Arkansas Recycling Coalition

ReCell ADVANCED BATTERY RECYCLING

RECELL CENTER

WORKING TO MAKE BATTERY RECYCLING PROFITABLE

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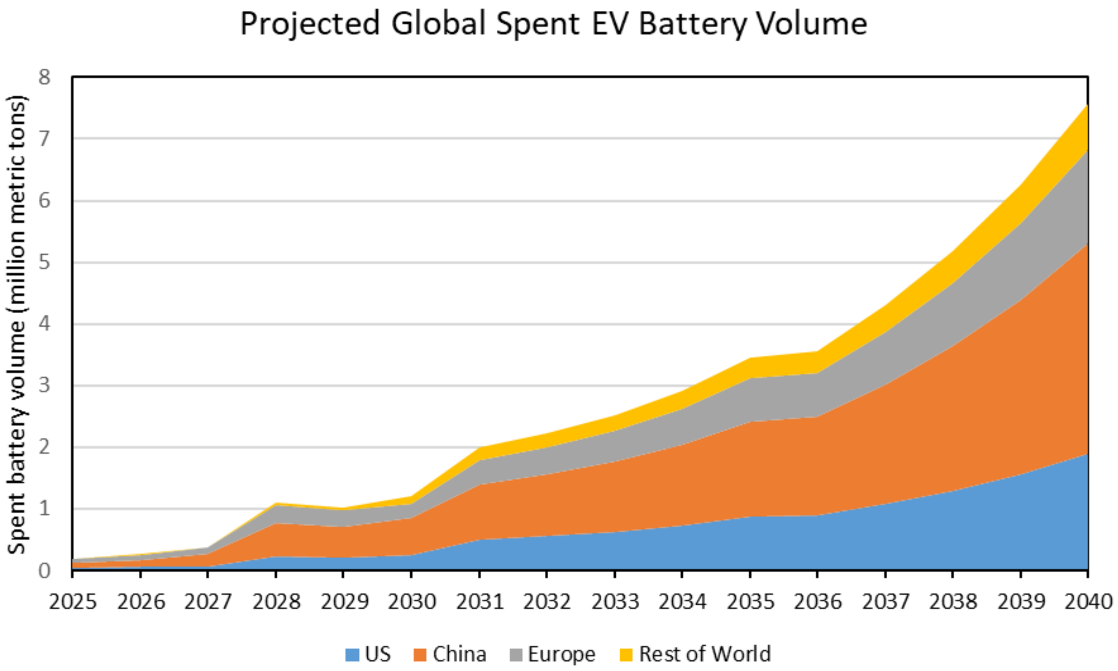
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy
VEHICLE TECHNOLOGIES OFFICE

SETTING THE STAGE

- A flood of Lithium-ion batteries coming in electric vehicles (EV)
- Cannot meet demand without recycling
- Recycling relieves strain on critical materials supply chain



(ANL projection based on IEA global PEV projection)

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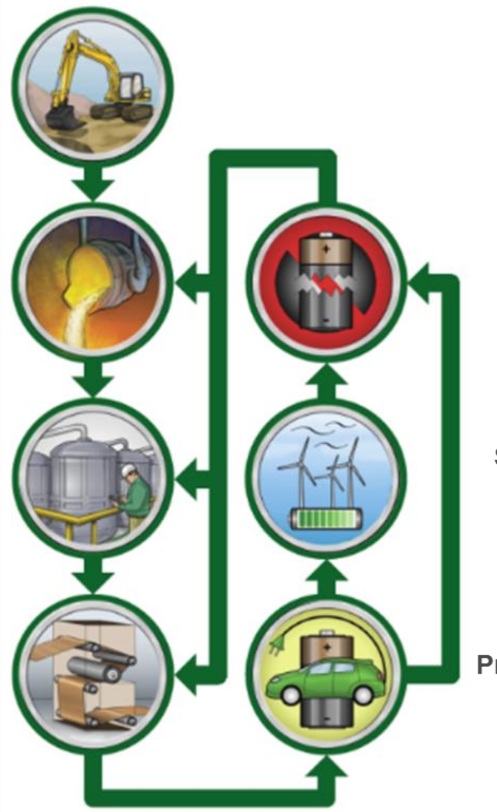
CURRENT PROCESSING

- Recycling lithium-ion batteries is possible today
  - Pyrometallurgical
  - Hydrometallurgical
- These processes are over a hundred years old and very mature
- Products are low value metal salts



THE RECELL CENTER

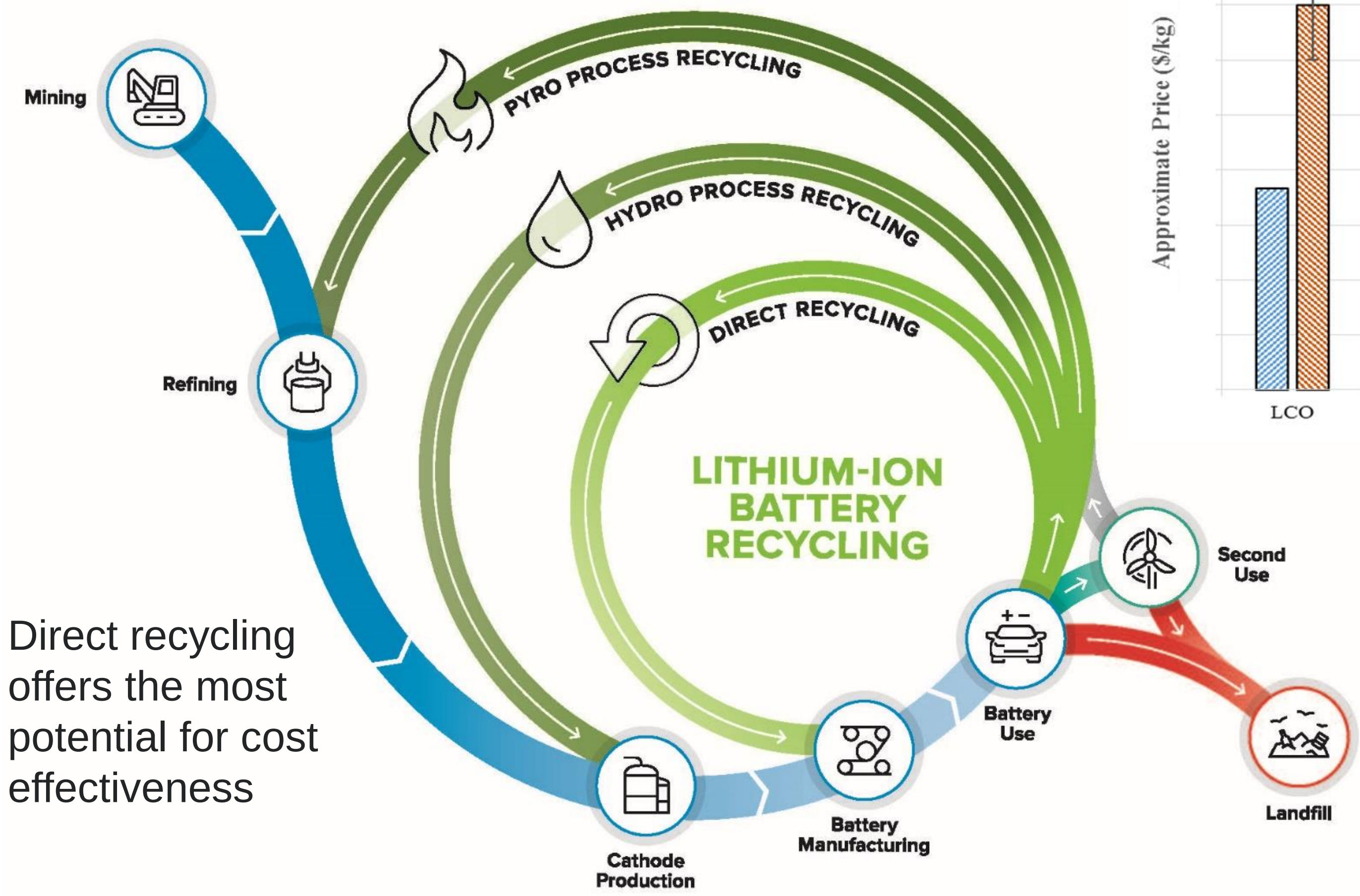
Purpose

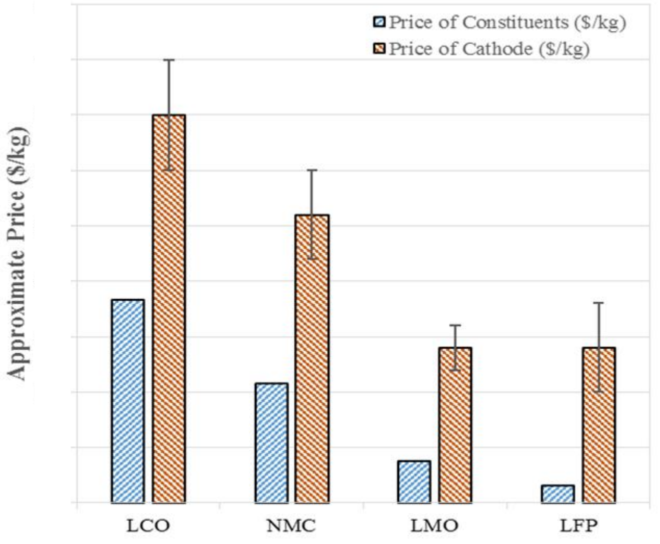
- Foster the development of cost-effective and environmentally sound processes to recycle lithium-ion batteries.
- Bring together experts from various battery recycling areas and bridge the gaps between them.
- Efficiently address the many challenges that face a successful advanced battery recycling infrastructure.

Outcome

- Minimize use of the earth's limited resources, reduce energy consumption and increase our national security.
- Drive battery costs down to DOE's $80/kWh goal

DIRECT RECYCLING





Direct recycling offers the most potential for cost effectiveness

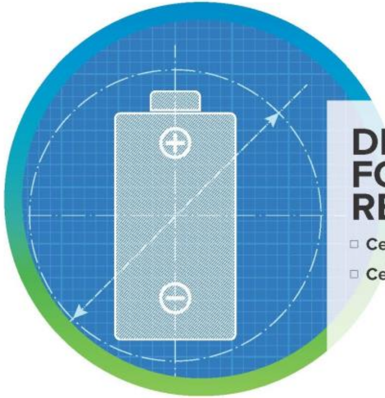
FOCUS AREAS

DIRECT CATHODE RECYCLING

- Cathode Separation
- Binder Removal
- Relithiation
- Compositional Change

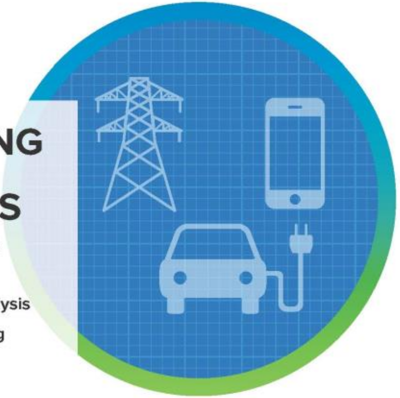
OTHER MATERIAL RECOVERY

- Electrolyte
- Graphite
- Electrode/Foil



DESIGN FOR RECYCLING

- Cell Design
- Cell Rejuvenation



MODELING AND ANALYSIS

- Materials Analysis
- Thermal Analysis
- Supply Chain Analysis
- TEA/LCA Modeling

DIRECT CATHODE RECYCLING

CHALLENGE

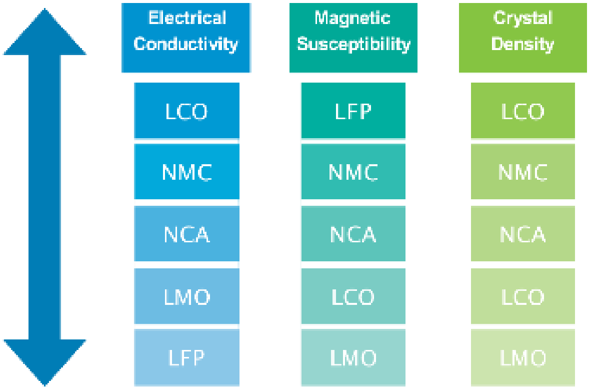
- Contaminants from processing
- Mixtures of cathode chemistries
- Old chemistry

SOLUTION

- Binder removal
- Cathode separation
- Compositional change
- Relithiation

IMPACT

- Increased product value (even w/out Co)
- Decreased processing and waste
- Decrease dependence on raw materials



Many different aspects of the cathode material can be exploited to separate cathode powders. Electrical conductivity, magnetic susceptibility, and crystal density are just a few. *Courtesy of Argonne*

RECOVERY OF OTHER MATERIALS

CHALLENGE

- Low value materials
- Cost effective processes

SOLUTION

- Cost effective recovery of electrolyte components
- Direct recycling of anode

IMPACT

- Increased revenue potential
- Decreased waste treatment

A laboratory scale froth flotation unit is used to separated anode powders from cathode powders.
Courtesy of Michigan Technological University

DESIGN FOR RECYCLE

CHALLENGE

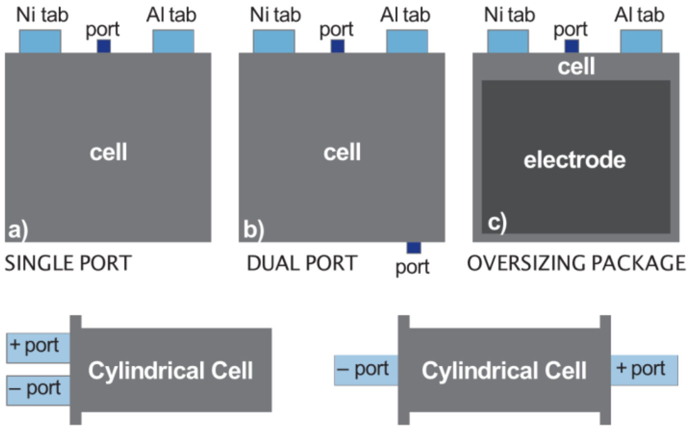
- Minimizing cost and performance impacts

SOLUTION

- New cell designs
- New cell component design
- Enabling cell flushing for rejuvenation

IMPACT

- Reduced cost of recycling
- Overall cost reduction
- Reduced number of cells reaching end of life
- Extended cell life



Initial pouch and cylindrical cell designs that will be used to determine the pressures and flows needed to "rinse" used cells.

MODELING AND ANALYSIS

CHALLENGE

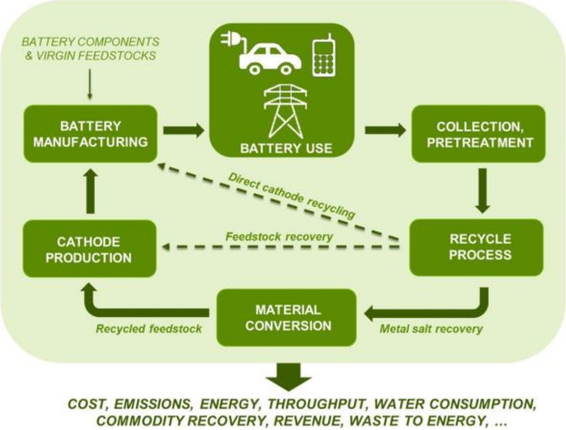
- Myriad of recycling pathways
- Need for preliminary review of new technologies to streamline work
- Need for research validation

SOLUTION

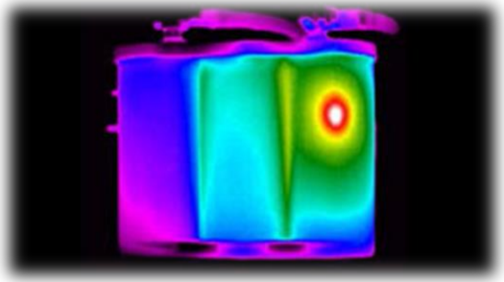
- Supply chain modeling (LIBRA)
- TEA/LCA modeling (EverBatt)
- Material Analysis at end of life
- Thermal analysis at end of life

IMPACT

- Cost/time efficient work plan to achieve the Center’s objectives



Process flow of EverBatt model. *Courtesy of Argonne*



Infrared thermal image of a lithium-ion battery cell with poor terminal design. *Courtesy of NREL*

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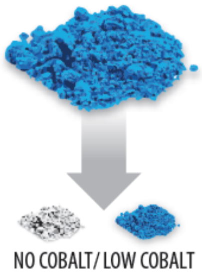
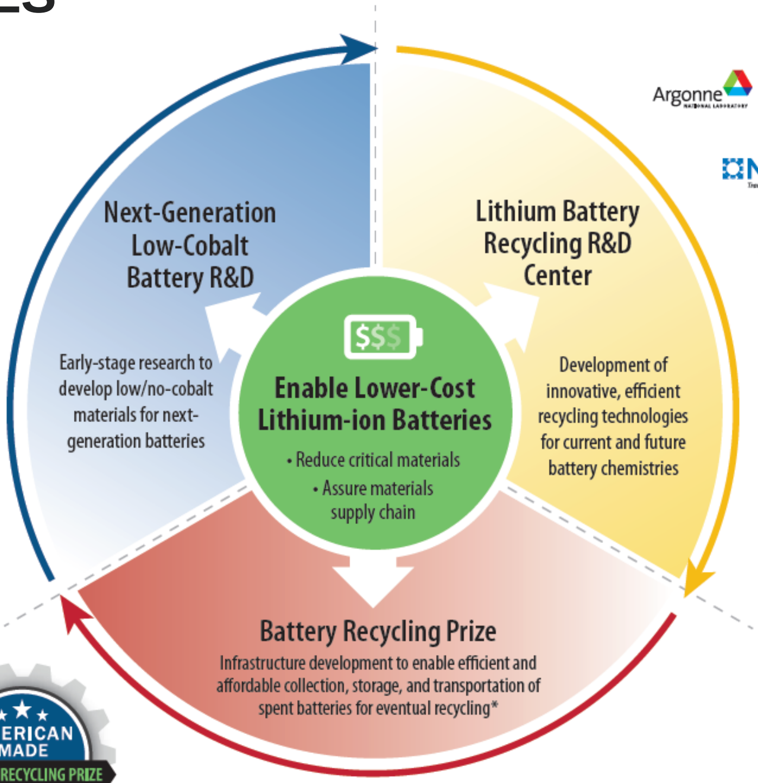
VEHICLE TECHNOLOGIES OFFICE BATTERY RESEARCH PLAN FOR CRITICAL MATERIALS





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THANK YOU!