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Beginning of a New Era
Inevitable Future
Current Options - **Smelters**

1. **Harmful Emissions**
   Smelting oxides requires a fuel and generates about 2 tonnes CO₂ per tonne of metal

2. **Low Recovery**
   40%-60% of the nickel and cobalt and no lithium recovery

3. **Additional Steps**
   Requires major processing to make cathode ready precursors
Current Options - Shred and Collect

1. **Shred**
   Low value sludge is produced and sold to open market

2. **Collect**
   Collected by off-shore refiners
Company Objective

Recovering Value from Lithium-ion Battery Cathode Metals
Inside Lithium-ion Batteries

[Diagram showing the components of a lithium-ion battery, including the anode, active cathode material, copper current collector, electrolyte solution, separator plastics, and aluminum current collector.]

Source: Argonne National Laboratory.

Credit: Mitch Jacoby/C&EN
Fully Burdened Lithium-ion Battery Pack Cost Breakdown

- **Cathode**: 25%
  - Land Cost for Cell Manufacturing: 6%
  - Anode Materials: 8%
  - Cell Labor: 8%
  - Depreciation of Equipment: 8%
- **Battery Pack Management System**: 16%
- **Pack Thermal System**: 8%
- **Other**: 3%
- **Cell Fixed Cost**: 6%
- **Pack Labor**: 5%
- **Current Collectors**: 3%
- **Separators**: 3%
- **Electrolyte**: 1%
Growing Demand for Lithium-ion and Production Waste

Planned Battery Manufacturing Capacity by 2028:

1,956,000,000 kWh

Estimated Battery Manufacturing Waste

- Standard: ~10%
- Early Production: >30%
- Industry best: ~5%

20M+ Tesla Model S Battery Packs
Pilot Plant Recycling

Cathode Manufacturing Waste

Nickel-Manganese-Cobalt (NMC) Precipitation

High Purity NMC (99.93%)

Nickel-Cobalt-Aluminum (NCA) Precipitation

High Purity NCA (99.94%)
99.99% Pure Nickel-Cobalt Sulfate
Produced From Tier 1 NCA Cathode Scraps
Using the RecycLiCo™ Patented Process
Patent No. 10,246,343

United States Patent and Trademark Office granted patent for lithium-ion battery recycling process and recovery of cathode materials on April 2, 2019

Patent No. 10,308,523

United States Patent and Trademark Office granted patent on June 4, 2019 for:

- Recovery of graphite and carbon from ground battery concentrates
- Treatment of fluoride originating from electrolyte solution
- Separation of aluminum from cathode active material
Commercial Demonstration Recycling Plant (3 Tonnes/Day)
Financial Model

Estimated Revenue Based on a **3 Tonnes/Day** Commercial Demonstration Plant

Estimated Capital Cost of **US$12 Million**

Reagent Consumption Cost Less Than **$1/kg** of Cathode Material Processed
Create a circular economy for the lithium-ion battery supply chain by recycling cathode manufacturing scrap and end-of-life lithium-ion batteries. Intend to commercialize intellectual property with joint venture partnerships and licensing agreements with industry leaders.
Battery Metal Supply Chain

**LITHIUM**
Mining: South America
Processing: South America

**ALUMINUM**
Mining: Australia
Refining: Middle East, Canada

**NICKEL & COBALT**
Mining: DRC, Canada
Smelting: China, Canada, Europe
Refining: China, Canada, Europe

**MANGANESE**
Mining: Africa
Refining: USA/China/Europe
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