U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Battery Recycling Prize Overview and Update

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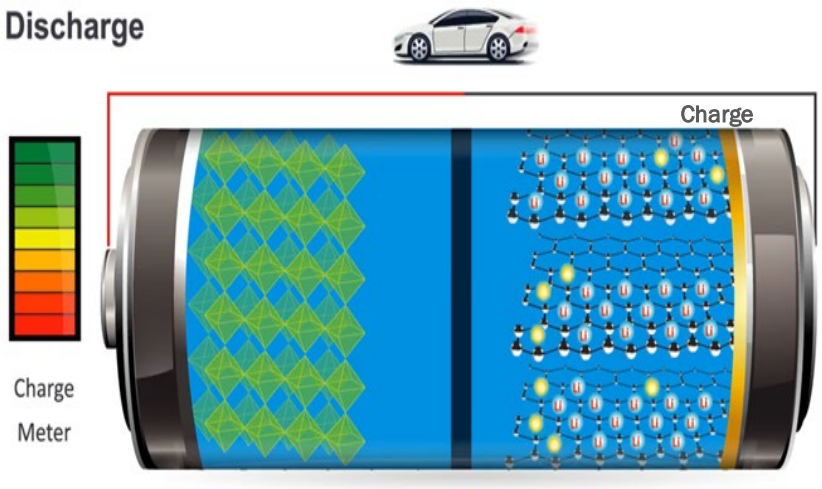
February 13, 2020

DOE Strategic Objective for Electric Vehicle Battery Storage

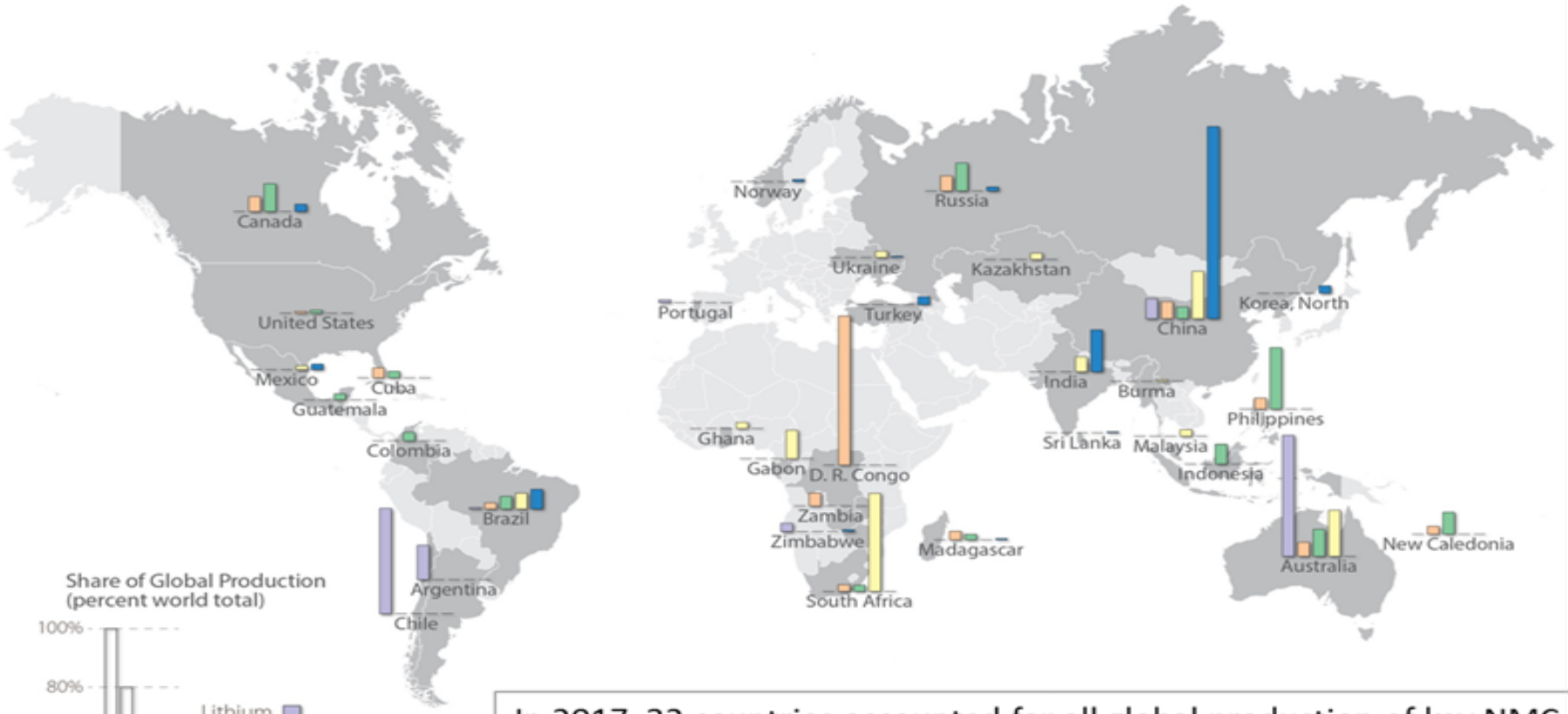
By September 30, 2022, reduce the cost of electric vehicle battery packs to less than $150/kWh with technologies that significantly **reduce or eliminate the dependency on critical materials (such as cobalt) and utilize recycled material feedstocks.**

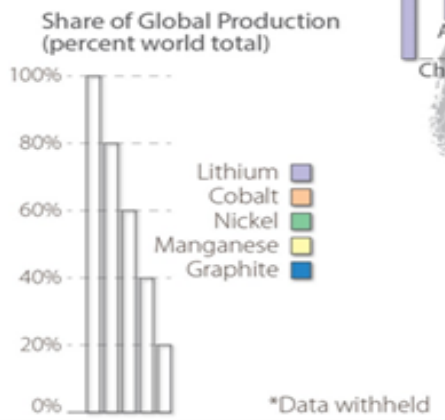


DOE R&D Focus is on materials innovations, cell level electrochemical optimization, improving sustainability, and reducing battery cost

Lithium Ion Battery Critical Raw Materials – Current Production

In 2017, 32 countries accounted for all global production of Li, Co, Ni, Mn and Graphite, with 50% of production of each element originating in one or two countries.





In 2017, 32 countries accounted for all global production of key NMC materials

- **43,000 tons lithium**: 44% Australia 34% Chile, Argentina 13%
- **1.2 million tons natural graphite** : 67% China, 13% India, Brazil 8%
- **2.1 million tons nickel**: 11% Philippines, 10% Canada, 9% Russia, 9% Australia
- **16 million tons manganese**: 33% South Africa, 16% China, 14% Australia
- **110,000 tons cobalt**: 59% Democratic Republic of Congo, 5% Russia, 5% Australia

Mining vs Recycling/Recovery

	Natural Resources	Spent Batteries
One ton of battery-grade cobalt can come from:	 **300 TONS** OF ORE	 **5-15 TONS** OF SPENT LITHIUM-ION BATTERIES
One ton of battery-grade lithium can come from:	 **250 TONS** OF ORE  **750 TONS** BRINE	 **28 TONS** OF LITHIUM-ION BATTERIES

Other benefits of Recycling

- Less dependence on foreign sources
- Material supply chain stability
- Domestic job creation
- Lower battery costs

Q. Dai, J. C. Kelly, and A. Elgowainy. Cobalt Life Cycle Analysis Update for the GREET Model. September 2018. https://greet.es.anl.gov/publication-update_cobalt. Data summary extraction by A. Mayyas, A. Pesaran, and D. Steward of NREL

VTO Strategy to Mitigate Potential EV Battery Critical Material Impacts

Low or No Cobalt Cathode R&D

Over $44M of R&D over three years

19 kg

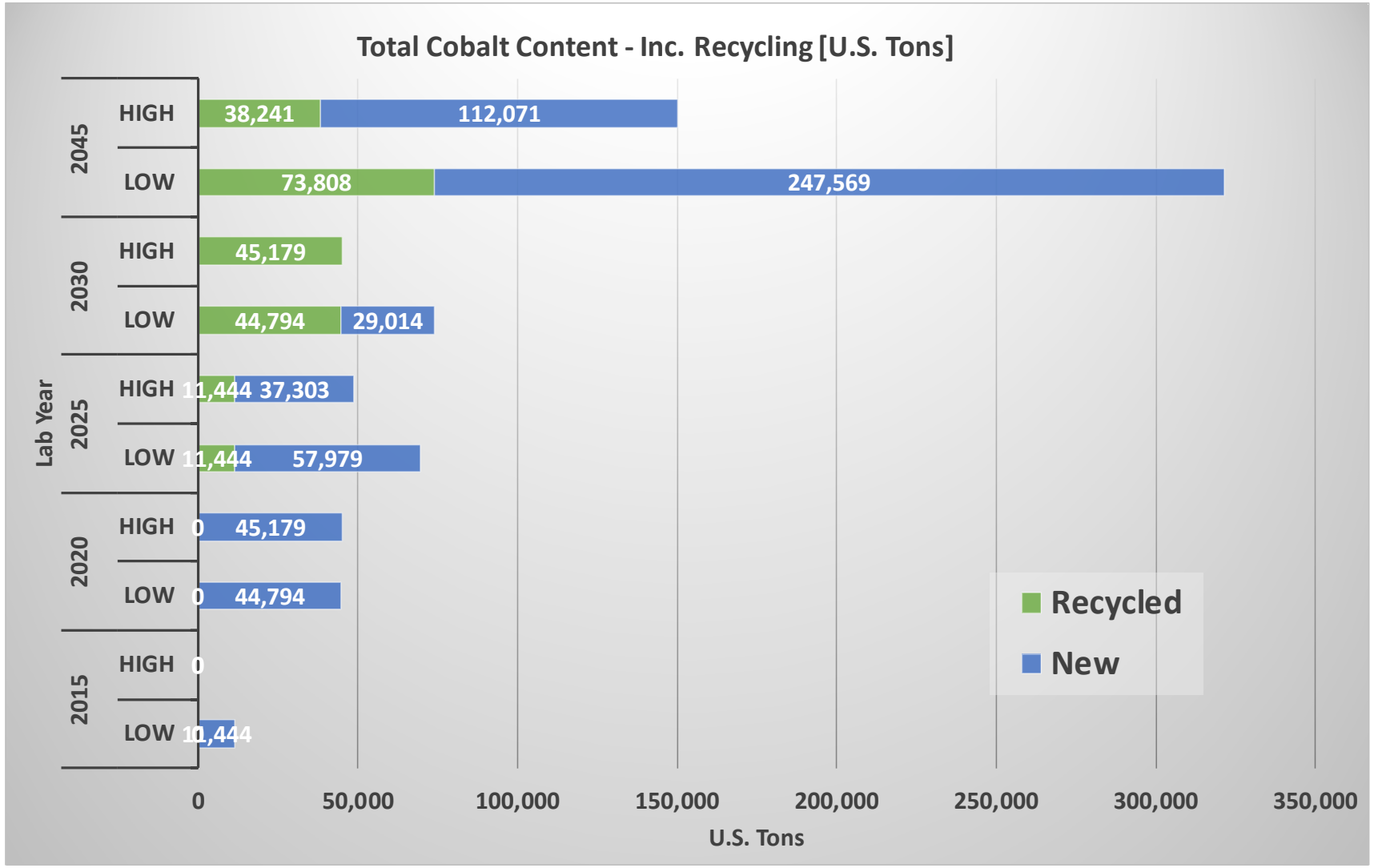
0-5 kg

Based on: 100 kWh battery pack and NMC622 cathode

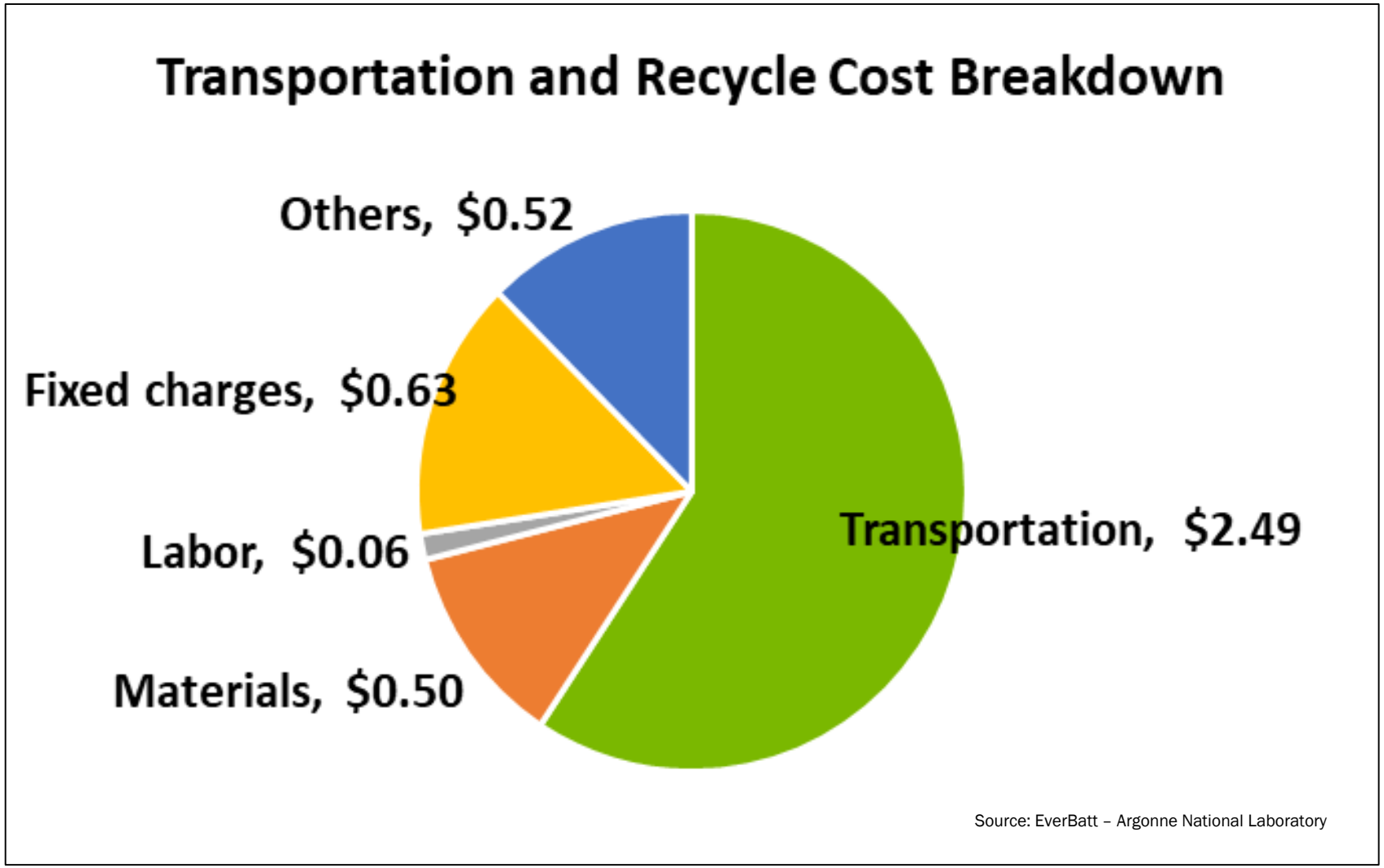
ReCell ADVANCED BATTERY RECYCLING

- Decrease recycling cost
- Recover critical and high value materials
- Reintroduce recovered materials into the material supply stream

Worldwide Energy Storage Material Demand (80M New Sales)



End Of Life Costs for EV Batteries



Energy Secretary Rick Perry Announces the Battery Recycling Prize

January 17, 2019: At the Bipartisan Policy Center's American Energy Innovation Council

AMERICAN MADE
BATTERY RECYCLING PRIZE

U.S. DEPARTMENT OF ENERGY

"America's dependence on foreign sources of critical materials undermines our energy security and national security," …

The Battery Recycling Prize will encourage American entrepreneurs to find innovative solutions to collecting, storing, and transporting discarded lithium-ion batteries for eventual recycling.

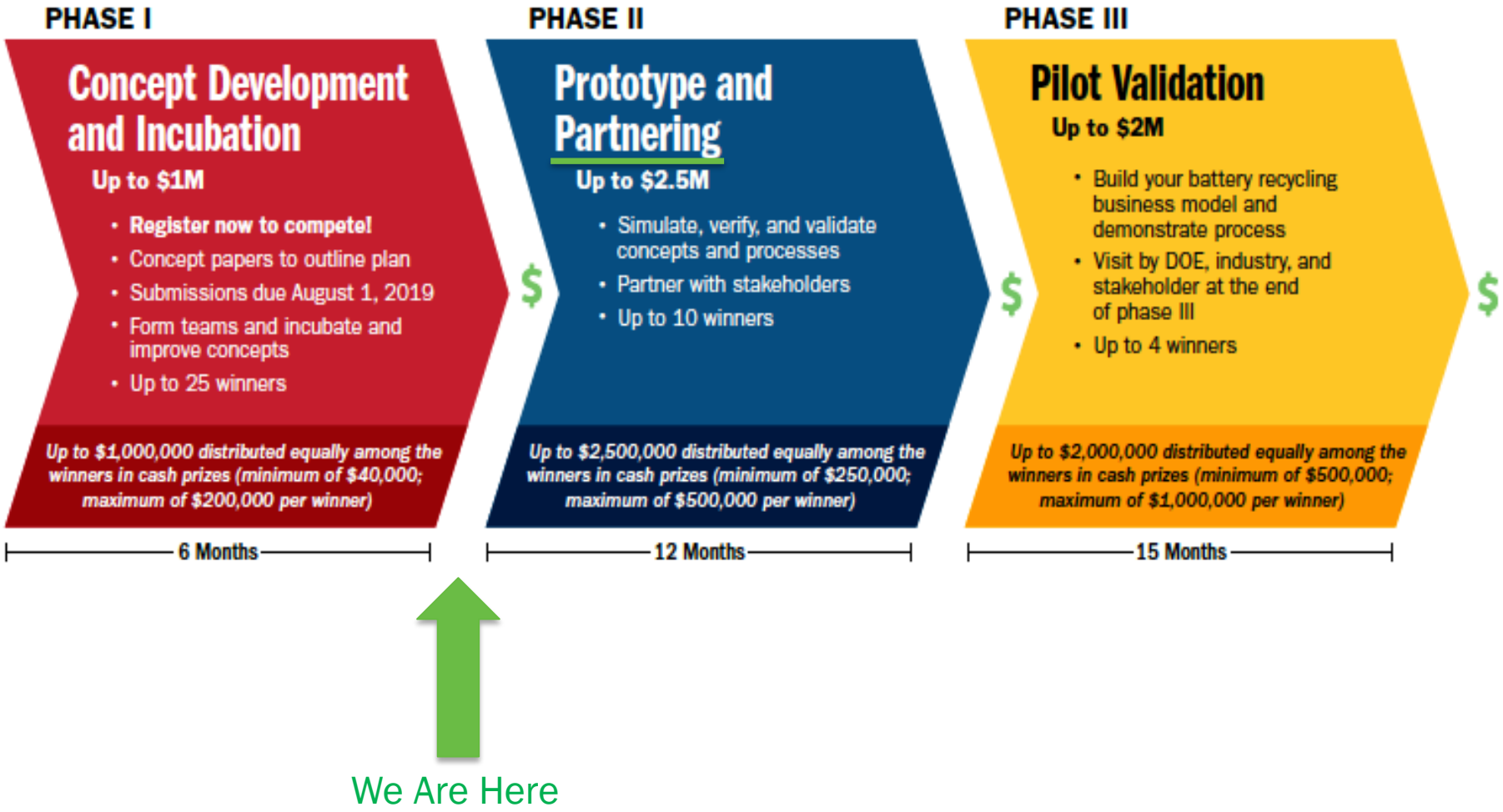
A $5.5 million phased competition over three years

- Funded by DOE's Vehicle Technologies Office and DOE's Advanced Manufacturing Office

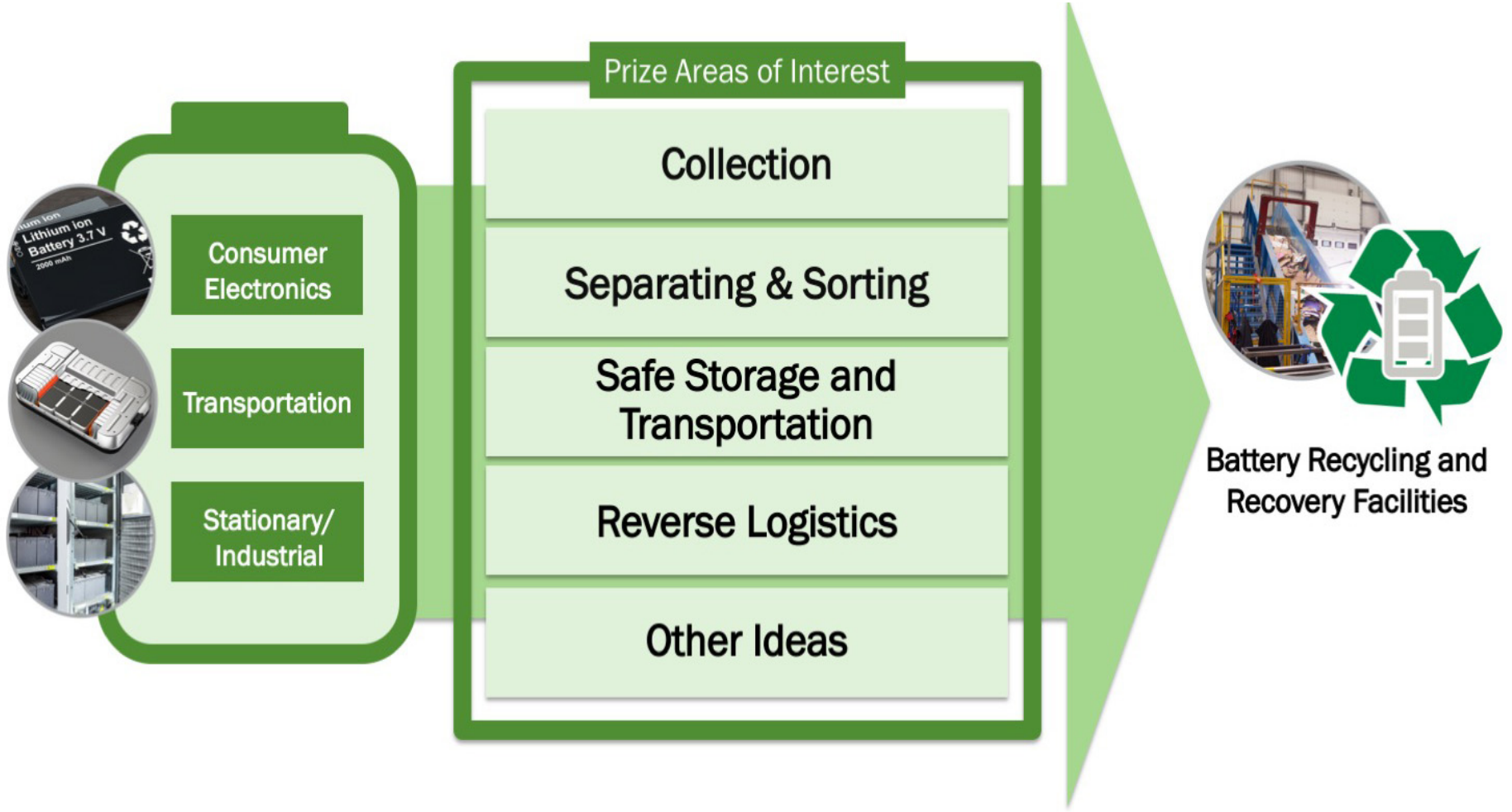
About the Prize

- A $5.5 million phased competition over three years
- Cofunded by the DOE's Vehicle Technologies Office and the Advanced Manufacturing Office
- Administered by the National Renewable Energy Laboratory
  - Lauren Lynch, Prize Administrator
- Prize is administered by HeroX – for more information, please visit the site below
- (https://www.herox.com/BatteryRecyclingPrize

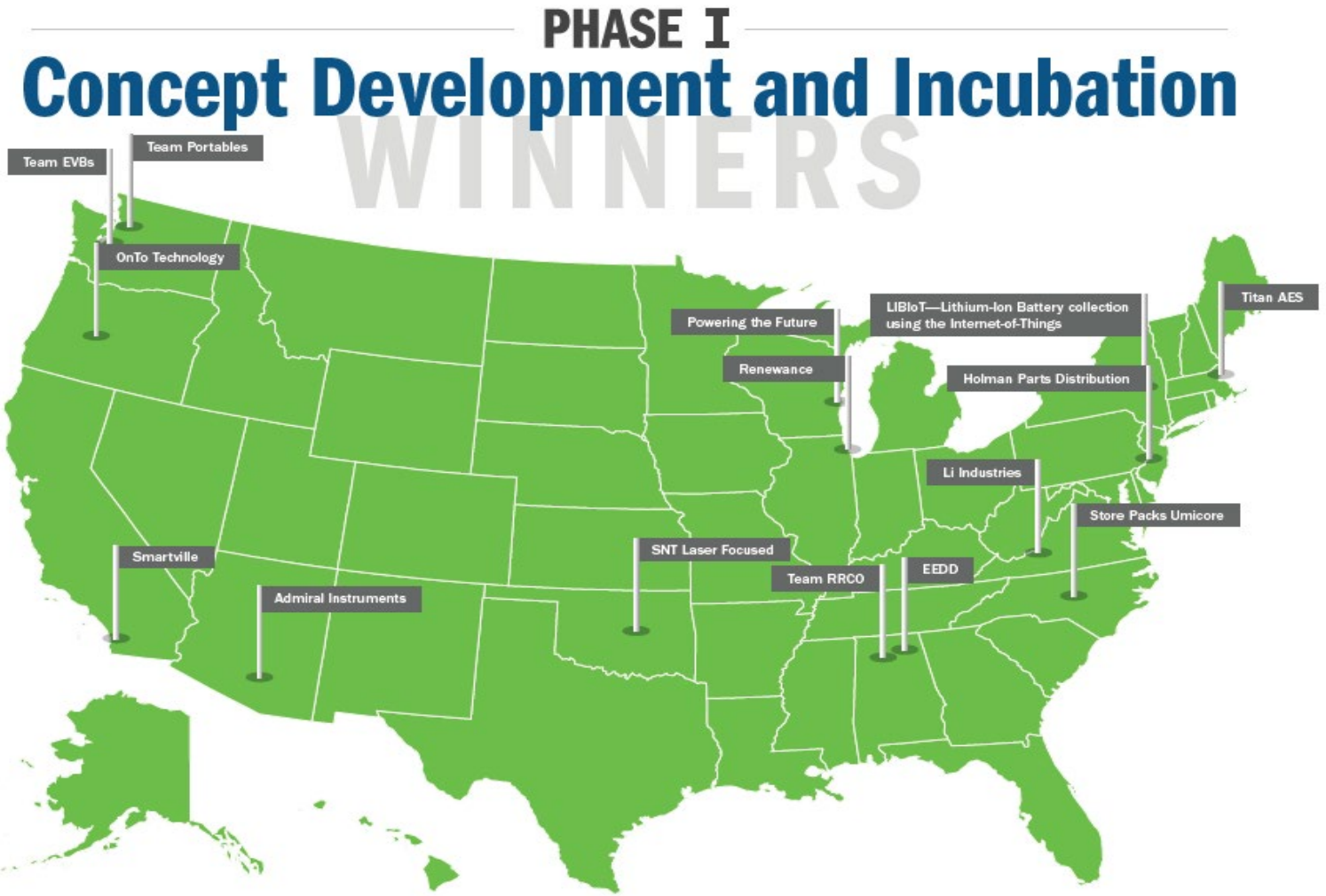
Recycling Prize Phases



Phase I Tracks



Prize Phase I Winners



VTO Critical Materials Research Plan

Summary document available at the link below

https://www.energy.gov/eere/vehicles/downloads/vehicle-technologies-office-s-research-plan-reduce-recycle-and-recover