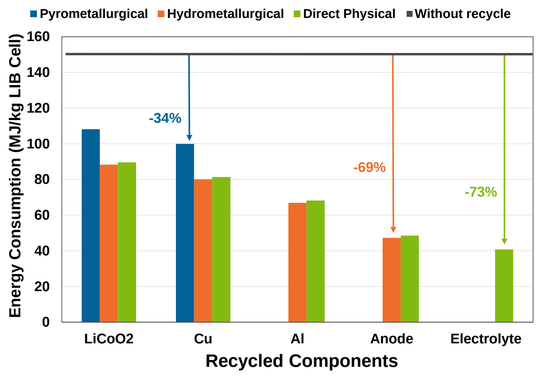
- ☐ Batteries are expensive
- ☐ They contain potentially scarce materials
- ☐ We need to recover the critical materials, especially cobalt.

Element	Projected Demand	USGS Reserves
Lithium	230	16,000
Cobalt	910	7,100
Nickel	340	74,000

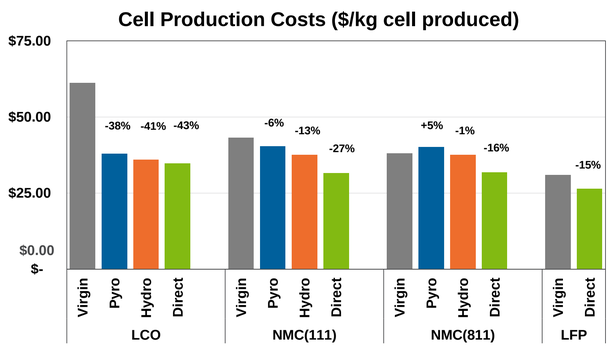
Projected cumulative world battery material demand to 2025 (1000 tons). Note: Reserves from U.S. Geological Survey (USGS).

Benefits of Recycling

- ☐ Reduces impacts and costs
- ☐ Displaces virgin raw materials
- ☐ The more materials recovered, in as valuable a form as possible, is better.



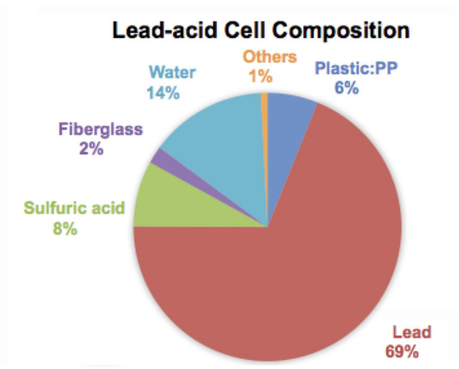
If cathode, anode, foils, and electrolyte can all be recovered, energy to produce a cell is reduced by 73%.

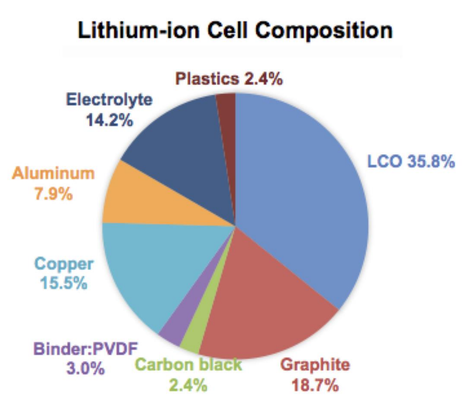


Production costs for new cells are generally reduced by including recycled materials.

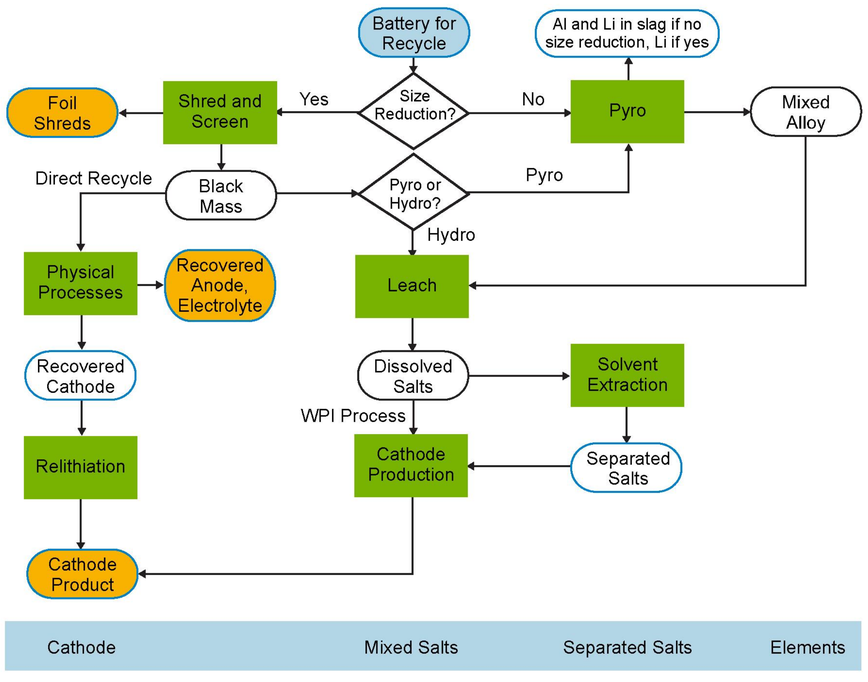
Recycling Complex Systems

- ☐ Li-ion battery recycling is complicated
  - Many different materials contained
  - Complex battery design
  - Numerous paths to material recovery, which can occur at different process stages, as shown by the flowchart.
- ☐ Lead-acid battery design is simpler, leading to over 99% recycling.





Lead acid batteries contain few materials, predominantly lead, while lithium-ion batteries contain a large variety of materials that all must be separated for effective recycling.



Recycling of Li-ion Batteries Faces Many Issues

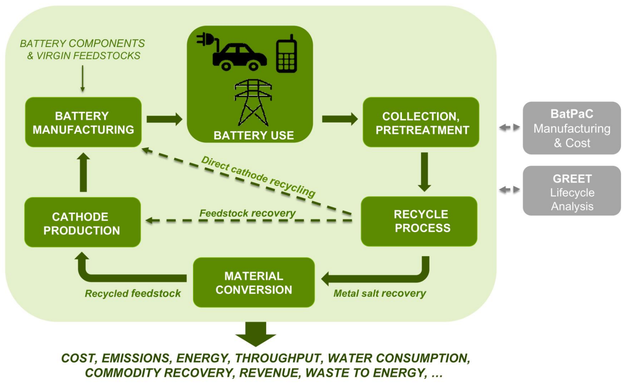
- ☐ Chemistry and design still evolving
- ☐ Material tied up for 10 or more years while in use
- ☐ Best recycling process may depend on chemistry
- ☐ Transportation as hazardous material may be expensive
- ☐ Regulations may impede recycling
- ☐ Batteries designed for performance, not end-of-life

Research is Needed to Develop Best Processes

- ☐ Disassembly and material separation methods
- ☐ Design for recycling
- ☐ Recovered material upgrading technology
- ☐ Methods to reuse entire structures
- ☐ Optimized process design
- ☐ Modeling of recycling processes

ReCell Model

- ☐ Argonne's closed-loop Li-ion battery model provides cost and environmental impacts through all lifecycle stages and processing steps
- ☐ Simulates process behavior and costs without building a plant
- ☐ Provides insight into the relative impacts of different recycling paths
- ☐ Accelerates research by guiding it toward processes with minimum economic, energy, and environmental impacts



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