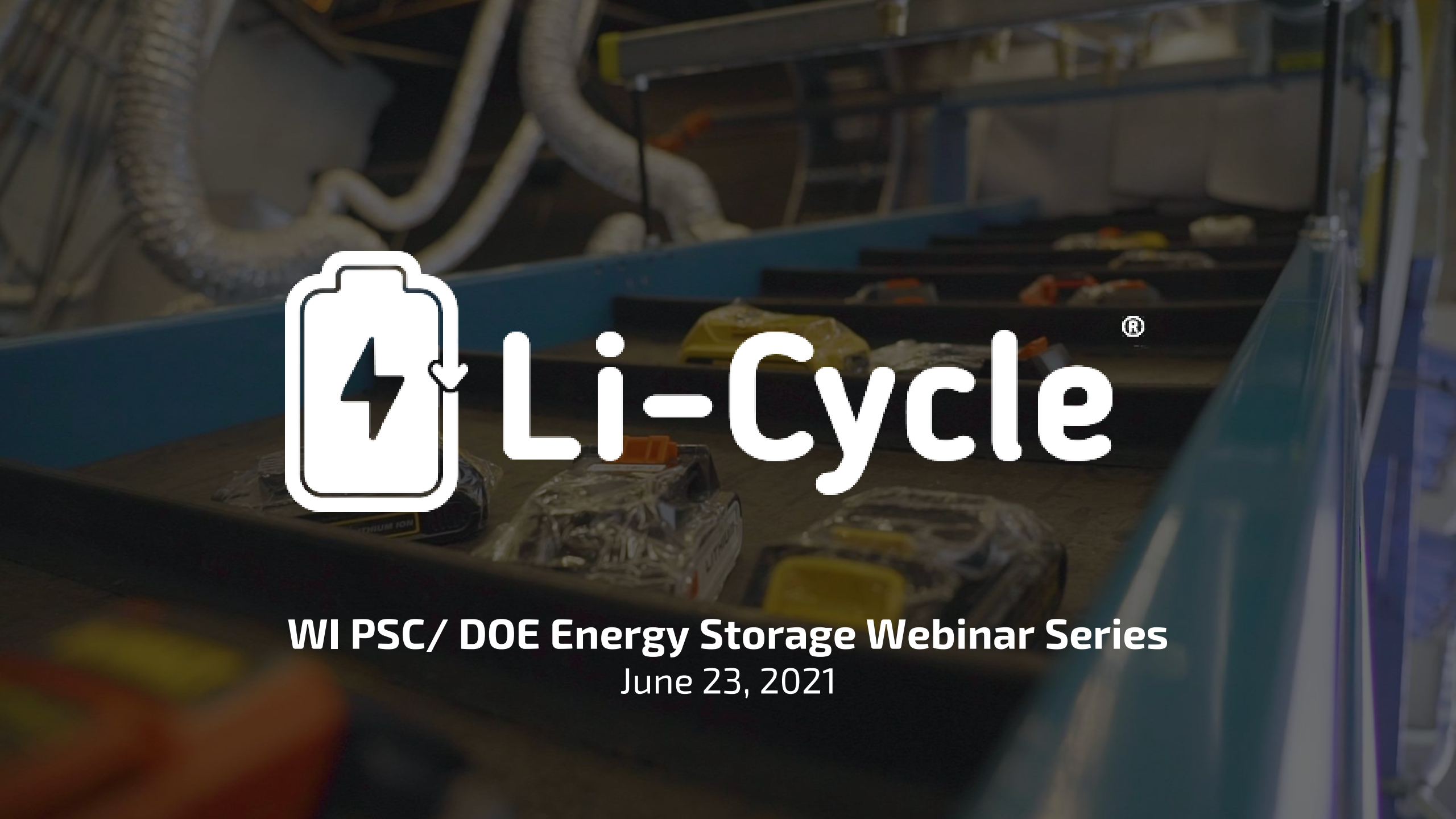
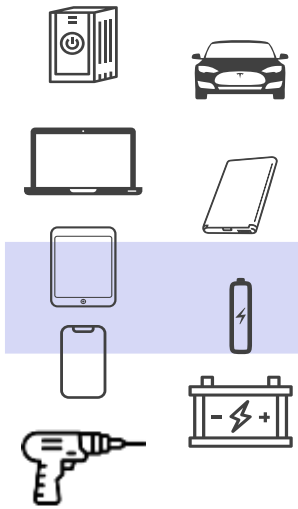


Li-Cycle®

WI PSC/ DOE Energy Storage Webinar Series

June 23, 2021

MATERIALS CONTAINED INSIDE A LITHIUM-ION BATTERY



Black mass concentrate 25,000 tpy

Lithium Carbonate (4,000+ tpy)	• Battery cathode production • Glass making
Cobalt Sulphate (10,000+ tpy)	• Battery cathode production • Glass pigment
Nickel Sulphate (18,000+ tpy)	• Battery cathode production • Electroplating • Glass pigment
Manganese Carbonate (4,000+ tpy)	• Steel making (e.g., alloys) • Intermediate for MnO_2 production
Copper Sulphide (3,000+ tpy)	• Copper smelter feed • Semiconductor
Graphite (9,000+ tpy)	• Refractories • Lubricants
Sodium Sulphate (28,000+ tpy)	• Textiles • Thermal storage (solar) • Glass making
Gypsum (26,000+ tpy)	• Land application / remediation • Cement

DRIVERS OF RECYCLING

1. Economics

Lithium Carbonate	Cobalt Sulphate	Nickel Sulphate
		
$50,000 / tonne	$42,000 / tonne	$13,000 / tonne

2. ESG

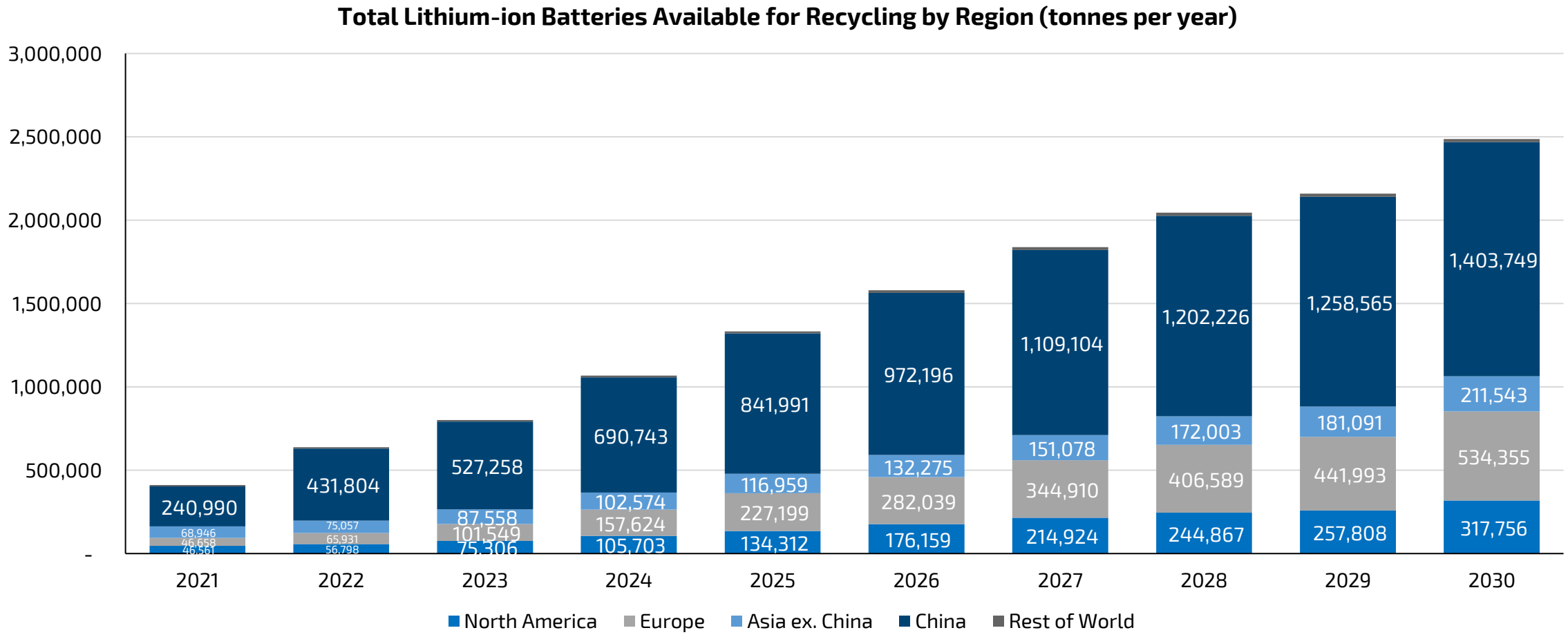
Relative to "Mining and Refining", GHG's and Water Offset

3. National Security

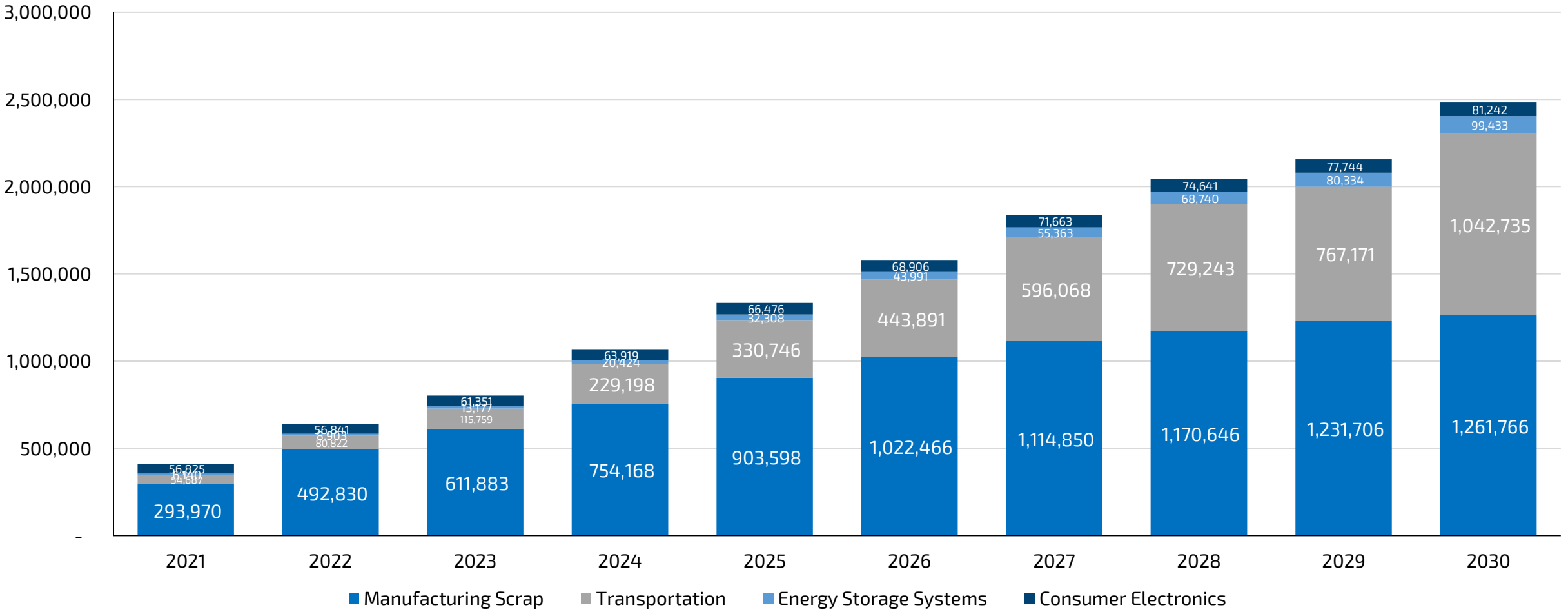
Access to Future Supply of Critical Minerals

GLOBAL MARKET LANDSCAPE

As evaluated in 2020, China continues to play an immense role in the total addressable market, with the sum of North America, Europe and Asia ex. China making up a remaining ~1/3rd of the total market

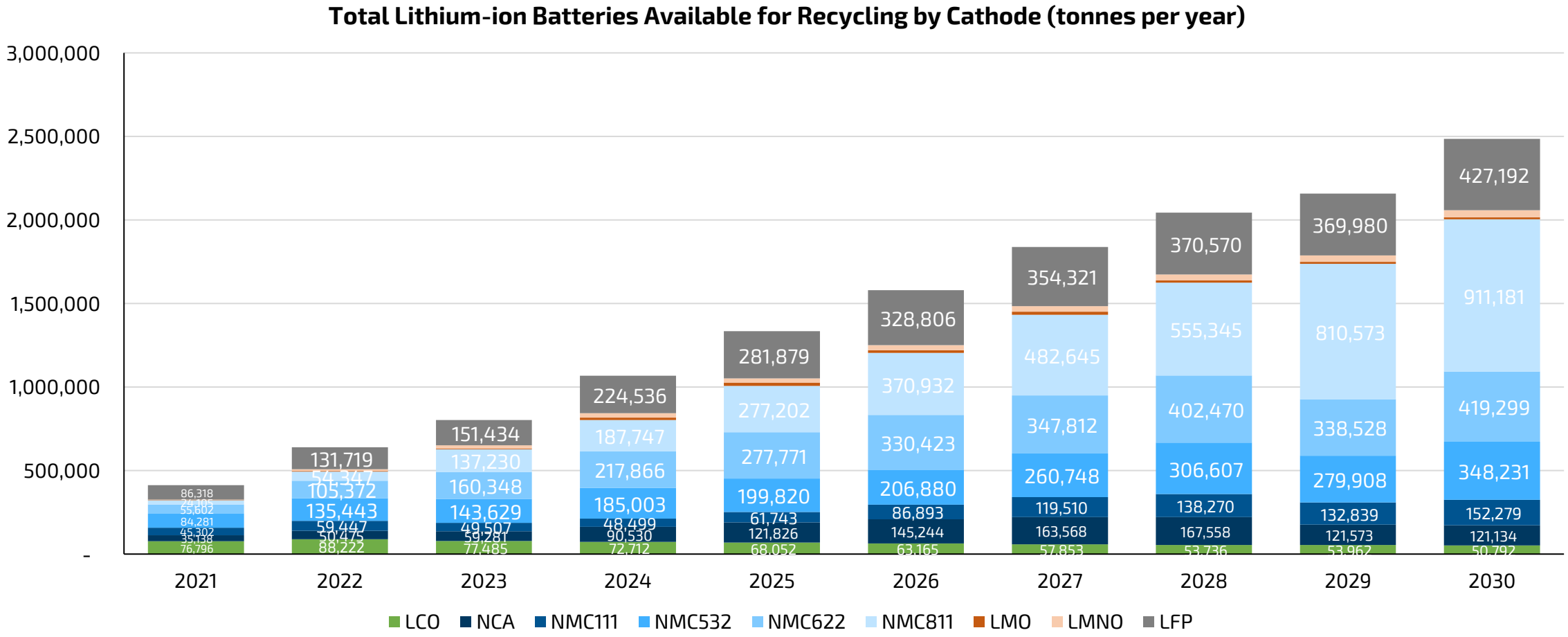


GLOBAL MARKET LANDSCAPE



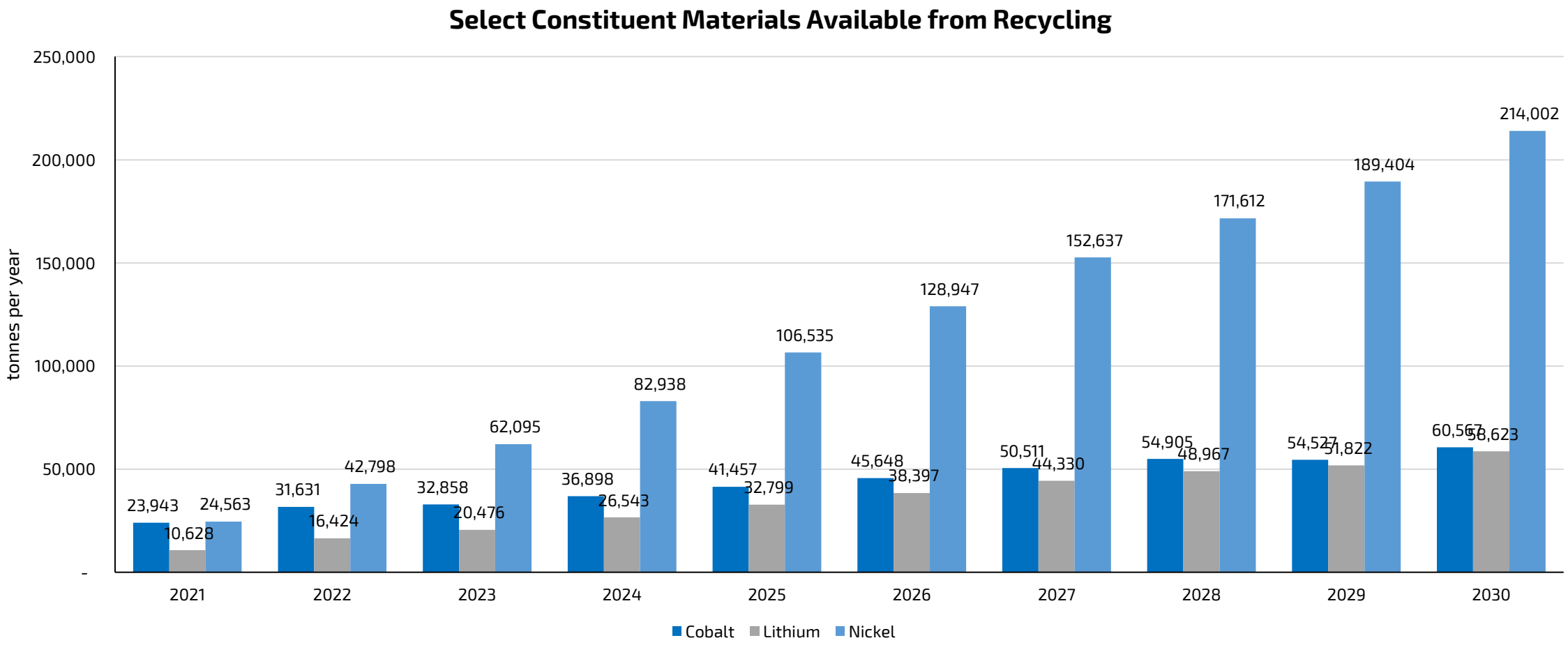
GLOBAL MARKET LANDSCAPE

Nickel-based cathodes (shaded blue) and LFP continue to dominate the majority of forecasted supply in the later years of the forecast, accounting for approximately 75% and 17% of the total addressable market by 2030 respectively



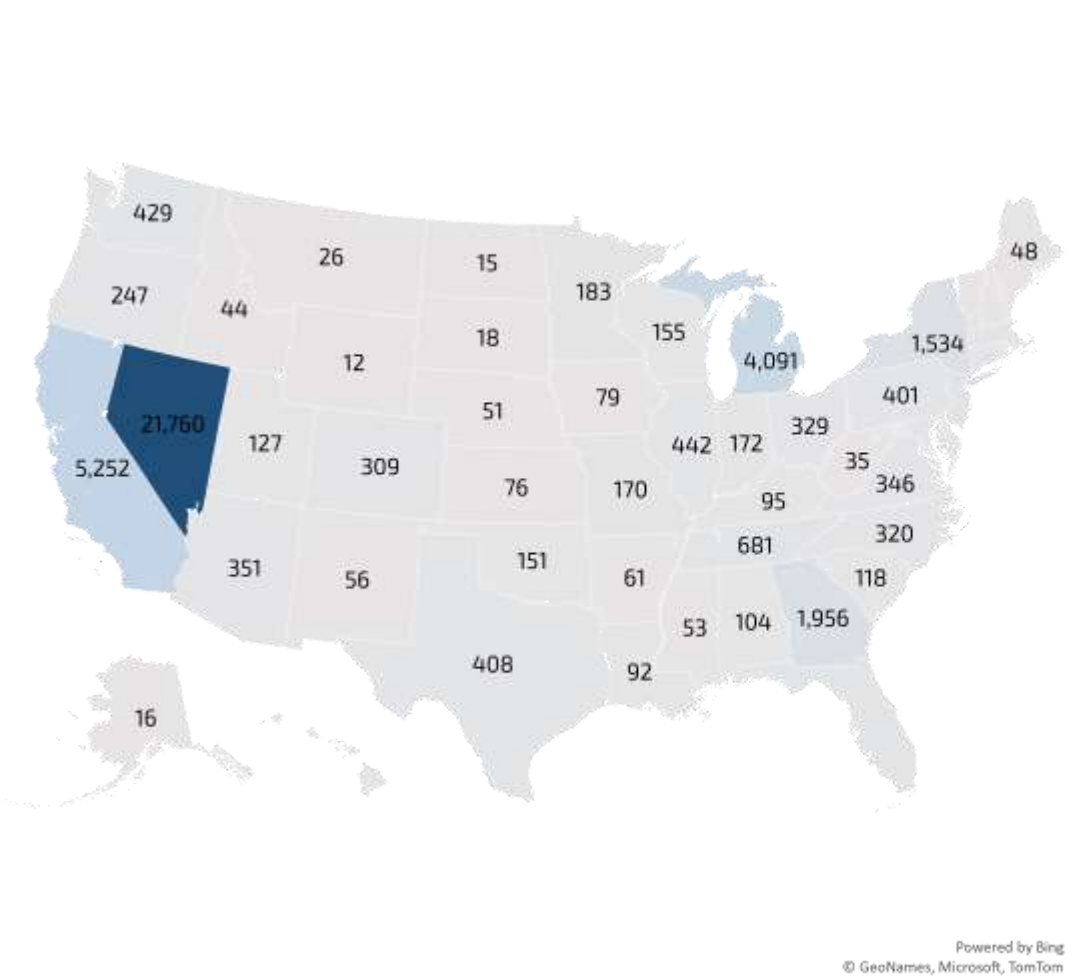
GLOBAL MARKET LANDSCAPE

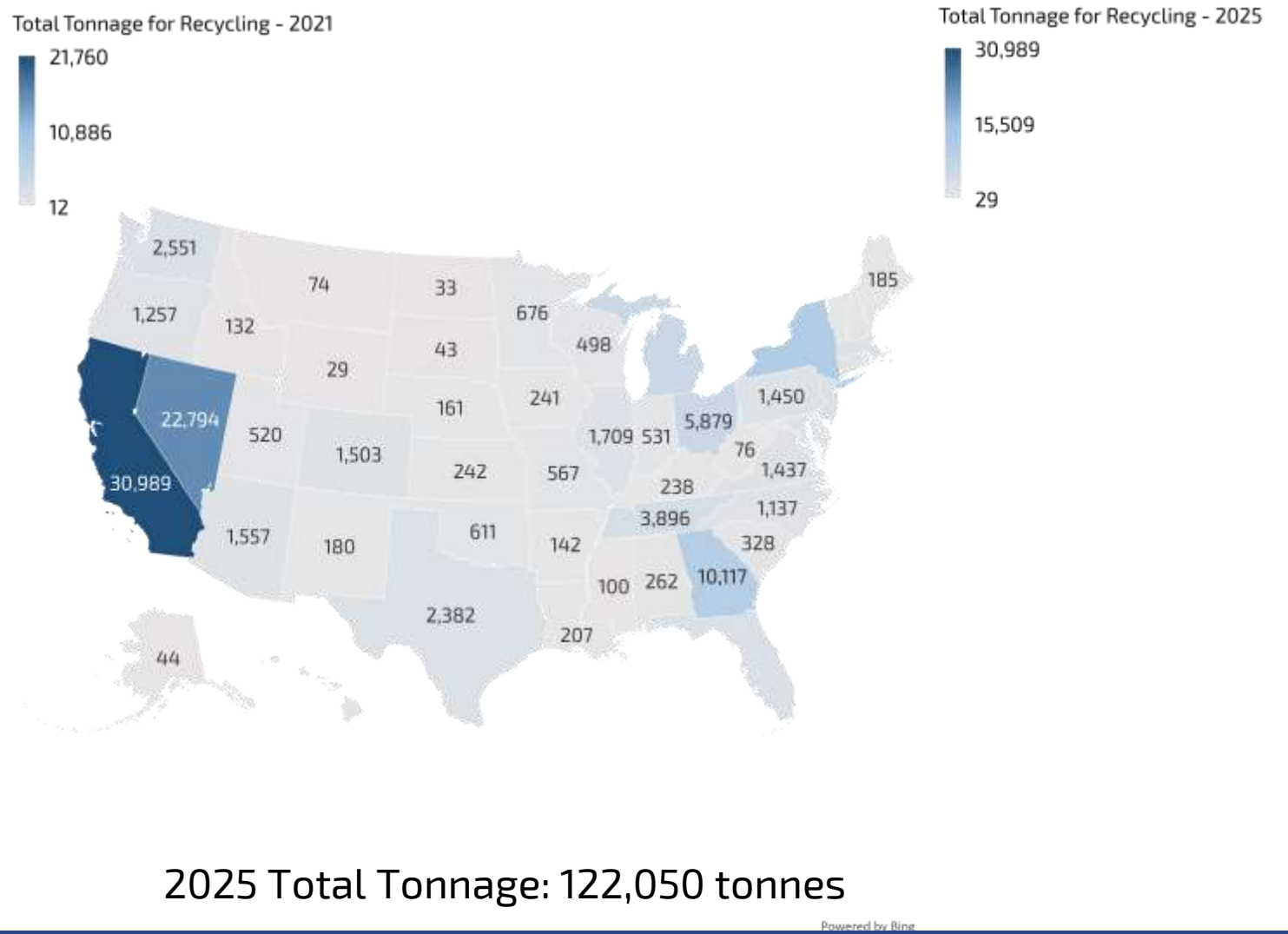
Recycling has the potential to become a key secondary source of cobalt, nickel and lithium



NORTH AMERICA – TOTAL BATTERY SUPPLY FOR RECYCLING

US state level data illustrates significant supply in California, Texas, Florida, and New York





2021 Total Tonnage: 43,020 tonnes

2025 Total Tonnage: 122,050 tonnes

THE MISSING SUPPLY CHAIN STEP

There is an incoming 'tsunami' of spent lithium-ion batteries…

…but how will these batteries be sustainably recycled at end-of-life?

RECYCLING SUPPLY CHAIN: INCUMBENT PROCESS

Incumbent recycling chain/processes

Disaggregated, inefficient, low recoveries, waste-oriented

≤50% recovery rate

Batteries received, discharged, dismantled heavily, potentially shredded

High temperature processing, calcining / roasted, burning off electrolyte, plastics, and other volatile components

Smelter – electric furnace process, processes black mass from the preceding step

Traditional hydromet refinery; processes the matte containing Ni, Co, Cu from the electric furnace; produces Ni, Co, Cu metal

Re-dissolve metals to produce Co & Ni chemicals (sulphates) that can be utilized by typical cathode precursor manufacturers

What's being lost:

Possibly the electrolyte; partially the plastics	*Electrolyte lost; fluorine emitted; potentially plastics; potentially graphite*	*Lithium goes into slag (uneconomic to recover thereafter); graphite, aluminum, and other light components – all directed to the slag and off-gas*	*Losing any residual manganese and other minor components in the matte from the smelter*	*N/A*

THE MOST SUSTAINABLE AND ECONOMIC SOLUTION

	Li-Cycle Spoke & Hub Technologies	Smelting or thermal pre-treatment + refining	Cathode-to-cathode
Recycling efficiency rate[1]	Up to 95%	≤ 50%	30% (cathode proportion only)
Battery chemistry & charge agnostic	✓	✗	✗
Non-thermal, zero impact air emissions	✓	✗	✗
No landfill waste or wastewater	✓	✗	✗
Minimal human operating risk	✓	✗	✗
"Future proofed"	✓	✗	✗

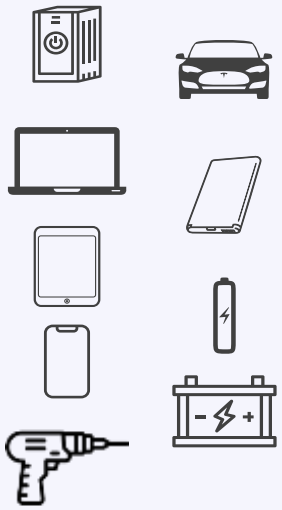
Source:
(1) Recycling Efficiency Rate (RER) is defined as [(The mass exiting the process and returning to the economy / The battery material mass entering the process) x 100%]

LI-CYCLE SPOKE & HUB TECHNOLOGY

Li-ion batteries for recycling → Shredding & mechanical separation → Intermediate products → Extraction & material recovery → Battery grade & refined materials

Spoke

Mechanical



Spoke 1
Kingston, ON

Spoke 2
Rochester, NY

Spoke "N"
Network of Spokes

Black Mass
Interim sales to nickel recovery; input to Hub; easily transportable relative to batteries

Hub

Hydrometallurgical

Hub 1
Rochester, NY

Hub "N"
Centralized Hub per region

Lithium Carbonate
Battery cathode, battery electrolyte salt, glass, pharmaceuticals

Cobalt Sulphate
Battery cathode, glass pigment

Nickel Sulphate
Battery cathode, electroplating, glass pigment

Manganese Carbonate
Intermediate for battery grade product production, steel making

Sold to the market

Shredded Cu/Al
Copper and precious metals recovery

Mixed plastics
Plastics conversion into products


Li-Cycle®