NAS EV Workshop

Panel Discussion: Policy, Technical, and Market Options for Supply Chain and End-of-Life

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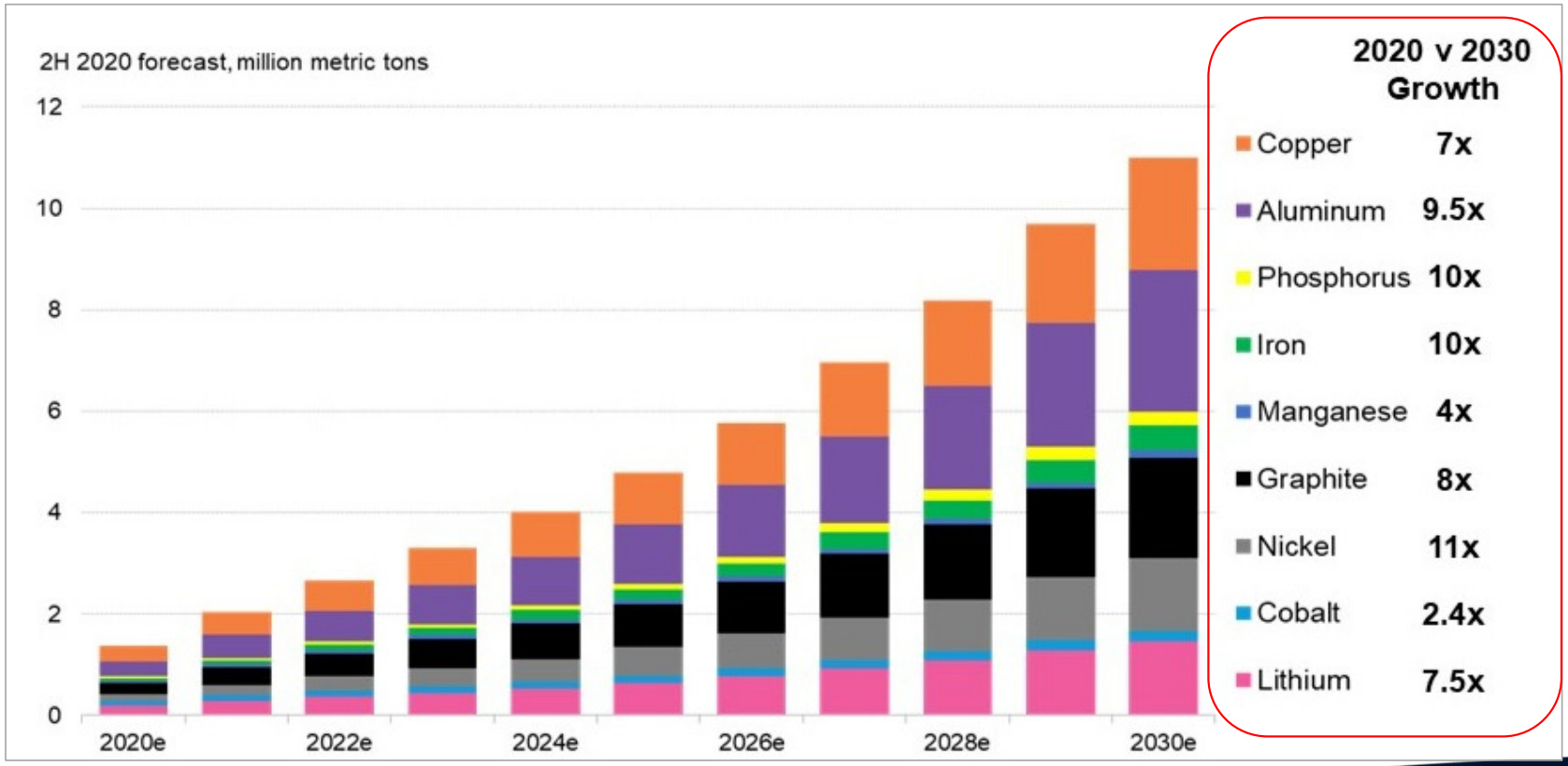
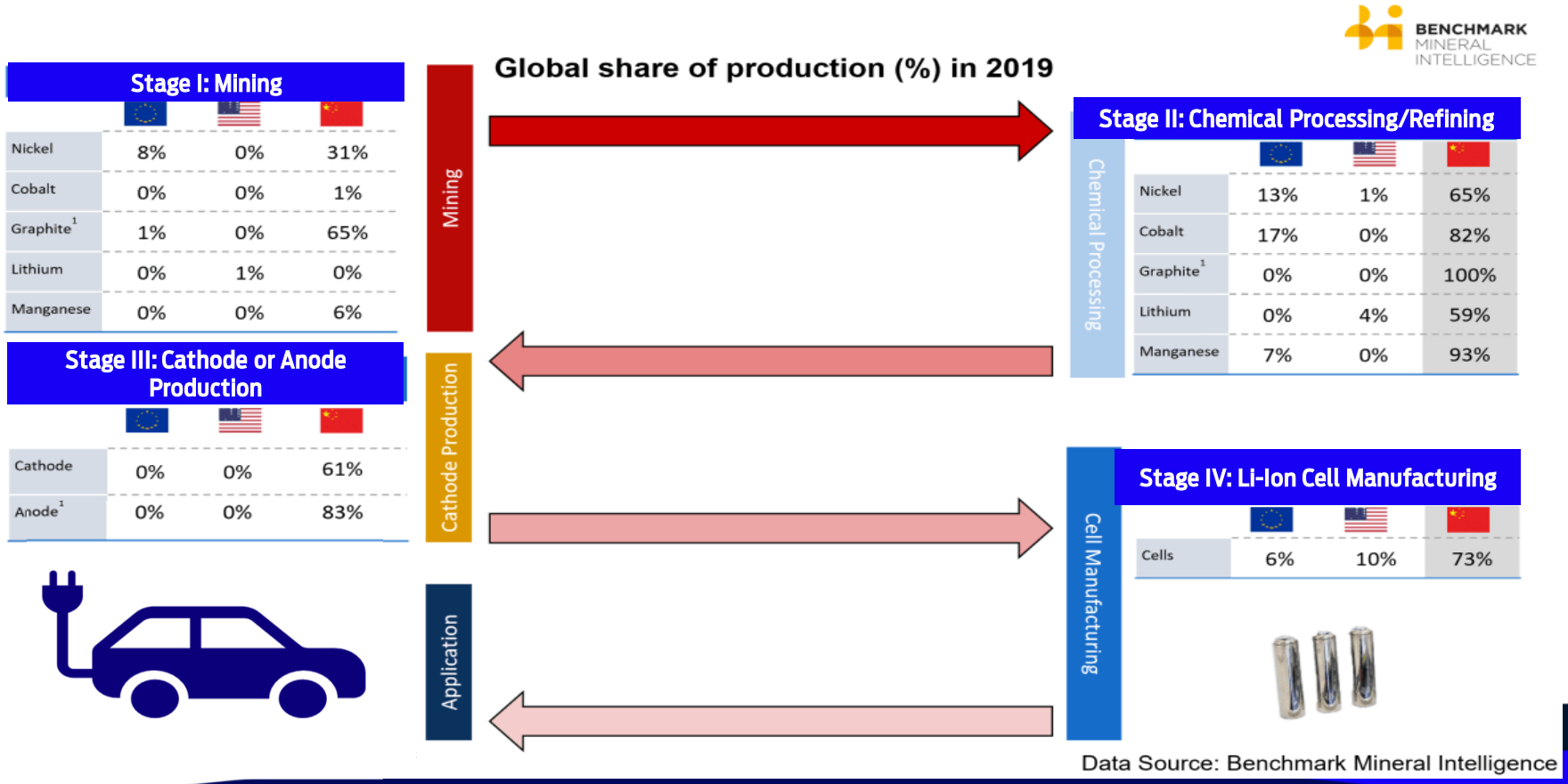
Soaring Demands for Cells and Battery Materials



Source: BloombergNEF

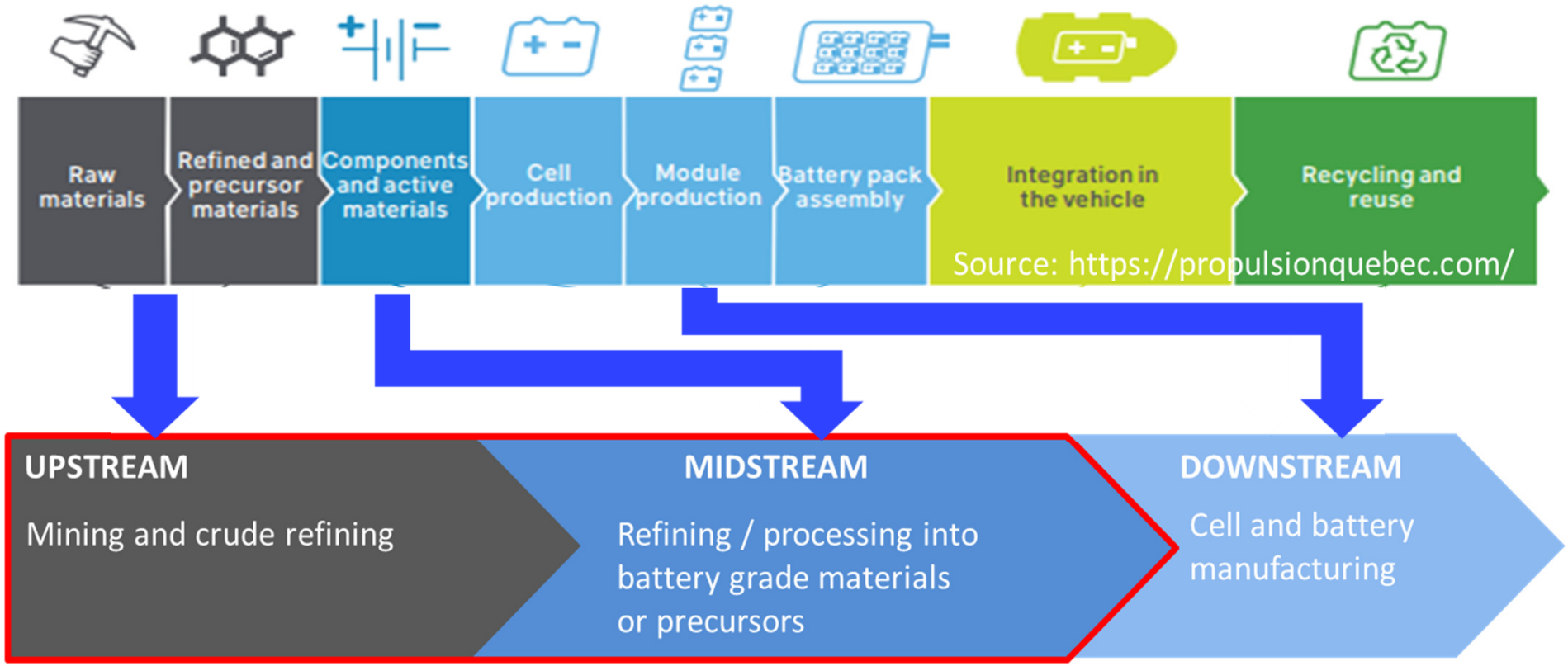
Global demand for battery metals is expected to grow by ~ >10x by 2030

The EV Battery Supply Chain in 2020



China leads in all stages of the supply chain

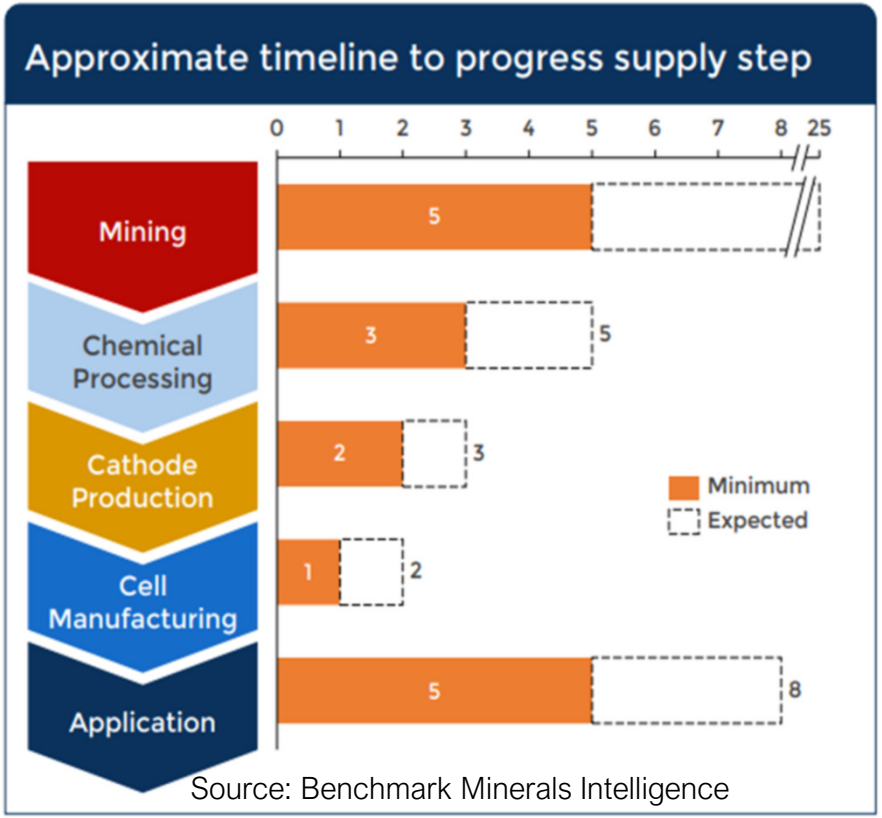
Three Main Segments of the Battery Supply Chain



A disproportionate (lower) investment in upstream and midstream assets is more of a risk for constraining supply chain than materials in the ground.

Mobilizing for Tomorrow

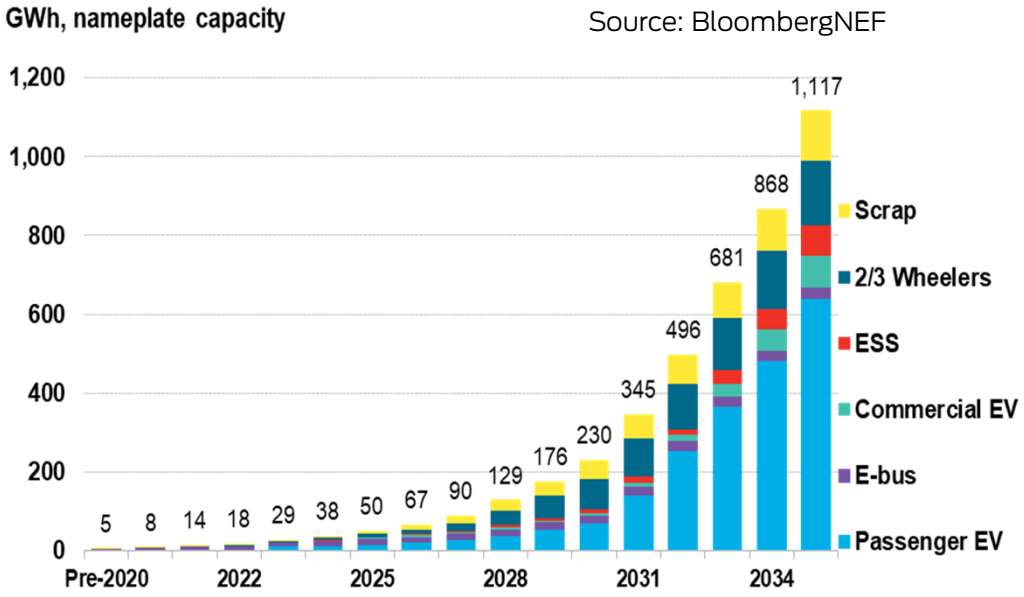
- New supply chains must be brought online
- Upstream and midstream infrastructure investment are needed in NA
- Both mining and refining are undercapitalized
- Concentration of supply (China currently owns much of the world's supply chain)
- Supply chains are complicated and need billions of investment dollars and many years of time to build up
- These timelines >> cell manufacturing



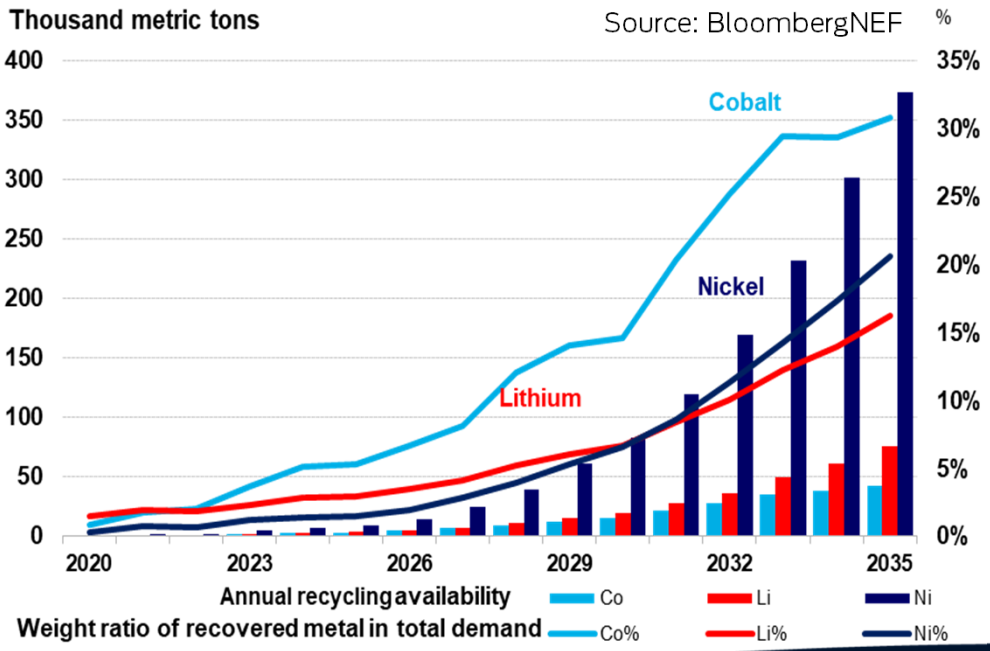
Building upstream and midstream infrastructures takes a long time!

Need for Battery Materials Will Be In Great Demand

Battery retirements by sector

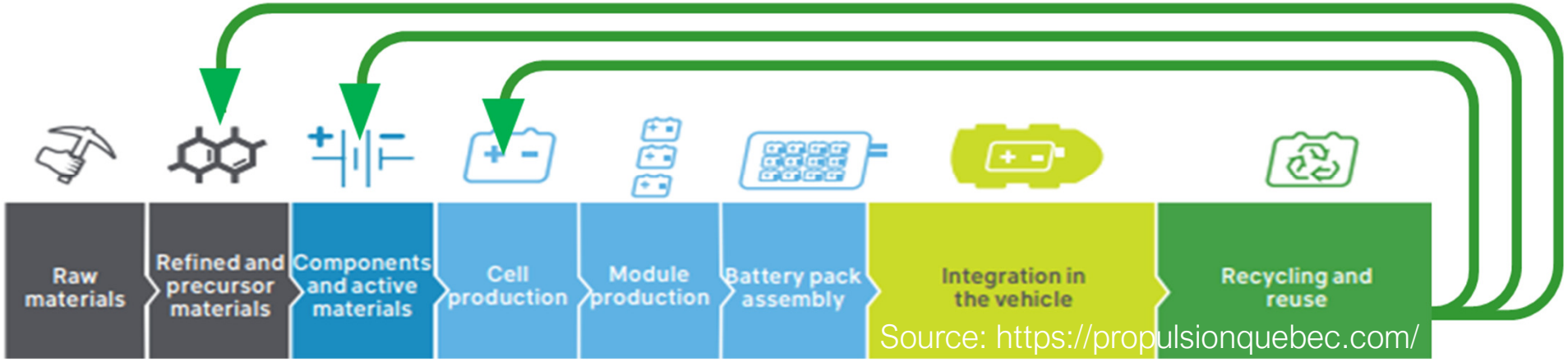


Metal availability from battery recycling



Significant percentages of global Li, Ni and Co demands can be met through recycling

The Role of Recycling



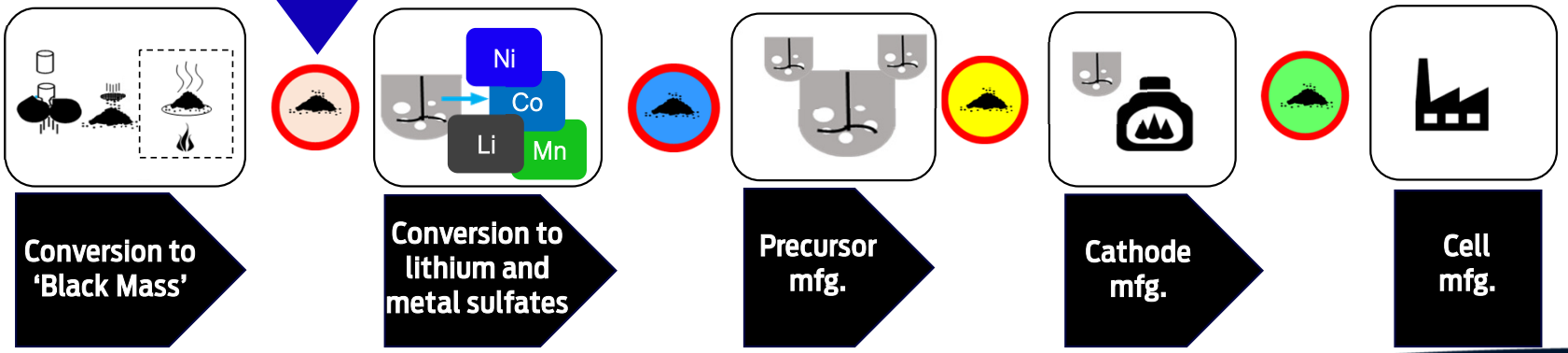
- Recycling is essential and will play a role in offsetting primary demand, but there is an important lag in time and volume.
- Near term→ high volumes expected from manufacturing scrap.
- Recycling offers a much greener source of critical materials versus primary extraction.

The urban mine can offset the demand for critical materials from primary sources

Recycling Output Determines Supply Chain Re-entry Point

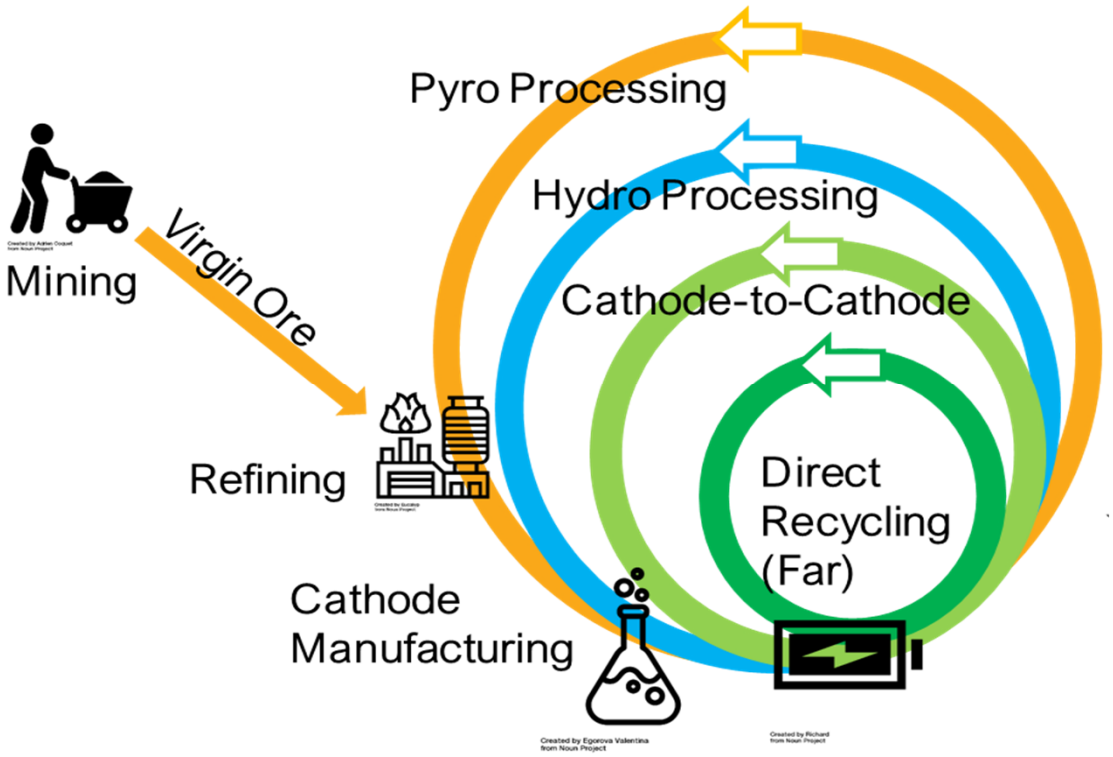
Different recycling processes have different outputs

- Cathode Active Material (CAM)
- Precursor to Cathode Active Material (pCAM)
- Metal sulfates, lithium compounds
- Black mass or alloy



Lithium-ion battery value chain varies by recycler.
OEMs must work with complex supply chains to reintroduce recycled materials.

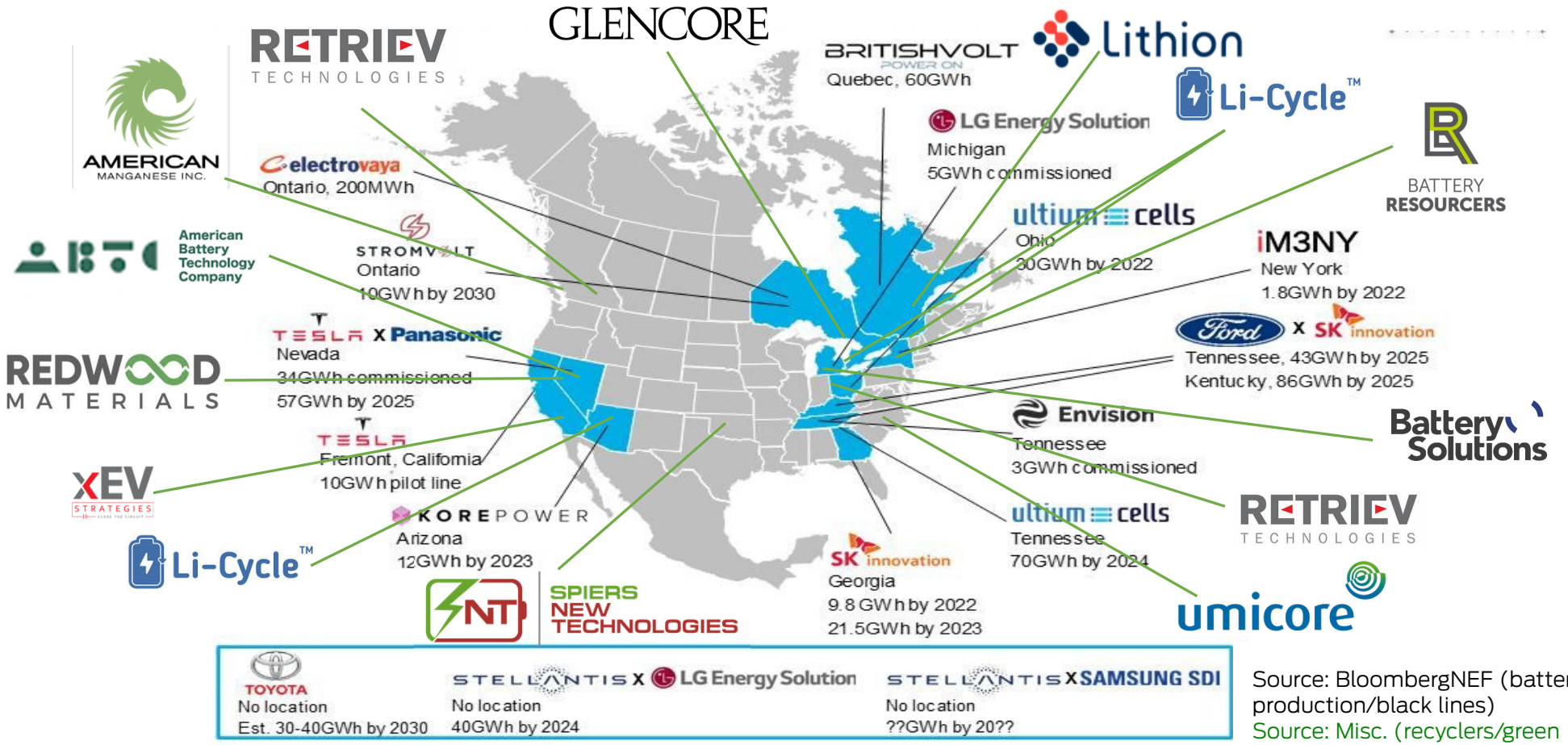
New-Gen Recycling Trends



- Shift from pyro → hydro
- High recovery efficiencies
- Zero/minimal effluent
- CO_2 footprint minimized
- Economics/cost-positive recycling
- Innovative logistics models
- Supply chain circularity

ESG increasingly front and center, driving move to industry-tuned hydro recycling.

Lithium-Ion Battery Manufacturers & Recyclers



Source: BloombergNEF (battery production/black lines)
Source: Misc. (recyclers/green lines)

Massive deployment of battery and recycling infrastructure.
Strategic partnerships and vertical integration.