NAATBatt Annual Meeting 2019

ReCell
ADVANCED
BATTERY RECYCLING

RECELL CENTER

WORKING TOWARD A COST-EFFECTIVE LITHIUM-ION BATTERY RECYCLING PROCESS

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Argonne National Laboratory

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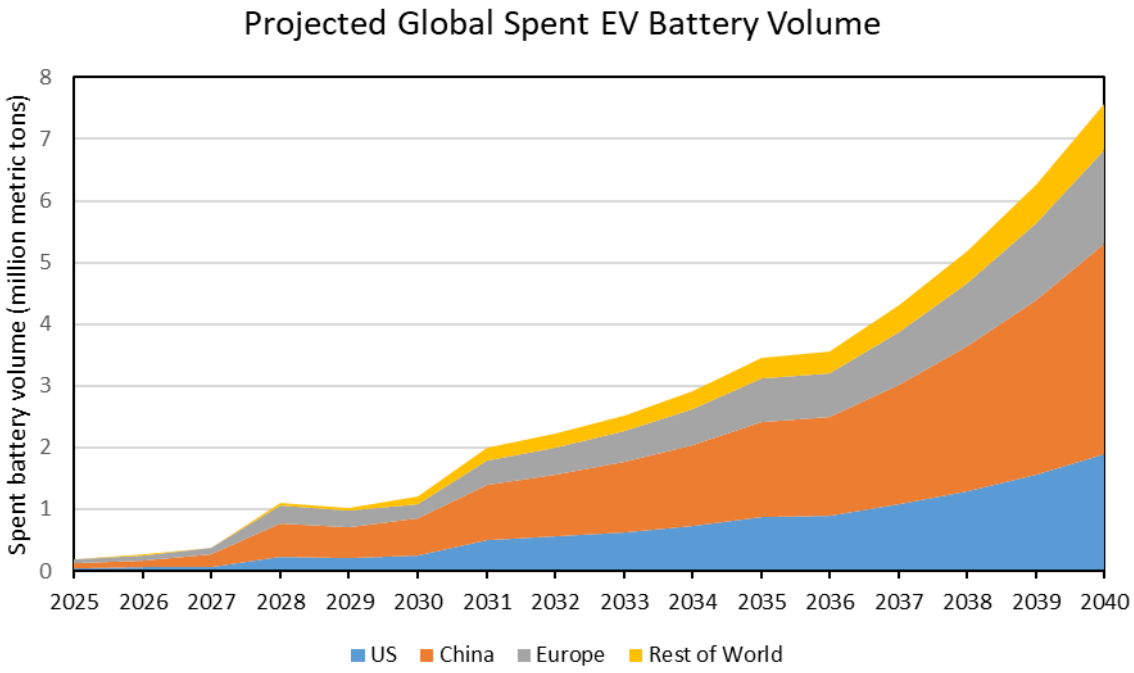
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy
VEHICLE TECHNOLOGIES OFFICE

SETTING THE STAGE

- Collection of Consumer Electronics is poor
- Electric vehicles haven't reached their end-of-life yet
- Stationary storage is even further out; different challenges
- Lithium-ion batteries in electric vehicles and stationary app's typically cost money to recycle
- Profitable recycling is needed to drive a healthy infrastructure



(ANL projection based on IEA global PEV projection)

ReCell ADVANCED BATTERY RECYCLING

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 without competing with industry

Efficiently address the many challenges that face a successful advanced battery recycling infrastructure.

Outcome

Our success will result in aiding in the development of a profit-driven recycling framework inherently minimizing the use of earth's limited resources, reducing energy consumption and increasing our national security. This translates to the continued establishment of green transportation by reducing cost of ownership and helping to drive battery costs to DOE's $80/kWh goal.

COLLABORATIVE TEAM

Argonne NATIONAL LABORATORY

NREL NATIONAL RENEWABLE ENERGY LABORATORY

OAK RIDGE National Laboratory

UC San Diego

WPI

Michigan Technological University

1885

And Industry!!!

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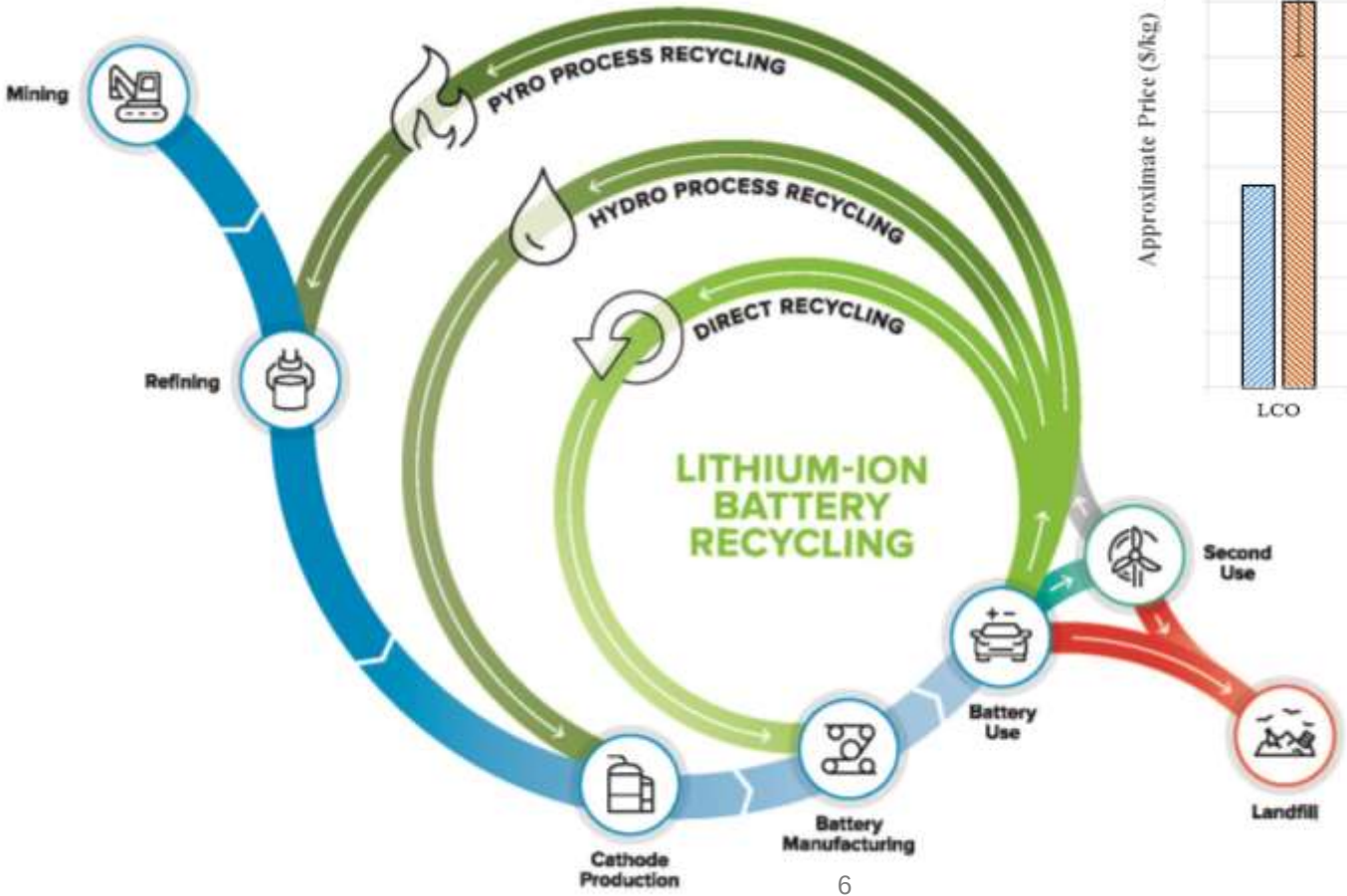
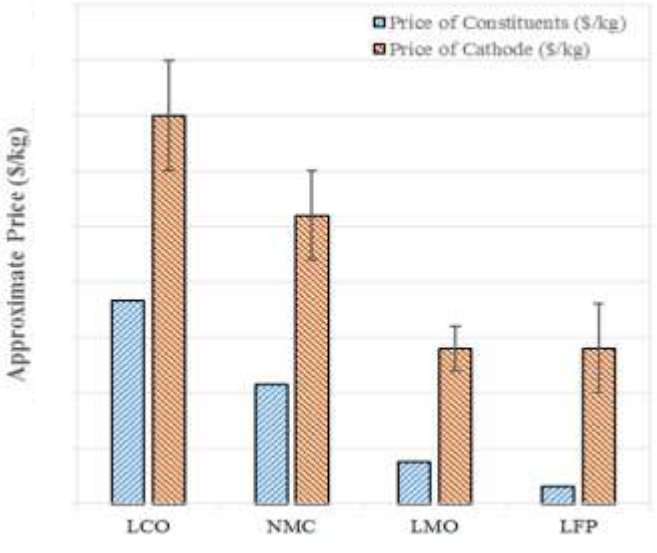
FOUR FOCUS AREAS

DIRECT RECYCLING





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DIRECT RECYCLING

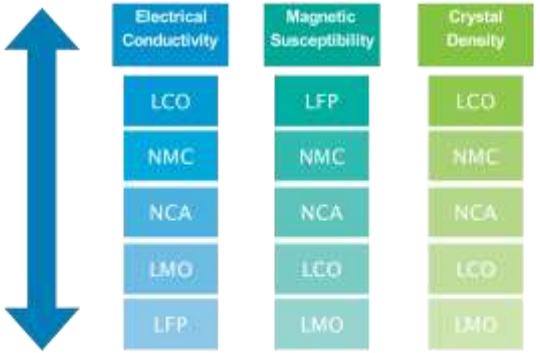
CHALLENGE

Current recycling methods for lithium-ion batteries recover lower-value materials than the cathode itself. To make recycling profitable and to encourage industry growth, methods of direct recycling are needed. However, there are hurdles because of the large variety of materials used in lithium-ion batteries and the on-going development of new battery chemistries.

SOLUTION

Direct cathode recycling enables recovery of material for reuse in cell manufacturing with minimal re-processing. The center will develop processes to separate mixed cathodes from each other and renew recovered material via relithiation. Novel techniques will upgrade obsolete cathode compositions to current ones.

Recycled cathode powder ready to be used in a new battery. *Courtesy of University of California San Diego*



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

Current recycling processes fail to recover many of the potentially valuable materials in lithium-ion batteries. This perpetuates reliance on foreign sources and encumbers recyclers with high costs for waste disposal.

SOLUTION

The ReCell Center will create economical industrial processes for separating electrolyte components, anode powders, and cathode powders from black mass. Anode powders are disposed of now, but could be reused in new batteries. The center will also develop a process to recover fluorine based electrolyte salts for reuse.

A laboratory scale froth flotation unit is used to separate anode powders from cathode powders. This is the first step in recovering the anode powder. *Courtesy of Argonne*

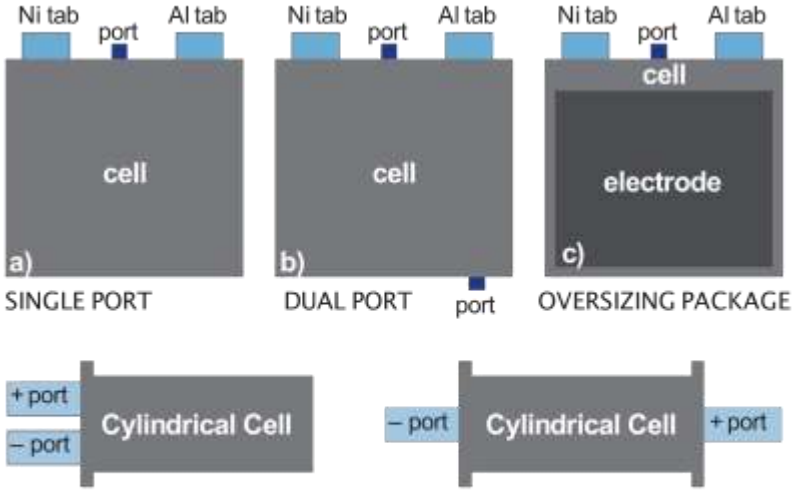
DESIGN FOR RECYCLE

CHALLENGE

Current batteries are designed with performance in mind, without much thought towards end-of-life. Designing new batteries with consideration of end-of-life can improve recyclability. But to keep the batteries marketable, the center will develop new designs that trade minimal loss in energy-density performance for the ability to use lower-cost, new recycling processes.

SOLUTION

The center will explore new designs for wound, prismatic, and pouch cells to enable them to be flushed clean at end-of-life and refilled for reuse. A rinse will be flowed through cathode and anode to renew the surface before adding a new electrolyte.



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

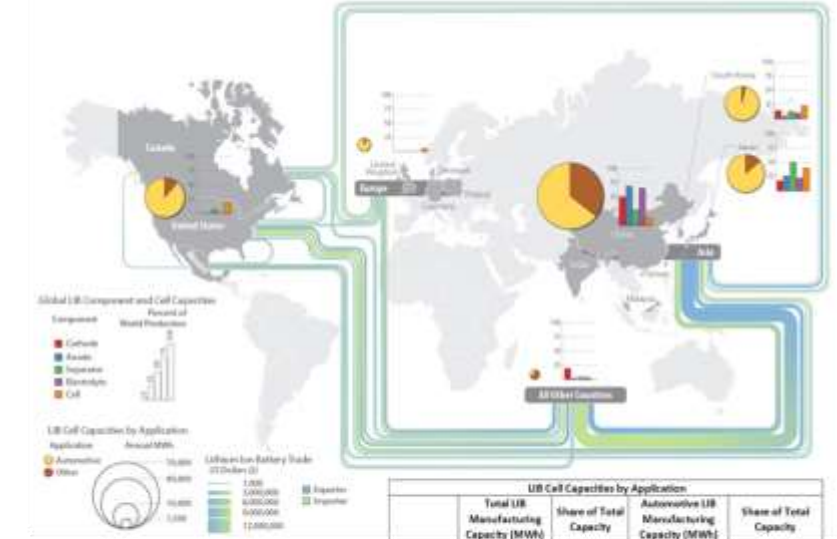
MODELING AND ANALYSIS

CHALLENGE

There are many potential recycling pathways for batteries that no longer meet their performance criteria. It would be expensive and time-consuming to explore all possible process options; researchers need tools to direct them to the most efficient and economic processes.

SOLUTION

Modeling and analysis can guide process development without the need to actually try all options. These tools help researchers identify the most promising directions of research and validate work that has been completed



Note: Automotive manufacturing capacities were calculated based on the total production capacity of the studied facilities that make batteries for autos. Some of these facilities make batteries for autos and other applications.

LIB Cell Capacities by Application

	Total LIB Manufacturing Capacity (MWh)	Share of Total Capacity	Automotive LIB Manufacturing Capacity (MWh)	Share of Total Capacity
China	118,734	62.3%	50,630	44.3%
Japan	22,479	11.8%	19,434	17.0%
S. Korea	18,547	9.8%	17,834	15.6%
U.S.	24,766	13.1%	22,096	19.2%
E.U.	2,626	1.4%	2,400	2.1%
Rest of World	3,110	1.6%	2,110	1.8%
Total	189,762	100%	114,484	100%

Using supply chain modeling, a holistic approach can be taken to understand the battery market and the impact that recycling will have on it. *Courtesy of NREL*

RIBBON CUTTING

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recycling today
Chicago Tribune
The New York Times
JAPANTODAY
NEWS

National

US Seeks Ways To Recycle Lithium Batteries In Cars, Phones

the japan times
Green Car Congress
Taiwan News
South China Morning Post
The Chronicle Journal

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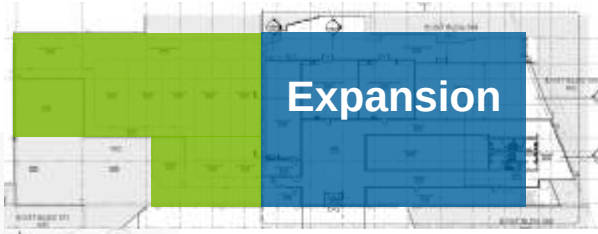
FLEXIBLE LABS AND COLLABORATIVE SPACE



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Expansion Labs

Future Labs

Collaborative Space

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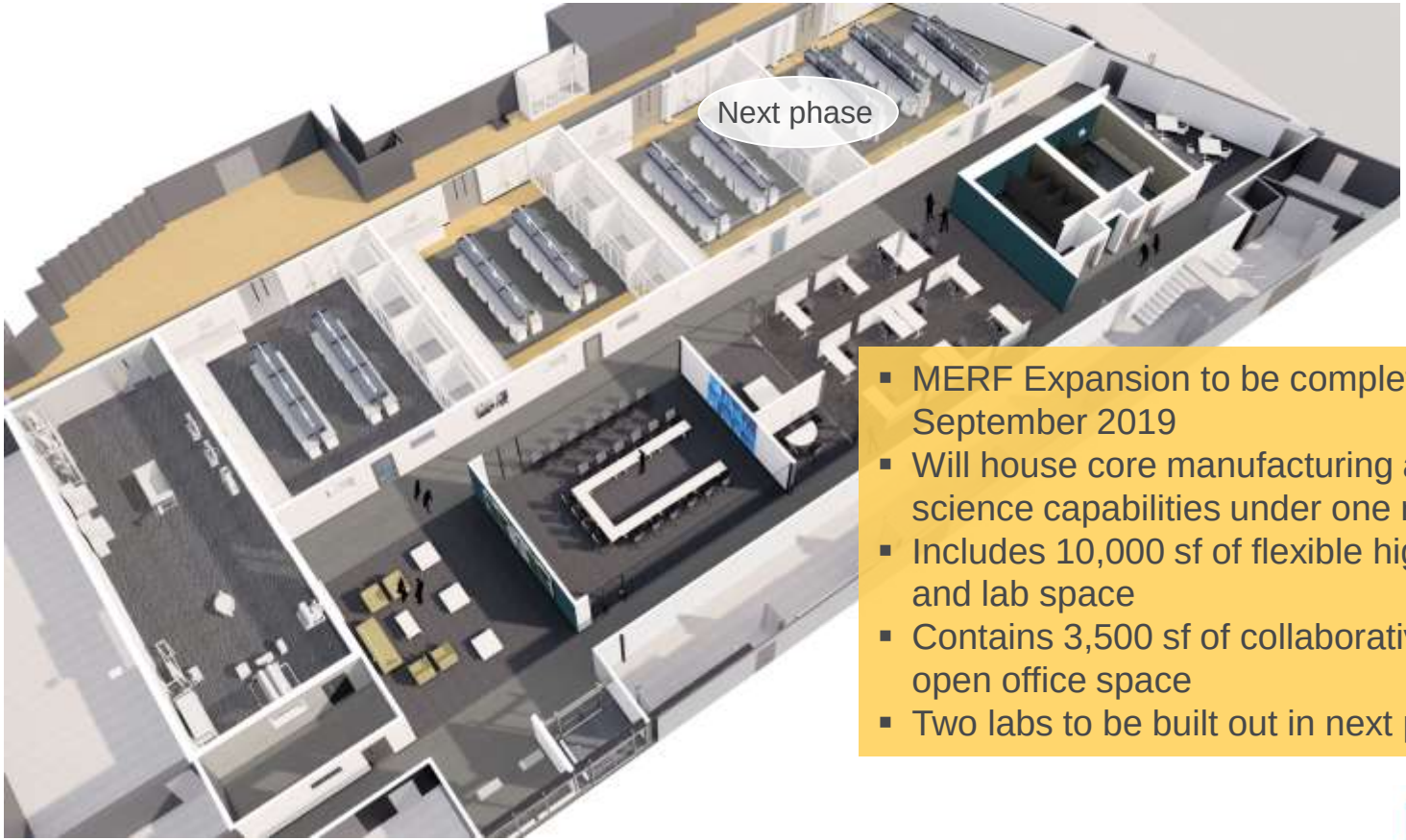
MERF EXPANSION 3D VISUAL



- MERF Expansion to be completed September 2019
- Will house core manufacturing and science capabilities under one roof
- Includes 10,000 sf of flexible highbay and lab space
- Contains 3,500 sf of collaborative and open office space
- Two labs to be built out in next phase

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THANK YOU!

(ASK ME HOW TO GET INVOLVED)

This Center is made possible by the U.S. DOE, EERE, VTO

Samm Gillard and Dave Howell

And the entire ReCell team