



Incentivizing Innovators

Health, Safety and Disposal of New Power Sources

Disclaimer: All details necessary to participate in the Lithium-Ion Battery Recycling Prize program are provided in the Official Rules document online. The information provided in this presentation is not intended to amend, modify or substitute details provided in the Official Rules. Information presented should be used in conjunction with the Official Rules. In addition, any reference in presentation to any specific commercial product, process, or service, or the use of any trade, firm or corporation name is for the information and convenience of the public, and does not constitute endorsement, recommendation, or preference by the U.S. Department of Energy. Visit americanmadechallenges.org



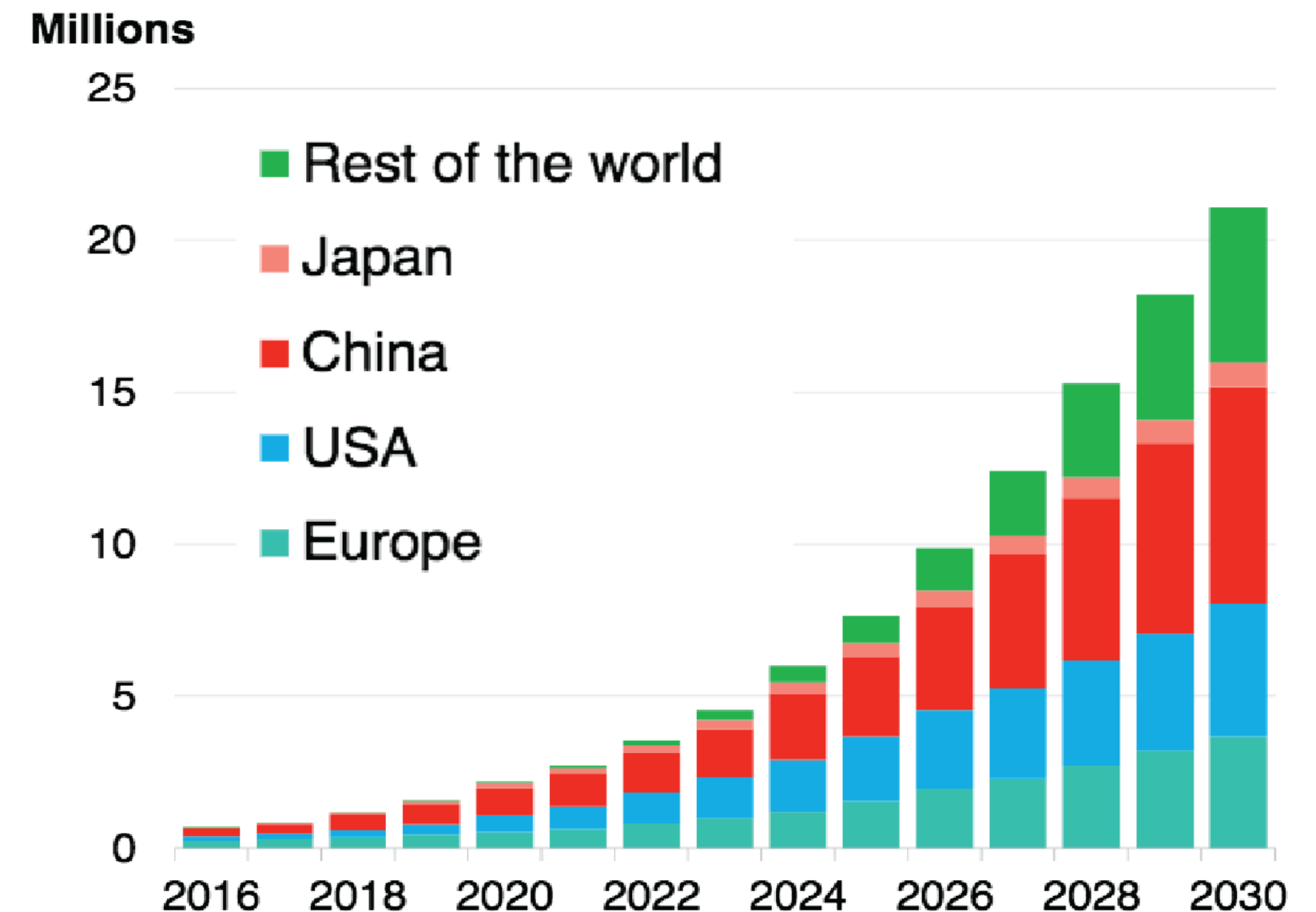
U.S. DEPARTMENT OF ENERGY

Light-Duty Passenger Vehicle Market and Potential Growth

U.S. Electric Vehicle (EV) Sales

- **Bloomberg New Energy Finance:**
 - Currently, there are more than 800,000 plug-in electric vehicles (PEV) on the road in the U.S.
 - Around 40 PEV models are available in show rooms of U.S. car dealerships.
- **Energy Information Administration:**
 - U.S. light-duty battery PEV sales are projected to reach 1.4 million by 2030.
 - EV batteries combined with consumer, stationary, and industrial applications are projected to quadruple the demand for lithium-ion batteries by 2030.

Global EV Forecast



Source: Bloomberg New Energy Finance

Battery EVs forecasted to achieve more than 20 million sales globally by 2030.

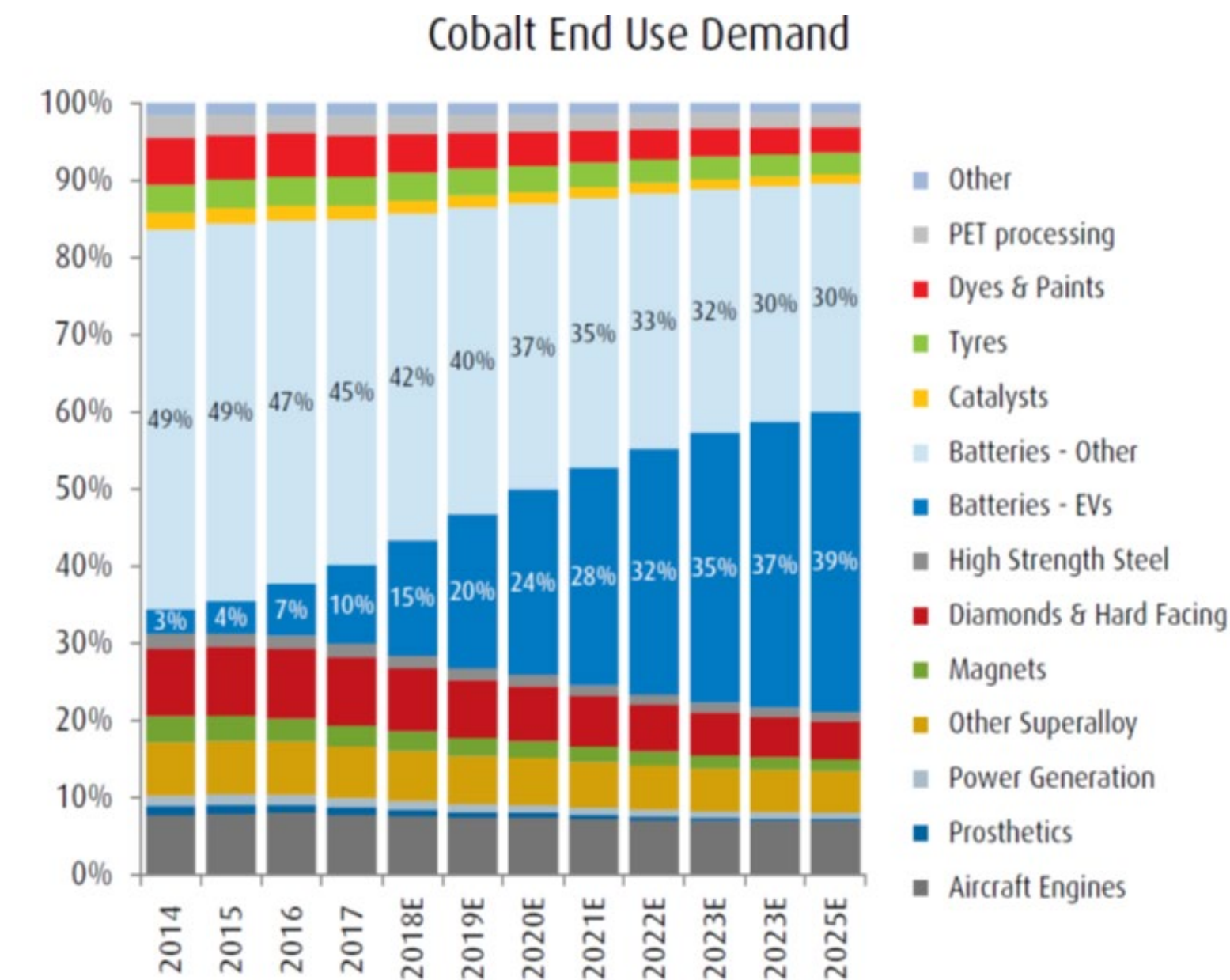
Critical Materials for EV Batteries

• Cobalt:

- Considered the highest material supply risk for EVs in the short and medium term
- Cobalt is up to 20% of the weight of the cathode in lithium-ion EV batteries
- Mined as a secondary material from mixed nickel and copper ore
- Demand in EVs is projected to surpass the portable electronics demand by 2023, even with assuming reduction of cobalt in cathodes.

• Lithium:

- Integral intercalating material for lithium-ion and lithium metal batteries due to its high energy, high power density, and low cost
- Lead time of 10 years to develop a new brine lake and produce large scale amounts of lithium—unexpected increases in demand can yield price spikes
- Critical for long term sustainability of EVs but should not be a supply risk if adequate recycling is implemented.

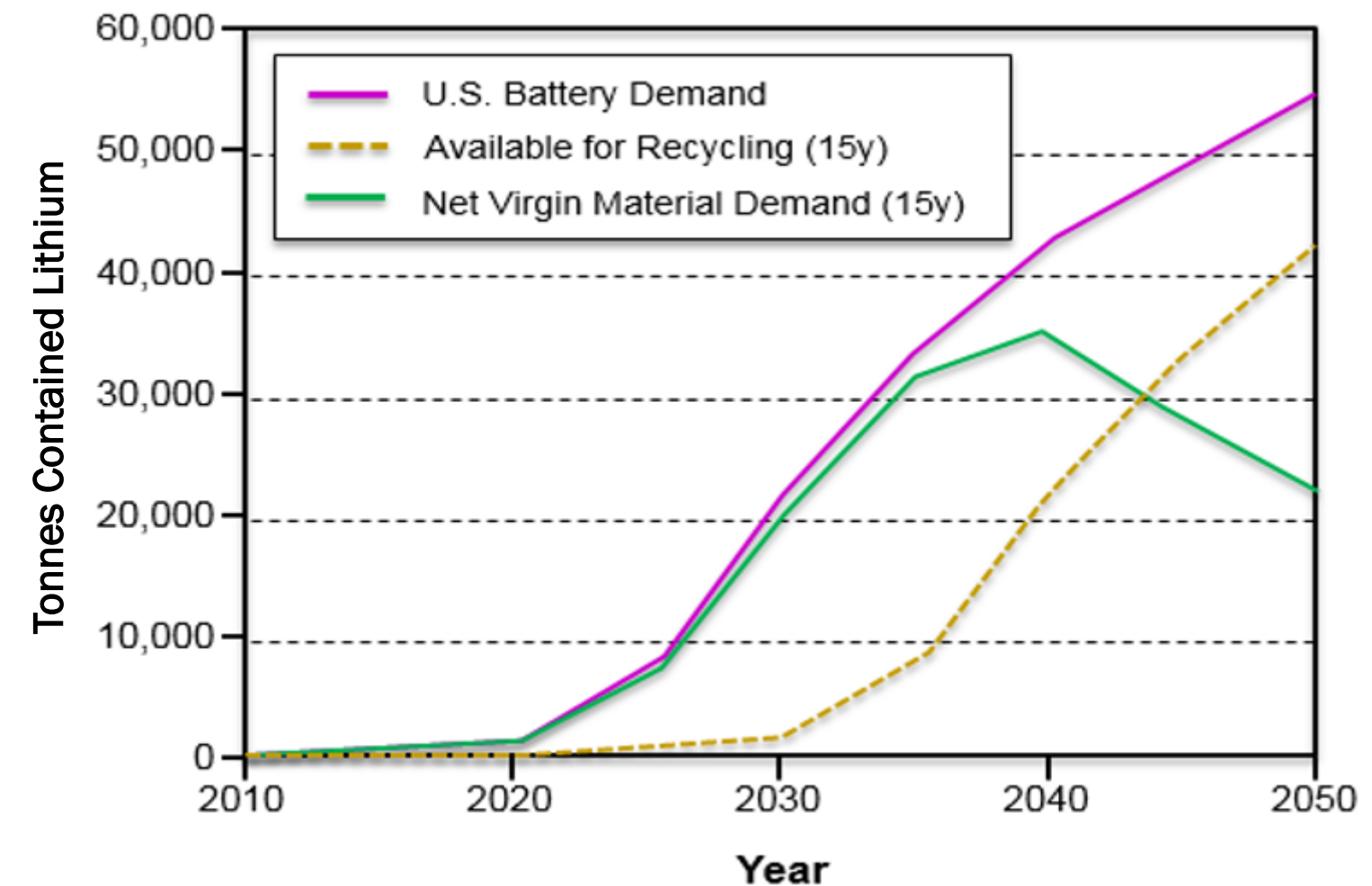
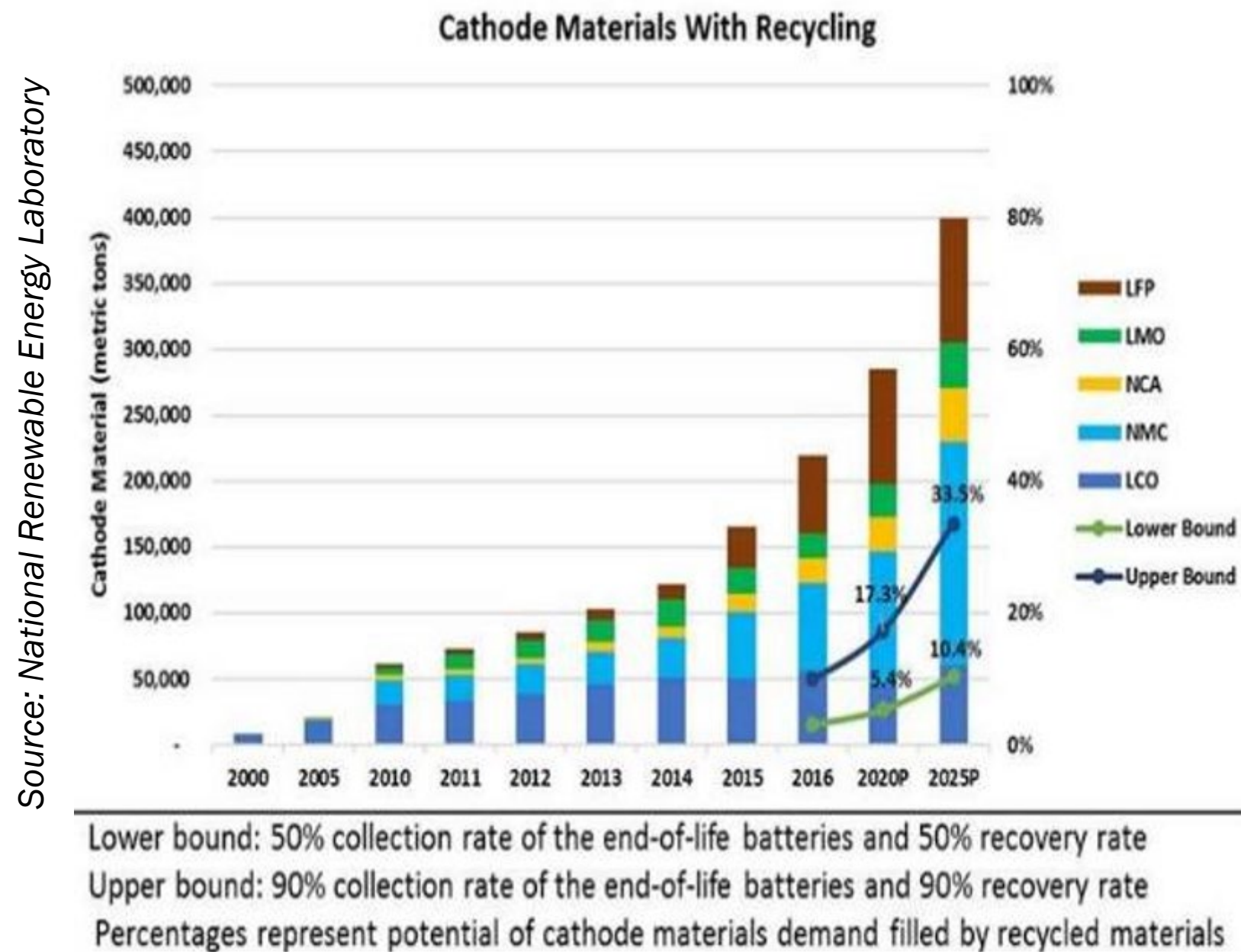


Source: National Renewable Energy Laboratory

Recycling Impacts to Material Costs & Availability

Recycling Cathode Materials:

- About half a million tons of battery materials are needed by 2030 to meet projected growth demands
- Closed-loop recycling can supply significant amounts of the demand material
- A 90% collection rate and a 90% material recovery rate can potentially supply 33.5% of the cathode material needs in 2030
- Studies indicate that recycled cathode materials (NMC) have the potential to reduce cathode cost from ~\$25/kg to ~\$10/kg.



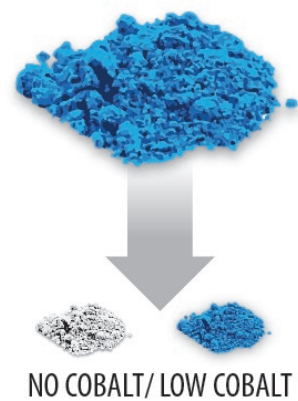
Source: Argonne National Laboratory

Ref: M. Mann, A. Mayyas, D. Steward, Impact of Li-Ion Recycling on the Supply Chain, NREL, presented at the International Li-Ion Battery Recycling Workshop, Golden, CO, May 30-31, 2018
 Lithium-Ion Batteries: Examining Material Demand and Recycling Issues, L. Gaines and P. Nelson, TMS 2010 Annual Meeting and Exhibition, Seattle, WA (February 2010)

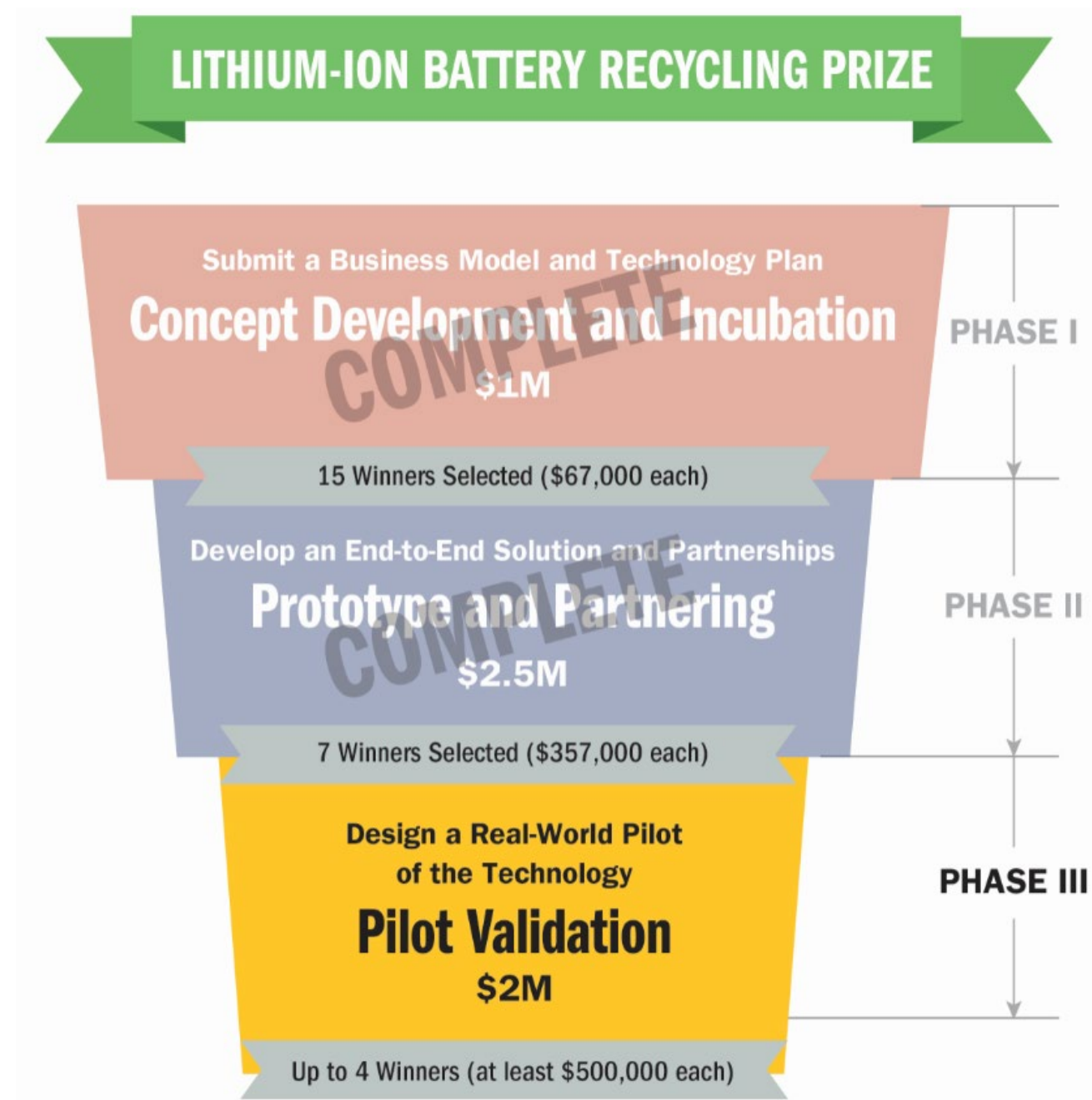
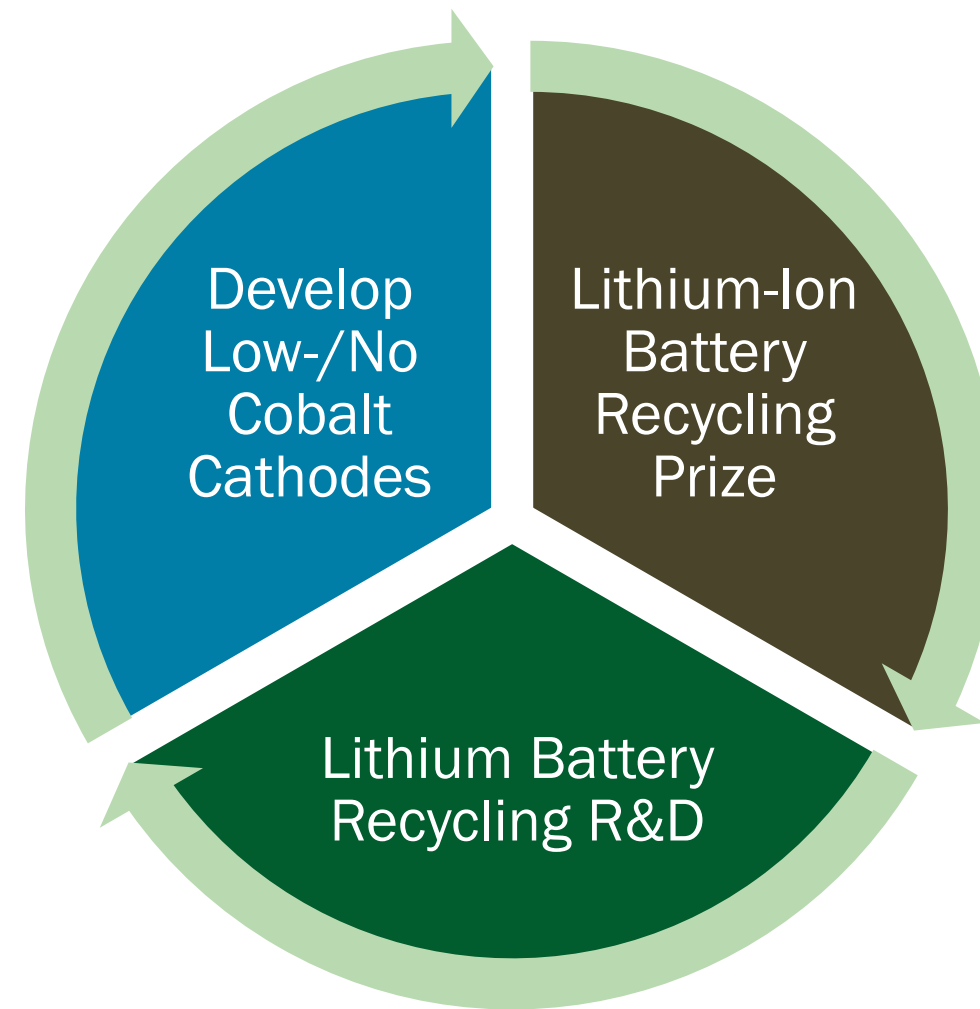
DOE Strategic Objective for Electric Vehicle Battery Storage

By September 30, 2022

- Reduce the cost of EV battery packs to less than \$150/kWh (long-term goal is \$80/kWh)
- Significantly reduce or eliminate the dependency on critical materials
- Utilize recycled material feedstocks.



Cobalt (CO) Content (kg) per 100 kWh battery pack	NMC622	19
	Low-no CO target	<5 or Zero



The ReCell Center: Advanced Battery Recycling

The center develops cost-effective, flexible processing techniques to extract as much value as possible from current and future batteries chemistries making recycling economically viable.



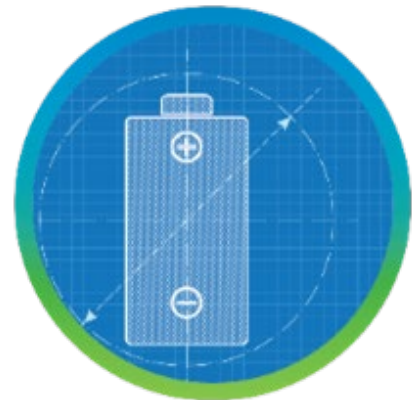
DIRECT CATHODE RECYCLING

- Cathode Separation
- Binder Removal
- Relithiation
- Upcycling



NON-CATHODE MATERIAL RECOVERY

- Electrolyte
- Graphite
- Foils



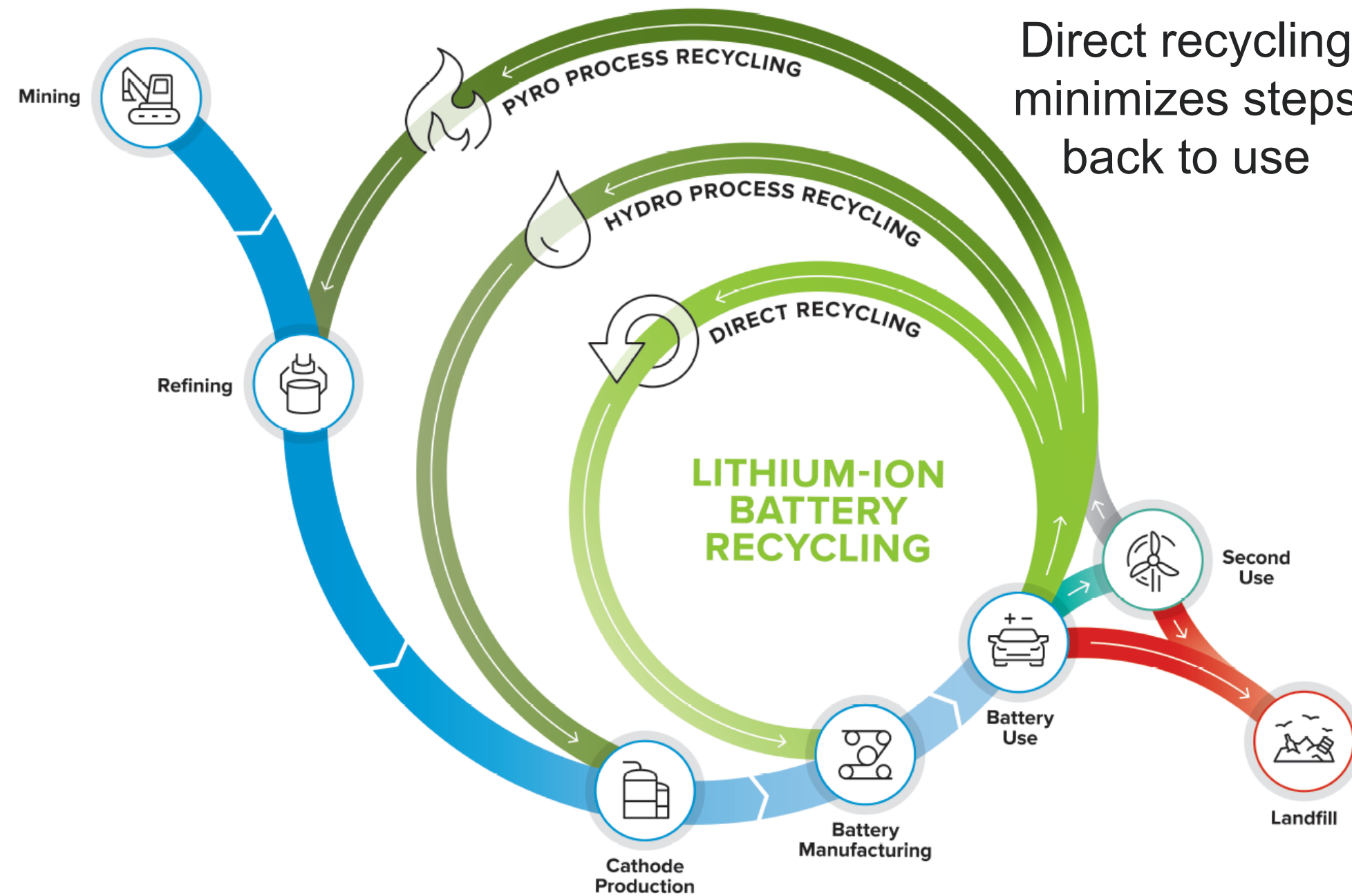
DESIGN FOR SUSTAINABILITY

- Materials
- Cell Design
- Cell Rejuvenation



MODELING AND ANALYSIS

- EverBatt (Cost/Environment)
- LIBRA (Supply Chain)



Direct recycling minimizes steps back to use

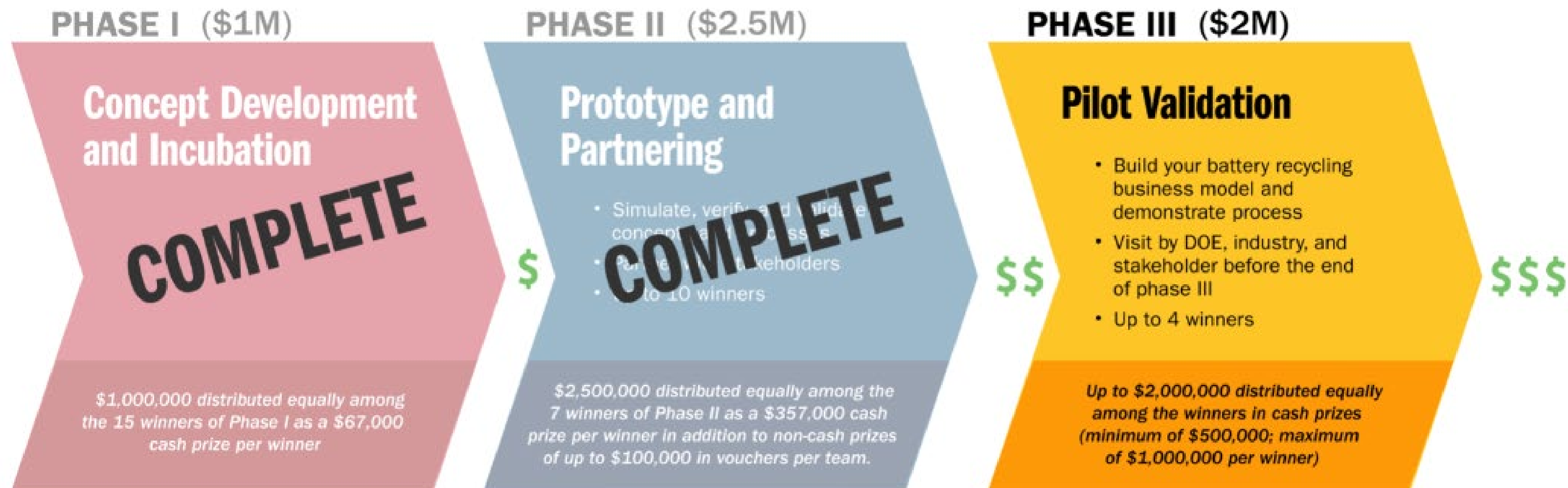


Bringing together battery recycling expertise and bridging the gaps between them to efficiently address the many challenges that face a successful advanced battery recycling infrastructure.

Lithium-Ion Battery Recycling Prize

The Prize is designed to incentivize a diversity of problem solvers to create end-to-end solutions to help DOE achieve an overall lithium-ion battery (LIB) recovery rate of 90%. This might be accomplished by:

- Increasing collection
- Implementing cost-effective, automated methods or technologies for separation and sorting
- Developing safe methods or technologies for lithium-ion battery storage and transportation
- Optimizing the efficiency of logistics
- Designing an entirely unanticipated solution
- Some innovative combination of all these solutions.



Lithium-Ion Battery Recycling Prize



Li Industries

Machine learning-based, automated Smart Battery Sorting System.



OnTo Technology

Deactivate, identify, sort, and cut (DISC) solution for end-of-life processing.



Powering the Future

Leveraging the existing network of collection for lead-acid batteries to collect end of life LIBs.



Renewance

Renewance Connect digital platform tracks and manages LIBs throughout their full life cycle.



Smartville

Distributed heterogeneous unifying battery facilities to reduce costs in the reverse logistics supply chain.



Team Portables

Reward to Recycle is a smartphone app that rewards consumers for recycling.



Titan Advanced Energy Solutions

Battago Battery Market Intelligence platform built to generate, aggregate, and connect data.

<https://www.herox.com/BatteryRecyclingPrize>