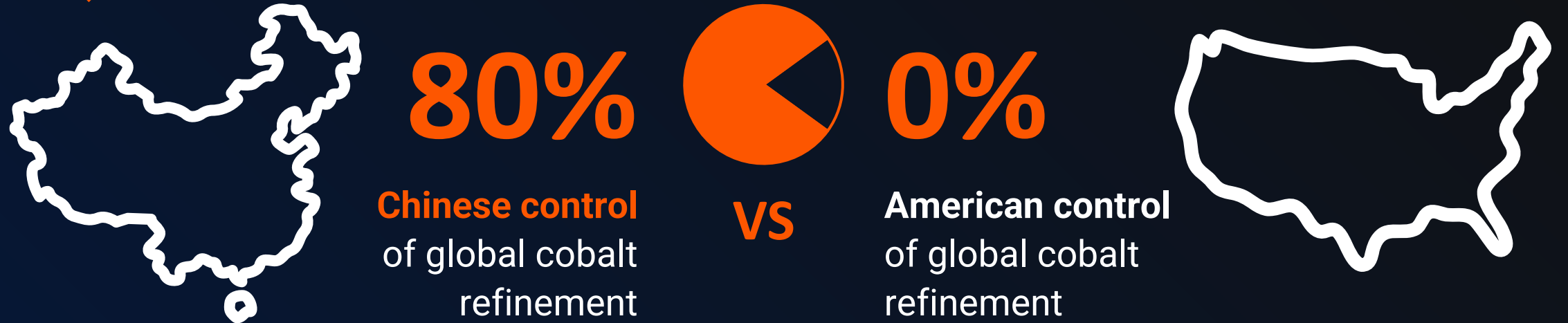




# Securing America's Critical Mineral Supply Chain

# Cobalt Refinement is Controlled by China

## 1 Supply-side Fragility



*Processed by the Chinese and purchased from commodity traders*

## 2 Critical Mineral



### Defense

Cobalt super-alloys and magnets are key components of America's military aircraft engines & sensor arrays.

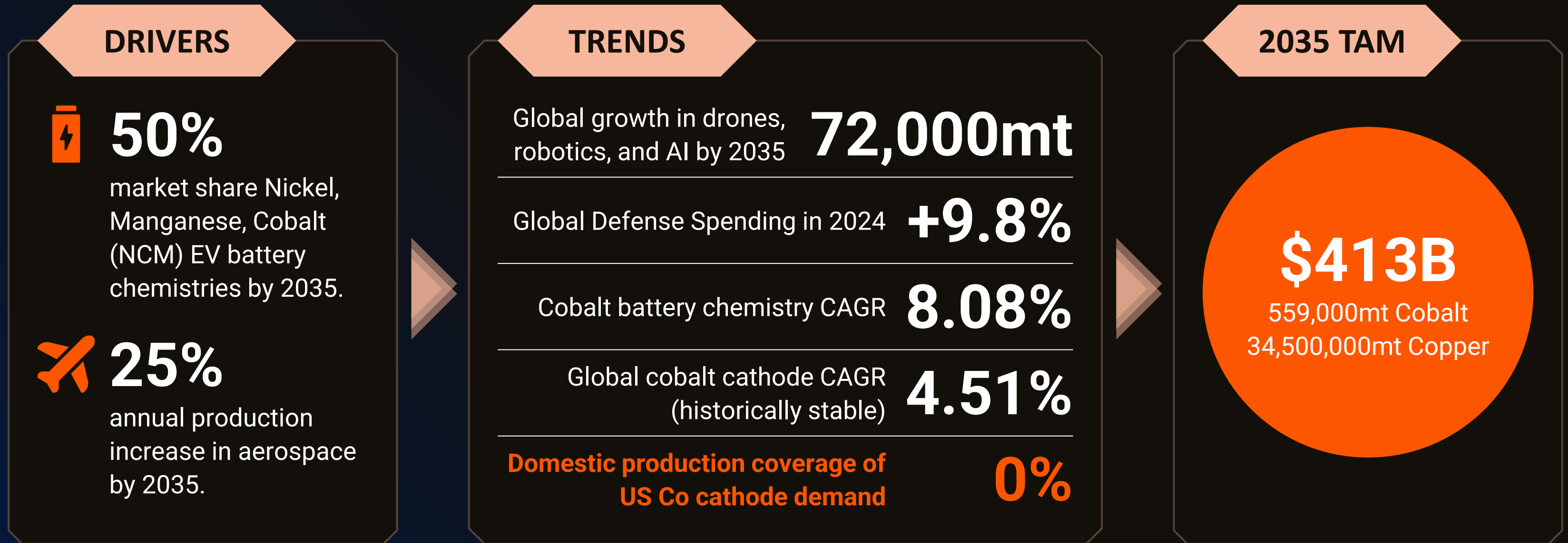


### Green Revolution

Cobalt demand is forecasted to grow 3x by 2035, primarily driven by electric vehicles.

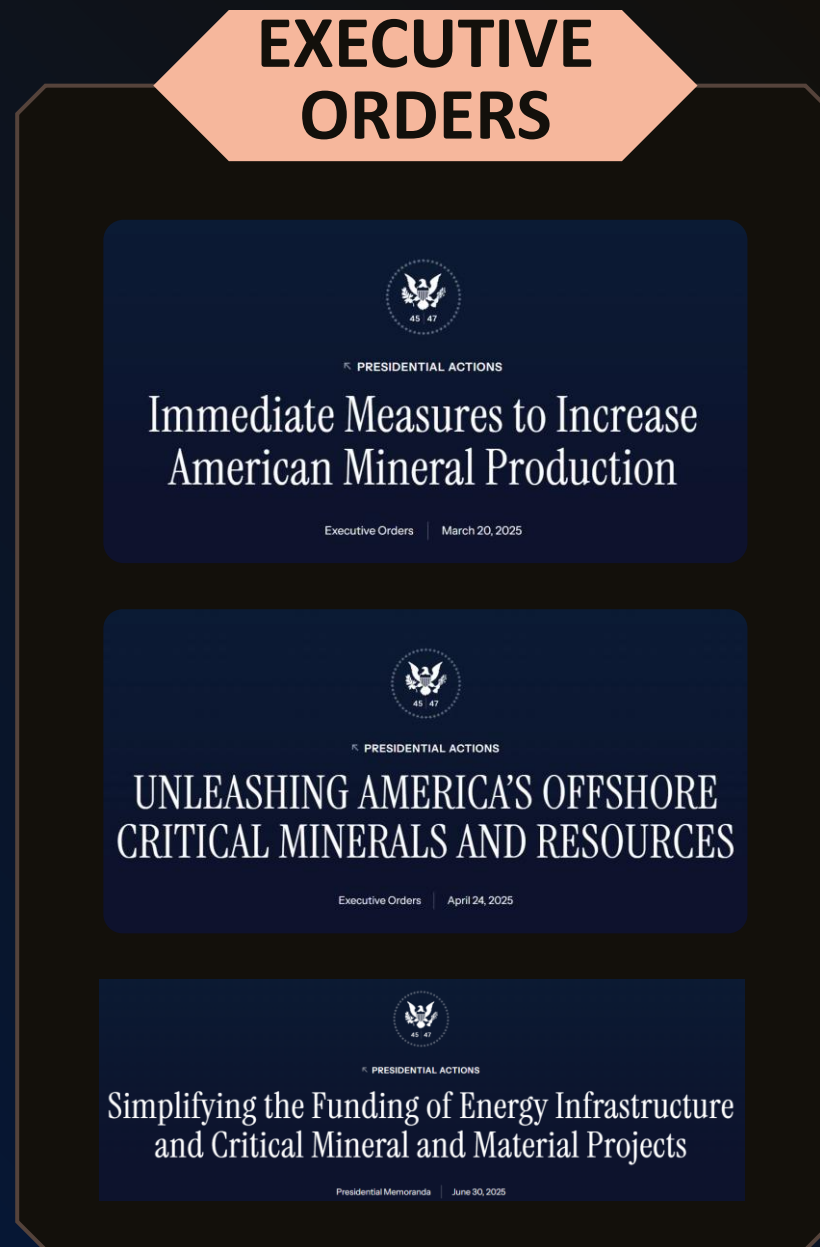
# Rapidly Growing Domestic Demand

The urgent demand for self-sufficiency in critical mineral processing rings loud and clear—*Without altering course, the US industrial base stands to remain entirely beholden to foreign inputs in perpetuity.*



Sources: US Geological Survey, Cobalt Institute, BloombergNBEF

# Strong Government Support



### GOVERNMENT AGENCIES

Offices dispersing the allocated funds for critical minerals projects

<b>DoD</b>	Manufacturing Capability Expansion and Investment Prioritization (MCEIP)	<b>432.8M</b>
<b>DoD</b>	Small Business Innovation Research (SBIR)	<b>2.2B</b>
<b>DoE</b>	Advanced Materials & Manufacturing Technologies Office (AMMTO)	<b>8B</b>
<b>DoI</b>	U.S. Geological Survey (USGS)	<b>67M</b>
<b>EXIM</b>	Make More in America (MMIA)	<b>4.4B</b>
<b>EXIM</b>	Supply Chain Resiliency Initiative (SCRI)	<b>344M</b>
<b>DFC</b>	Technical Assistance Program	<b>1B</b>
<b>NSF</b>	Small Business Innovation Research (SBIR)	<b>200M</b>

# Competing with Cutting Edge American Technology

In partnership with Idaho National Laboratory, **Ridgeline Elements** will commercialize novel leaching technology, replacing intensive chemical consumption with renewable inputs as the main oxidation and reduction reagents.

## SHORTENS PROCESSING

- ◆ Eliminates **FOUR** copper and **TWO** cobalt unit operations in a standard hydrometallurgical flowsheet for oxide feedstocks, reducing facility capex and opex.\*

\*Crundwell, F. K., Moats, M. S., Ramachandran, V., Robinson, T. G., & Davenport, W. G. (2011). Extractive metallurgy of nickel, cobalt and platinum-group metals. Elsevier. Details available in Appendix.

### OPERATING COST SAVINGS

- ◆ Reduces leaching energy & chemical reagent **costs by 70%** over industry standard peroxide-based leaching.
- ◆ Leaching and electrowinning conducted simultaneously.

### FEED AGNOSTIC

- ◆ Can extract critical minerals from oxide based virgin materials, intermediaries, electronic waste, and **end of life lithium-ion batteries**.

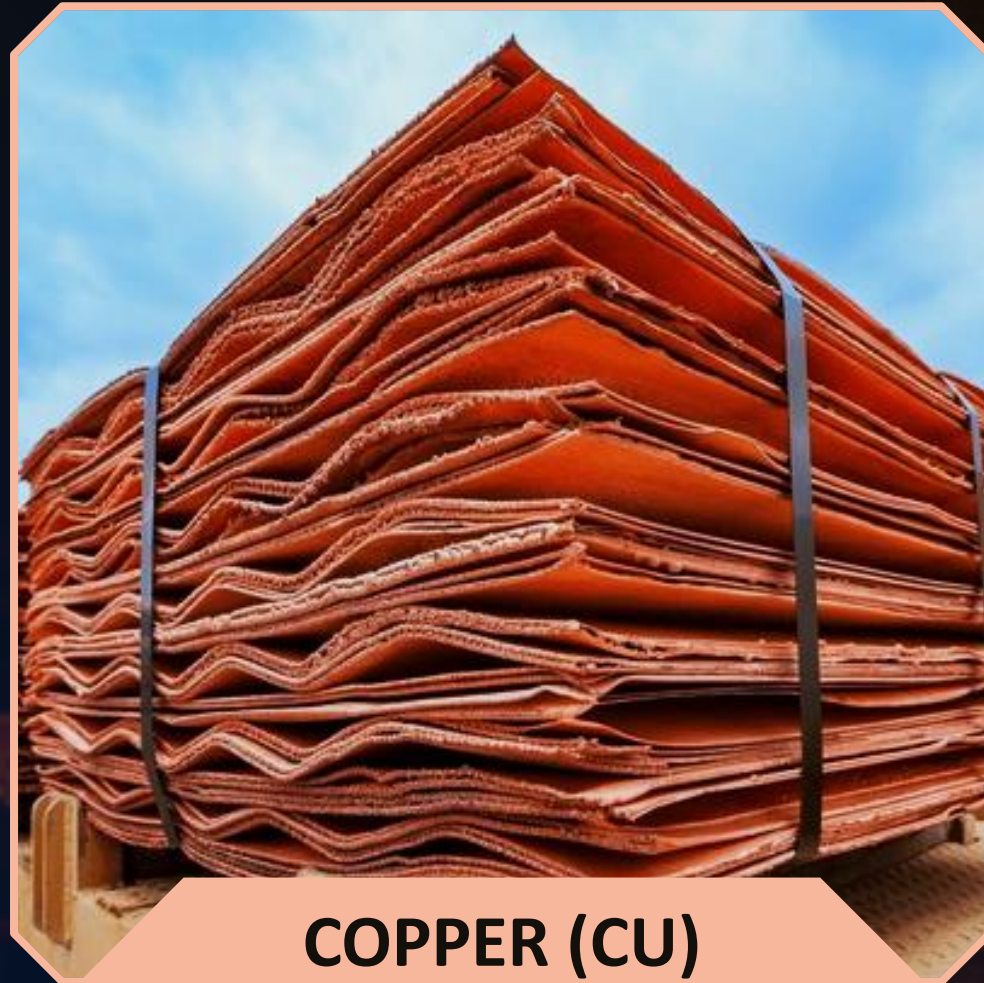
### FLEXIBLE

- ◆ Not limited to cobalt and copper but can be used to **target any specific critical mineral** based on standard reduction potential.
- ◆ Initial production line to **target cobalt and copper**.

### SCALABLE

- ◆ Modularity will allow for expansion at a fraction of the capital expenditure compared to existing technology.
- ◆ Utilizes same components as many existing hydrometallurgical units easing production and repair.

# What We Produce



**COPPER (CU)  
CATHODE**

**99.999% Purity**

- **Function:** Primary raw material for copper wires cables and tubing
- **Supply Risk:** ~45% of domestic demand met by foreign suppliers
- **Ridgeline Solution:** Scaling to produce 10,000 t annually providing a reliable domestic alternative



**COBALT (CO)  
CATHODE**

**99.999% Purity**

- **Function:** Primary alloying metal for high-performance aerospace systems and magnets
- **Supply Risk:** Virtually all supply is imported from China or Finland
- **Ridgeline Solution:** Scaling to produce 3,750 t annually cut cathode or powder




**COBALT SULFATE  
HEPTAHYDRATE**

**(CoSO4·7H2O) ~ 20% Co**

- **Function:** Stabilizes lithium-ion batteries and improves energy density
- **Supply Risk:** Entirely reliant on Canada, Norway, and China
- **Ridgeline Solution:** Scaling to produce 6,250 t annually at lower cost

# Secure Cobalt Source


Ridgeline Elements will import and refine copper/cobalt concentrates into copper cathode, cobalt cathode, and cobalt sulfate, providing the defense and EV industries with a vital domestic source of processed critical minerals.

 **1<sup>st</sup> Mover Advantage**

- ◆ No domestic facility currently producing cobalt cathode or sulfate.
- ◆ No domestic facility currently processing copper/cobalt concentrates.


 **Direct Procurement**

- ◆ Offtakes directly with minerals extractors for greater margin capture.


 **Circular Economy**

- ◆ Importing and refining cobalt and copper concentrates injects needed critical minerals into the domestic supply chain to build the battery industry.
- ◆ Opportunity to begin processing recycled materials grows with the supply of end-of-life EV batteries.




 **Product Diversity**

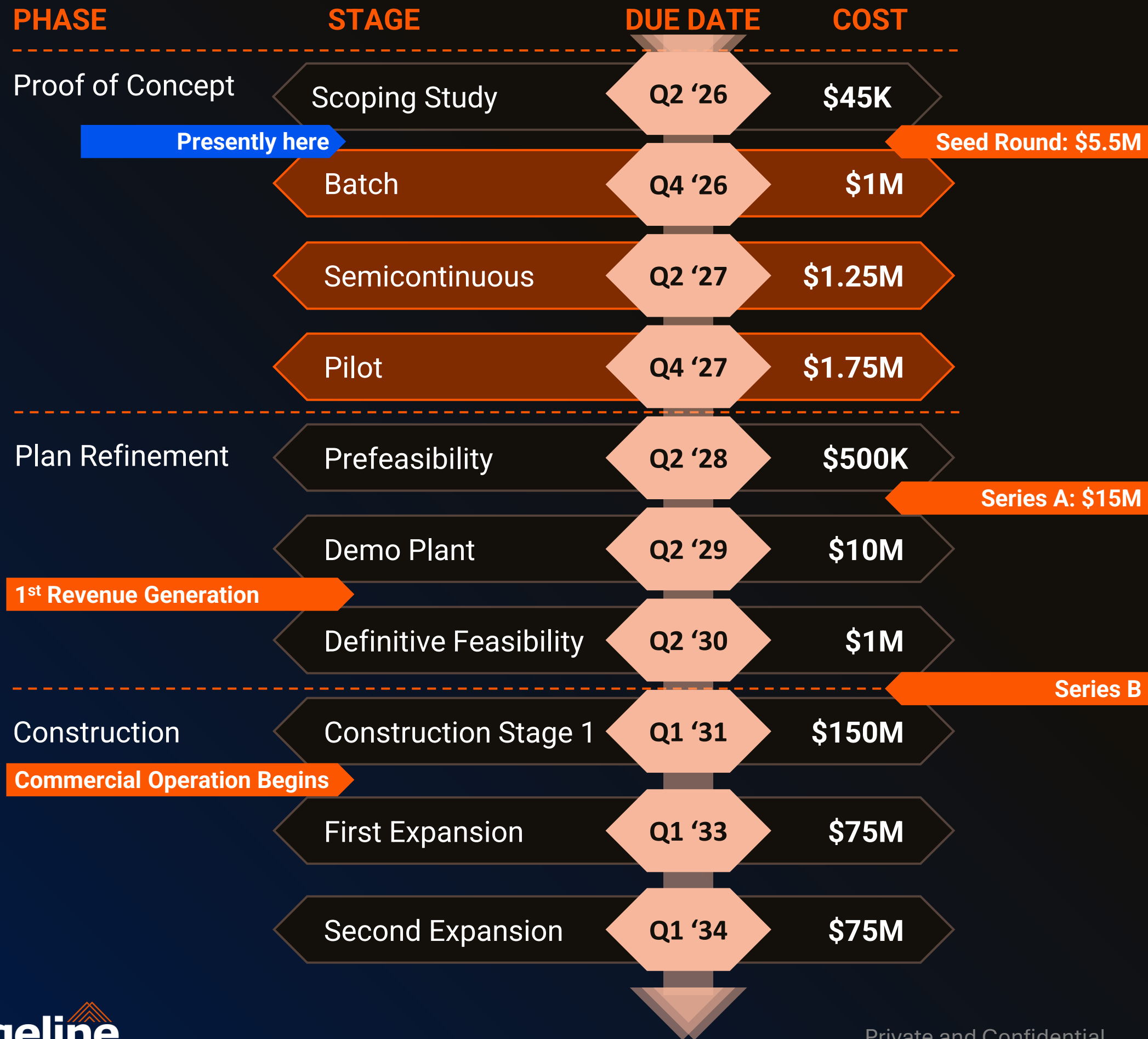
- ◆ Producing copper and cobalt insulates against cobalt price volatility.

 **Resilient System**

- ◆ The ability to intake a wide range of globally sourced feedstocks allows adaptation to supply conditions, mitigating risk.

 **Logistics**

- ◆ Direct access to cost effective river transport.
- ◆ Major rail and trucking arteries.
- ◆ Precursor Cathode Active Materials (PCAM) & CAM facilities being built or planned in TX, TN, and KY.
- ◆ Direct access to the Mississippi and Ohio river basin's **99.4 million residents.**



### TRACTION

#### Intellectual Property

- ◆ Exclusive License (From INL):
  - ◆ U.S. Patent No. 12,388,123
  - ◆ U.S. Patent Application Serial No. 19/271,618
  - ◆ U.S. Patent Application Serial No. 18/336,894

#### Joint Venture Agreements

- ◆ United Mining and Refining Inc.
  - ◆ Partner: Diesel Mining Katanga
  - ◆ Copper-Cobalt Concession, Huat-Katanga, DRC

#### Supplier Framework Agreements

- ◆ Ocean Minerals - MOU

#### Customer Framework Agreements

- ◆ 6k Energy – Letter of Intent
- ◆ Traxys – Letter of Interest

#### Partnership Agreements

- ◆ Idaho National Laboratory - SPP
- ◆ Barr Engineering

#### Letters of Support

- ◆ Arkansas Economic Development Commission (AEDC)
- ◆ Senator Tom Cotton

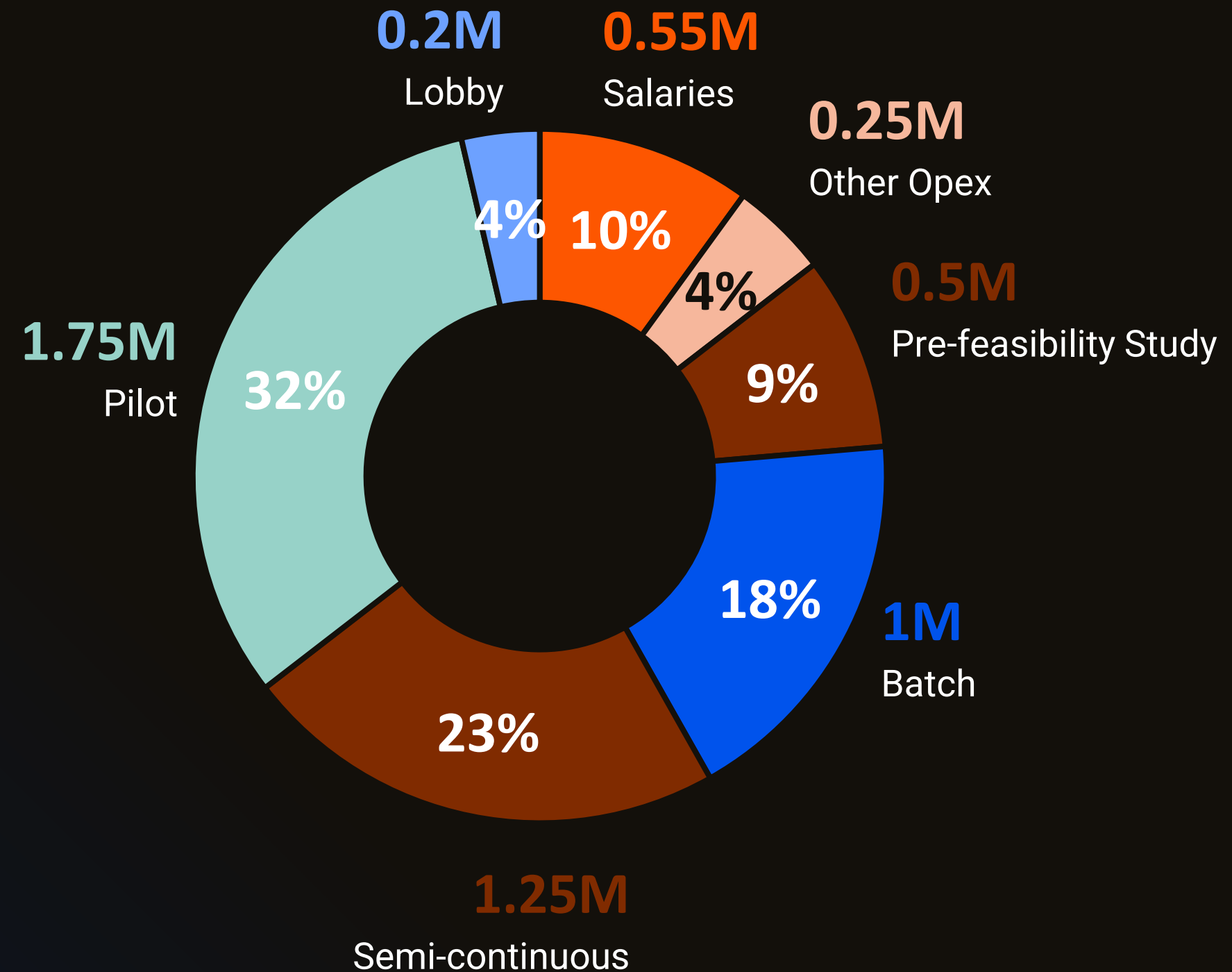
# Seed Round: \$5.5M

Capital to be used for batch testing, pre-feasibility study, semi-continuous testing, pilot, legal fees, travel expenses, and operating expenses.

**A successful pilot validates the IP at an appropriate scale to justify advancing offtake agreements and/or strategic partnerships**

Follow on financing via:

- ◆ Government Grants
- ◆ Equity Raise
- ◆ In-kind Contributions
- ◆ Government Backed Debt



CORE TEAM



**Alexander Corbett**  
COO

- ◆ Univ. of Massachusetts - BA
- ◆ UCLA MBA
- ◆ Managing Partner of Sachem Capital
- ◆ Former investment banker, USMC officer
- ◆ Hometown: Merrimac, MA



**Ian Killough**  
Founder - CEO

- ◆ Univ. of Arkansas - BS in Engineering & MBA
- ◆ Licensed Professional Engineer
- ◆ Former USMC officer
- ◆ Hometown: Wynne, AR



**Stephane Bossio**  
Dir. of Intl Relations

- ◆ Univ. of Arkansas BS in Engineering
- ◆ Licensed Professional Engineer
- ◆ Hometown: Kinshasa, DRC



KEY ADVISORS



**Tedd Lister**  
Ph. D. Analytical Chemistry



**“Ford” Duncan**  
>\$15B Transactional Eperience

PARTNERS





# Appendix

# Opportunity

**Potential with successful pilot**

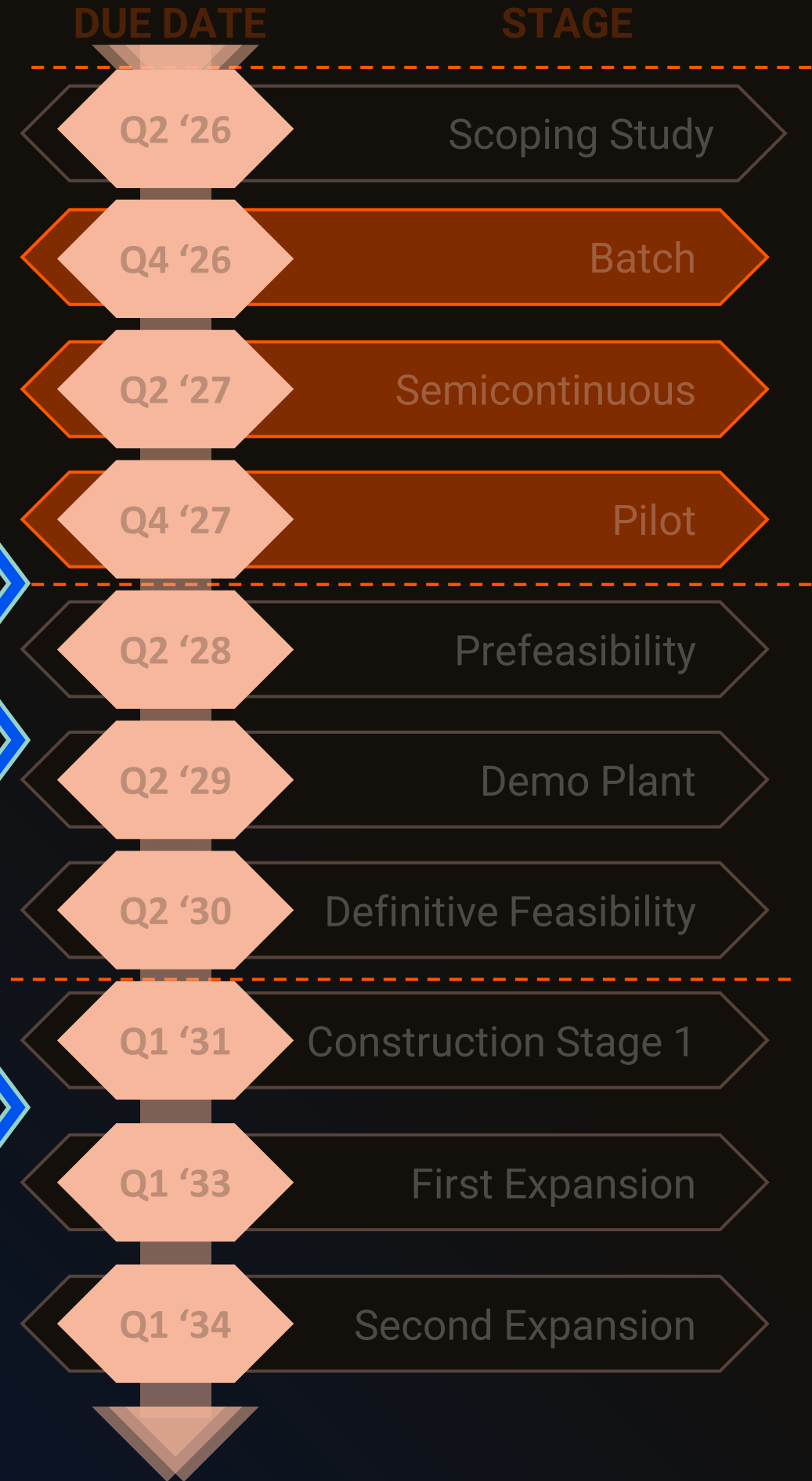
- ◆ Exit to strategic: LOW
- ◆ License IP to pilot: LOW
- ◆ Partner with strategic for R&D: MODERATE

**Potential with successful demo plant**

- ◆ Exit to strategic: Moderate
- ◆ License IP: Moderate
- ◆ Partner with strategic for co-dev/co-use: HIGH

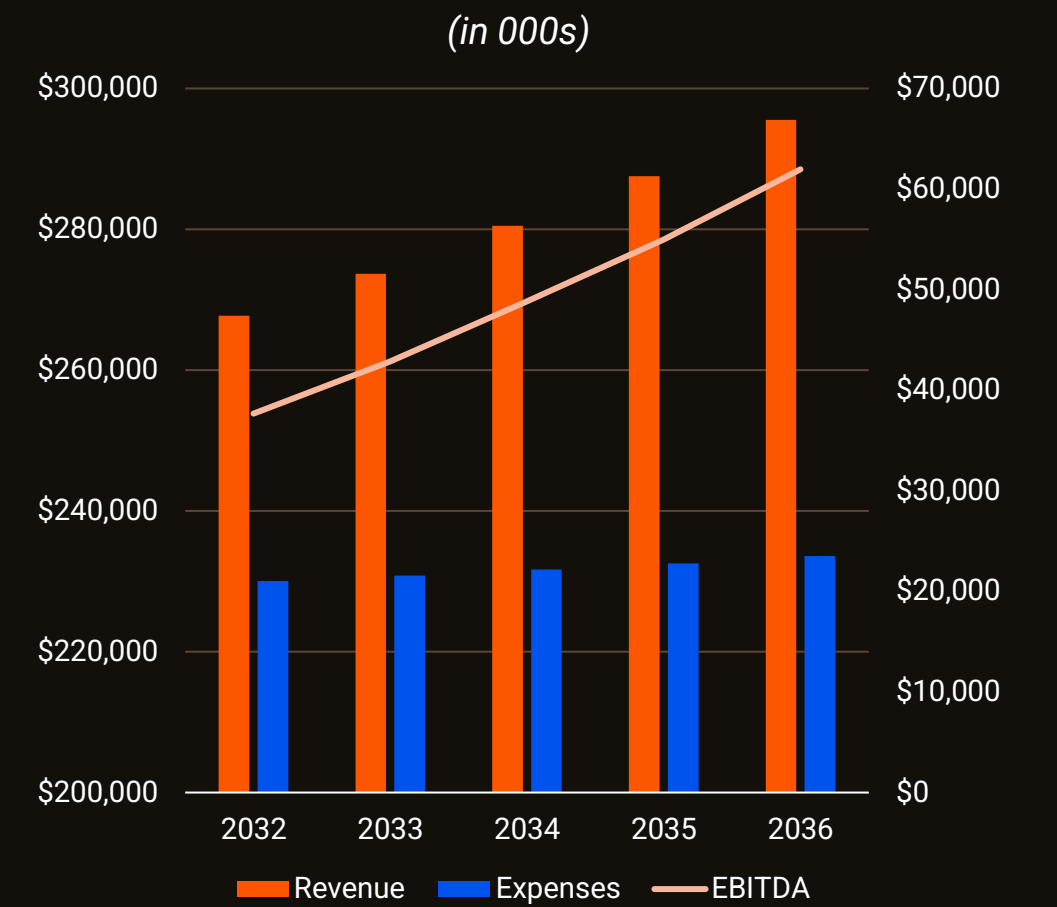
**Potential with commercial operational**

- ◆ Exit to strategic: HIGH
- ◆ License IP: HIGH
- ◆ Partner with strategic: HIGH



## Financial Projections:

Ridgeline Elements timeline is on track to be initially profitable in CY2032. Distributions to equity investors will begin in Q3CY2033. Further financial projections and preliminary models are available upon request.



# Legacy Concepts to Replace Legacy Systems

## NOVEL

Combining proven legacy concepts in a *new way* – using readily available components to shorten the development timeline.

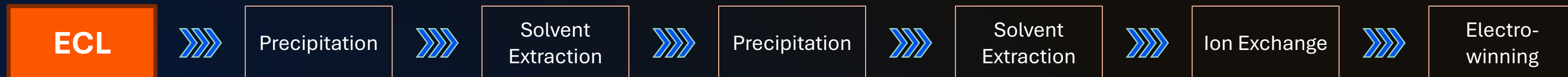


### That means..

- |                   |            |                  |                      |
|-------------------|------------|------------------|----------------------|
| ◆ Tanks           | ◆ Probes   | ◆ Potential      | ◆ Fluid Flow         |
| ◆ Agitators       | ◆ Cathodes | ◆ pH             | ◆ Two-phase leaching |
| ◆ Impellers       | ◆ Anodes   | ◆ Mass transport | ◆ Etc.               |
| ◆ Instrumentation | ◆ Etc.     | ◆ Kinetics       |                      |
- ..Are readily available**                      **..Are well modeled**

## THE CRITICAL TASK

Innovating where it matters most – pairing ECL with proven legacy units downstream.  
Delivering outsized impact on the entire system with lower risk.



"Only the dissolved metals can be recovered in the following stage, therefore, leaching is the critical step in the hydrometallurgical process, **determining the recovery effects of the whole process.**"

Wang, F., & Li, H. (Eds.). (2023). Hydrometallurgical process - an overview. In Comprehensive review on hydrometallurgical recovery of metals (Section 3.1.2.2.1). Elsevier.

# History

## 5 Awards :

- ◆ 2022 R&D 100 Award: EC-Leach
- ◆ 2018 R&D 100 Finalist: E-RECOV
- ◆ Federal Lab Consortium Far West Region, Outstanding Technology Development, E-RECOV, 2016.
- ◆ Idaho Innovation Awards Early-Stage Innovation of the Year - 2016, E-RECOV.
- ◆ Tech-Connect 2016 for Electrochemical Recovery of Constituents of Value (E-RECOV)

## 20 + Publications:

- ◆ Electrochemical leaching of critical materials from lithium-ion batteries: A comparative life cycle assessment. Resources, Conservation and Recycling 2023, 193, 106973.
- ◆ Electrochemical leaching of spent LIBs: Kinetics, novel reactor, and modeling. Sustainable Materials and Technologies 2024, 40, e00898
- ◆ Removal of impurity metals as phosphates from Lithium-ion battery leachates. Hydrometallurgy 2023, 106041.
- ◆ Electrochemical-assisted leaching of active materials from lithium ion batteries. Resources, Conservation and Recycling 2020, 161, 104900.
- ◆ Comprehensive process for the recovery of value and critical materials from electronic waste. Journal of Cleaner Production 2016, 125, 236-244.
- ◆ Optimization of the Electrochemical Extraction and Recovery of Metals from Electronic Waste Using Response Surface Methodology. Industrial & Engineering Chemistry Research 2017, 56 (26), 7516-7524

## 8 Patents:

- ◆ **Methods of Recovering Active Materials from Rechargeable Batteries, and Related Apparatuses, WO2020252495A1, December 17, 2020.**
- ◆ Methods of Recovering Lithium from a Lithium-Containing Material, and Related Systems. US20240055680A1, February 15, 2024.
- ◆ Methods of Separating Metals from a Lithium Ion Battery Leachate. WO2023039486A1, March 16, 2023.
- ◆ Methods of Recovering Metals from Electronic Waste and Related Systems, US10378081B2, August 13, 2019.
- ◆ Process for Recycling Rare Earth Magnets, US10323300B1, June 18, 2019.

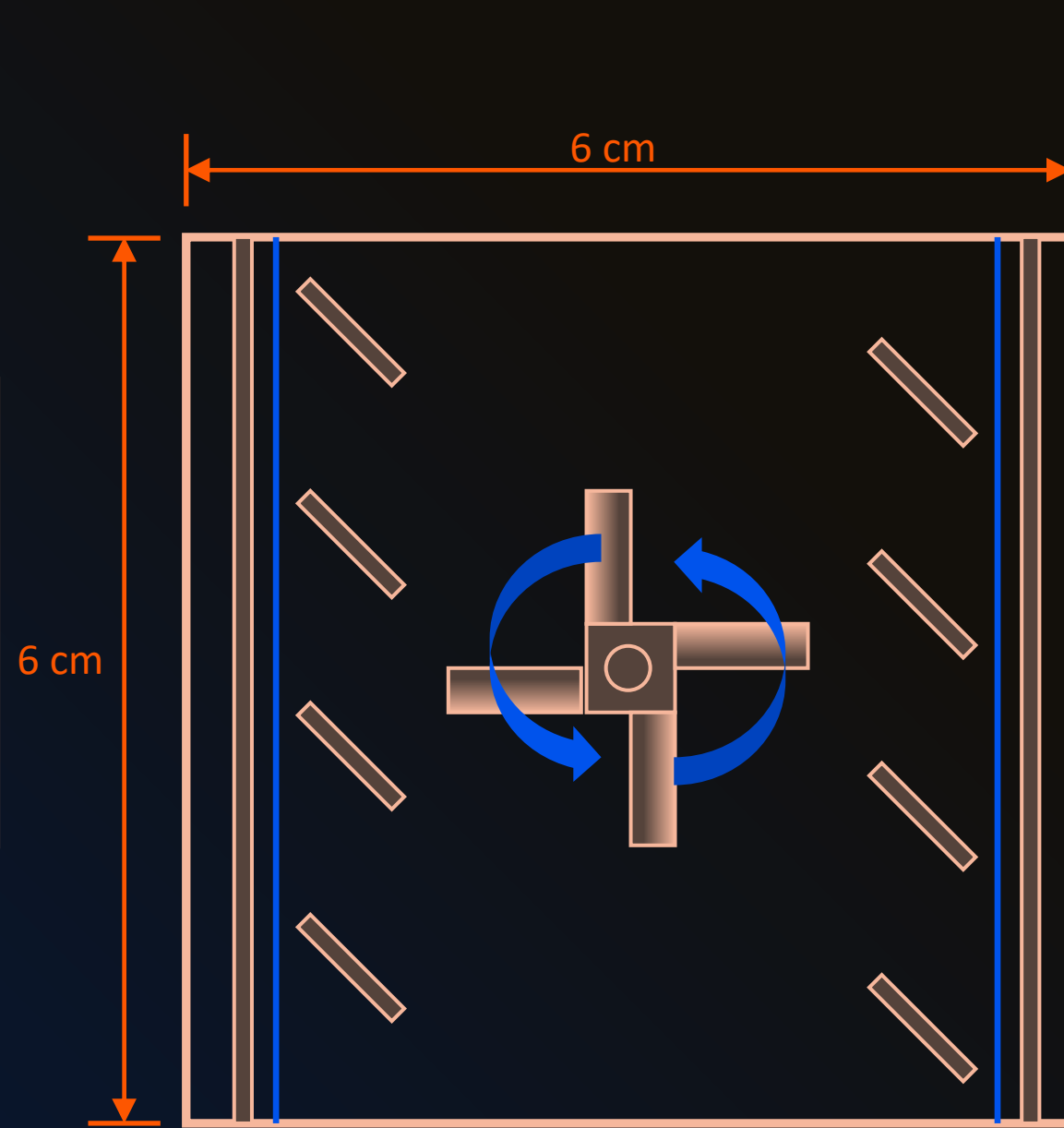
# Electrochemical Cell

**SPECIFICATIONS**

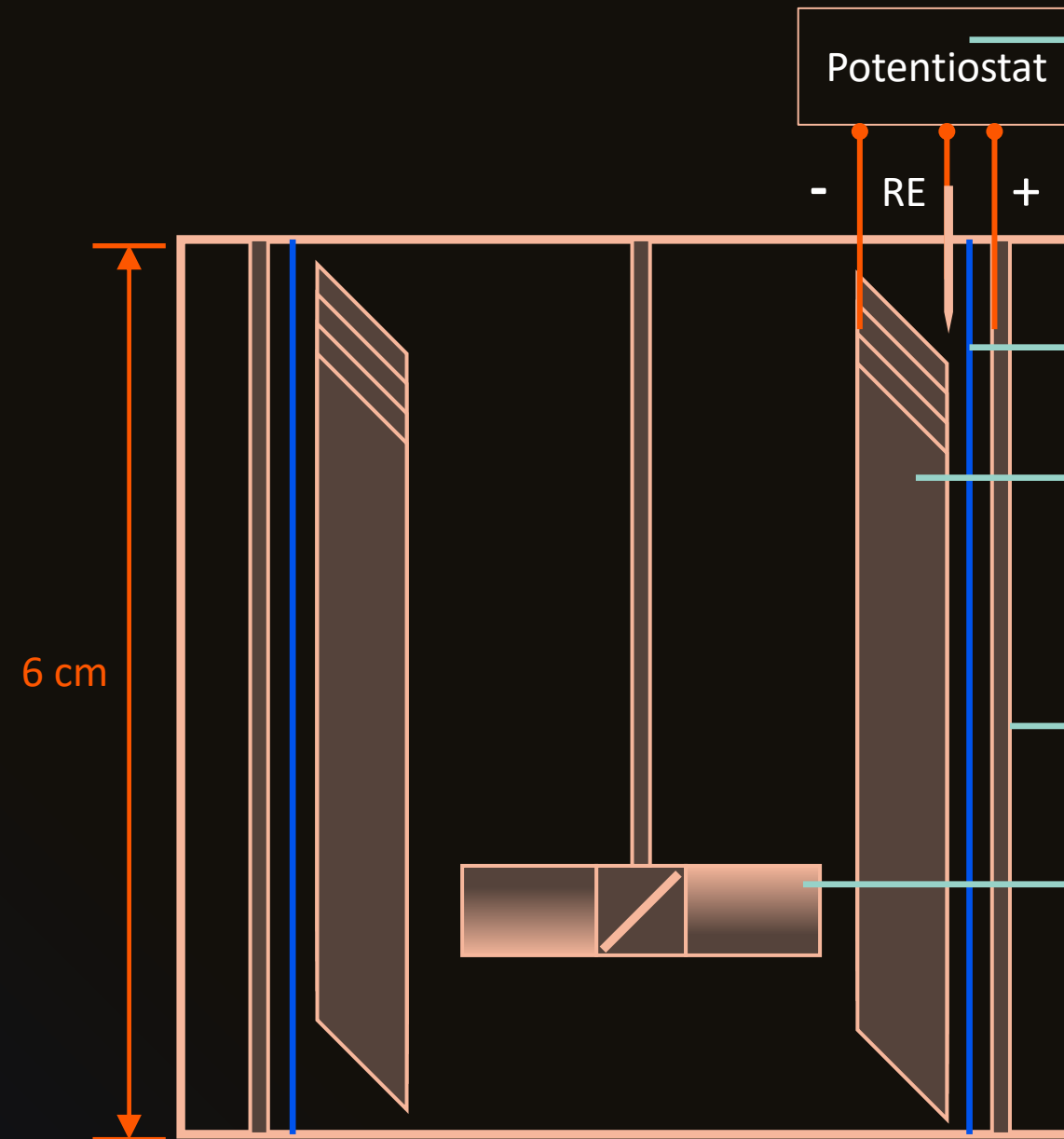
**Currently TRL 3**

- ▶ Cathode compartment: 250mL
- ▶ Anode compartment(s): 60mL
- ▶ Anolyte: KOH
- ▶ Catholyte: FeSO<sub>4</sub>, H<sub>2</sub>SO<sub>4</sub>
- ▶ Temperature: Ambient

Bench Scale



Top-down view



Side view

**Potentiostat:**  
Solartron 1286 or  
Biologic SP-50

**Membrane:**  
Fumasep FBM-PK

**Cathode:**  
(4) Parallel Baffle  
Electrodes (PBE)  
Stainless Steel

**Anode:**  
IrO<sub>2</sub>/Ti Mesh

**Impeller:**  
Caframo, PTFE 4  
Blade Pitched – A185

**Cell:**  
Polypropylene

# Operational Modes

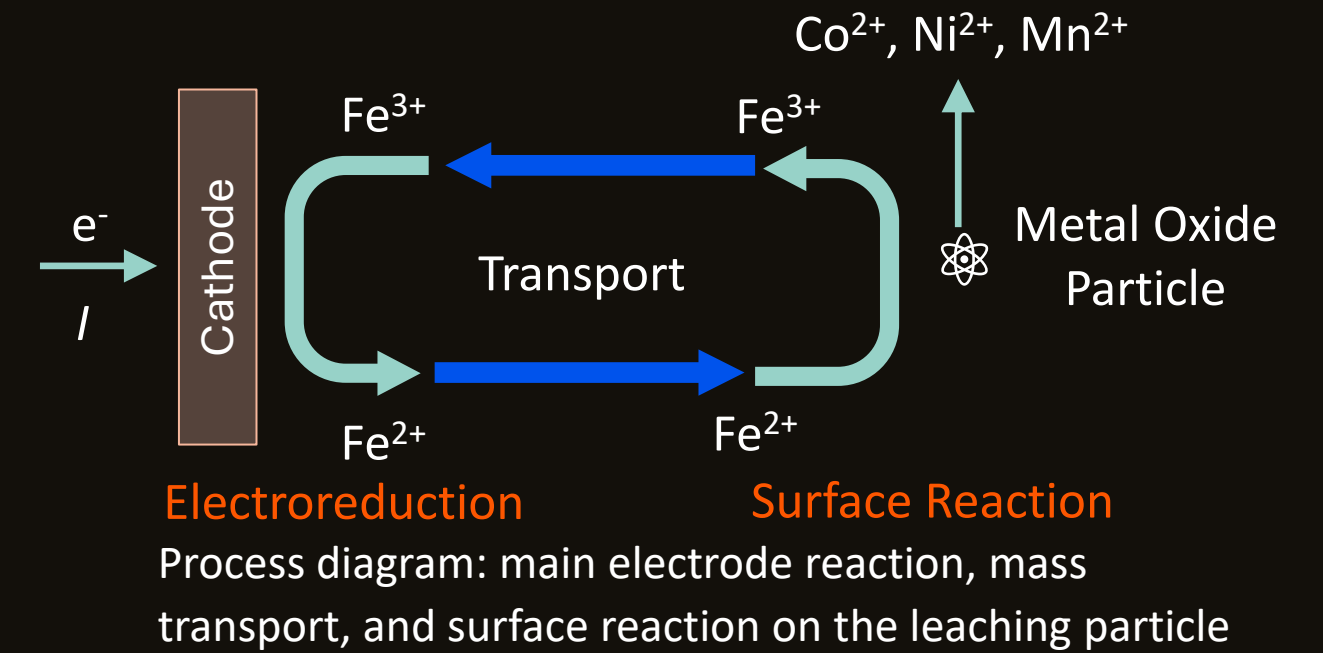
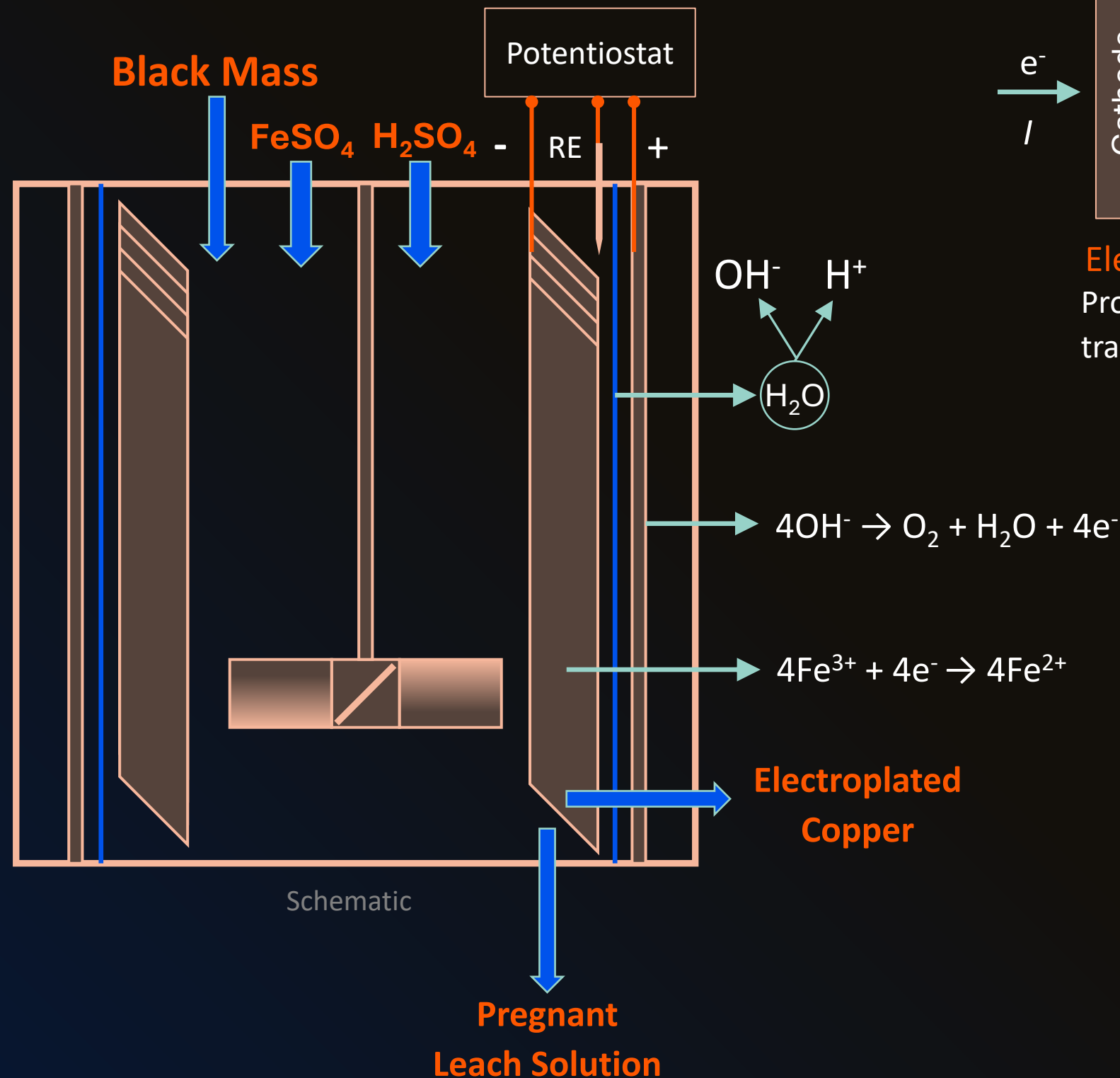
There are currently two modes for operating the system. A bi-polar membrane is added or removed while Fe serves as the oxidizer or reducer based on the chemical composition of the feed.

Feed	E-waste Sulfide Ores Solar Panels	Black Mass Oxide Ores Steel Slag
<b>Mechanism</b>	<ul style="list-style-type: none"> <li>◆ Oxidized by <math>\text{Fe}^{3+}</math></li> </ul>	<ul style="list-style-type: none"> <li>◆ Reduced by <math>\text{Fe}^{2+}</math></li> </ul>
<b>Setup</b>	<ul style="list-style-type: none"> <li>◆ Single Chamber</li> <li>◆ Flow in on cathode side, out on anode</li> </ul>	<ul style="list-style-type: none"> <li>◆ Two Chambers</li> <li>◆ <b>Bi-polar Membrane</b></li> <li>◆ Leaching in cathode side</li> </ul>
<b>Operation</b>	<ul style="list-style-type: none"> <li>◆ <math>\text{Fe}^{3+}</math> generated at anode</li> <li>◆ Base metals oxidized, plated on cathode</li> <li>◆ <math>\text{Fe}^{3+}</math> regenerated &amp; system repeats</li> </ul>	<ul style="list-style-type: none"> <li>◆ <math>\text{Fe}^{2+}</math> generated at cathode</li> <li>◆ <math>\text{Fe}^{2+}</math> reduces target metal &amp; oxidizes to <math>\text{Fe}^{3+}</math></li> <li>◆ Base metals oxidized, plated on cathode</li> <li>◆ <math>\text{Fe}^{2+}</math> regenerated &amp; system repeats</li> </ul>

# Black Mass Processing

**DATA**

- ▶ Leach time: 1 hr
- ▶ Pulp Density: 73– 240 g/L
- ▶ RPM: 700-800
- ▶ Charge to background current: 5500 - 6050C
- ▶ Peak current density: 48 -52 mA/cm<sup>2</sup>
- ▶ pH: <2
- ▶ Voltage: 2.1 VDC
- ▶ **Energy Consumption: 43.8 kWh/t<sub>feed</sub>**



Element	Black Mass wt%	Electrochemical leaching with Fe	
		Undissolved material wt%	Efficiency %
Li	2.79	0.081	<b>99.14</b>
<b>Cu</b>	<b>0.34</b>	<b>0.07</b>	<b>99.42</b>
Al	0.46	0.496	<b>68</b>
Mn	4.23	0.069	<b>99.52</b>
Fe	0.43	0.165	<b>88.67</b>
<b>Co</b>	<b>12.2</b>	<b>0.278</b>	<b>99.33</b>
Ni	7.48	0.333	<b>98.68</b>
Zn	0.09	0.004	<b>98.86</b>

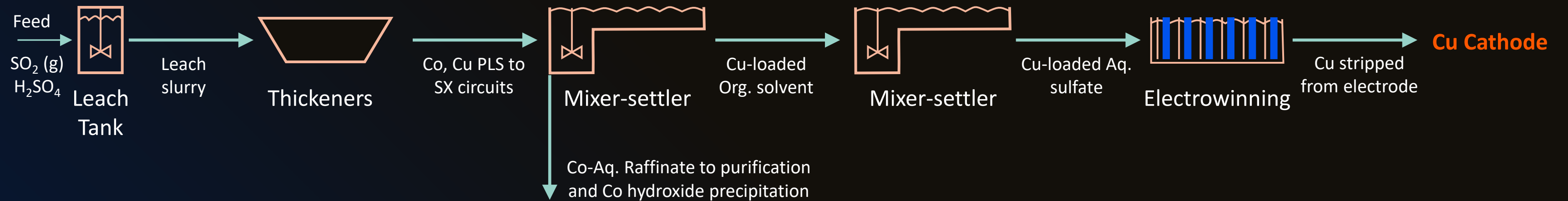
Leaching Efficiencies

# Shortening the Flowsheet

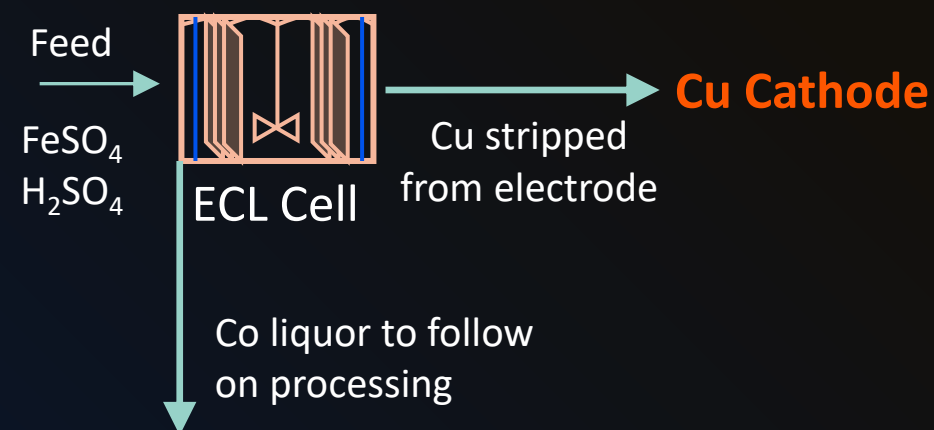
This is the basis for the pursuit of a potential licensing and royalty model

**Typical Process:** Extraction of Co and Cu from weathered (oxide) ores from the African copper-belt. Leaching & Solvent Extraction. *Illustrative, Non-Exhaustive.*

Crundwell, F. K., Moats, M. S., Ramachandran, V., Robinson, T. G., & Davenport, W. G. (2011). Extractive metallurgy of nickel, cobalt and platinum-group metals. Elsevier.



**Electrochemical Leaching:** Extraction of Co and Cu from weathered (oxide) ore concentrate. Leaching only.



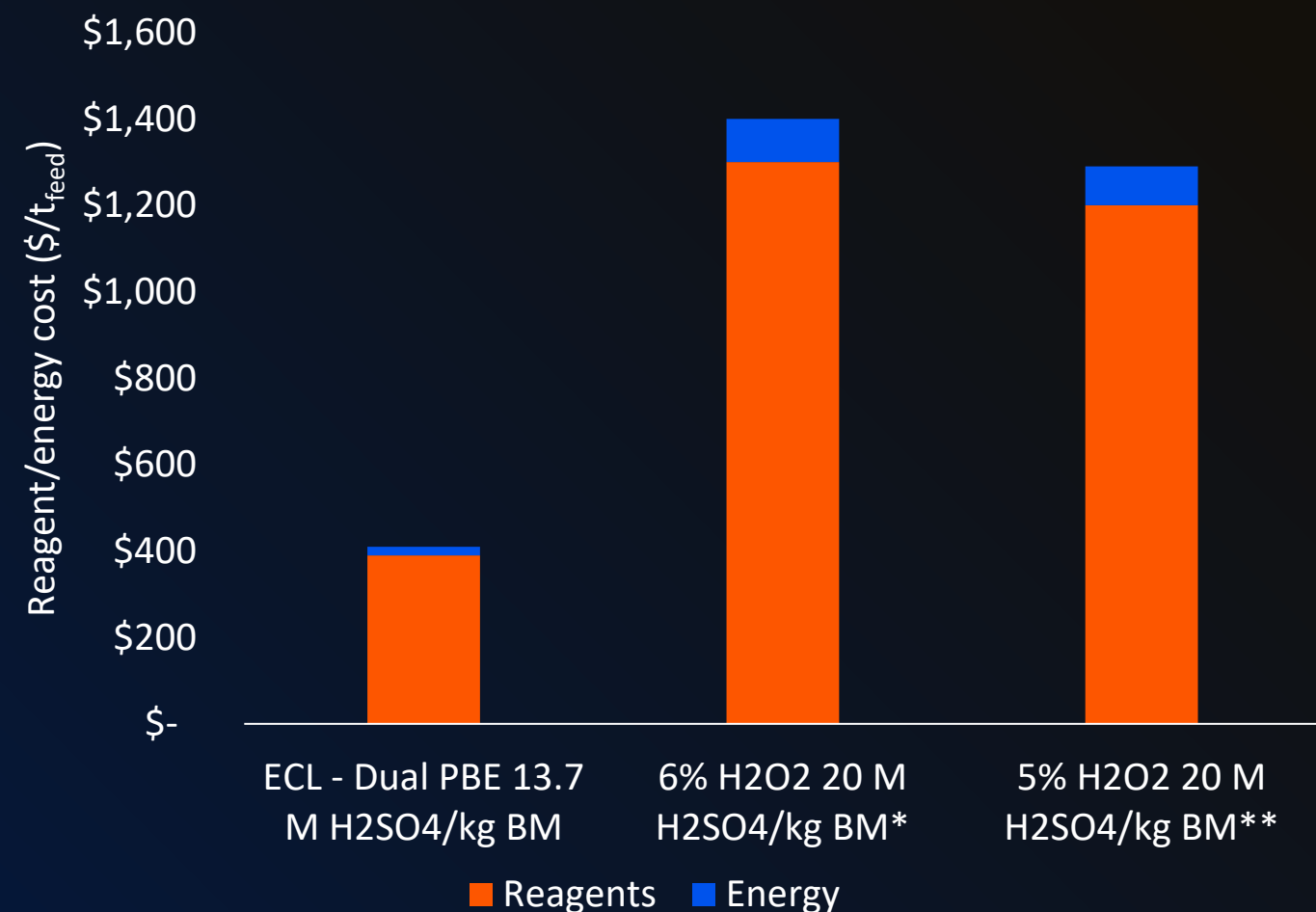
Shorten your flowsheet = **CapEx** ↓ **OpEx** ↓

# Economics & Scaling

## ECL COSTS

- ▶ **Energy Consumption:** 43.8 kWh/t<sub>feed</sub> – input for electrochemical process & 800rpm impeller speed.
- ▶ **Reagent Costs:** \$390/t<sub>feed</sub> FeSO<sub>4</sub>, H<sub>2</sub>SO<sub>4</sub>

## ECL vs H<sub>2</sub>O<sub>2</sub> Processes



\* Kang, J., Sohn, J., Chang, H., et al., 2010b. Preparation of cobalt oxide from concentrated cathode material of spent lithium ion batteries by hydrometallurgical method. Adv. Powder Technol. 21 (2), 175–179.

\*\*Kim, S., Yang, D., Rhee, K., et al., 2014. Recycling process of spent battery modules in used hybrid electric vehicles using physical/chemical treatments. Res. Chem. Intermed. 40 (7), 2447–2456.

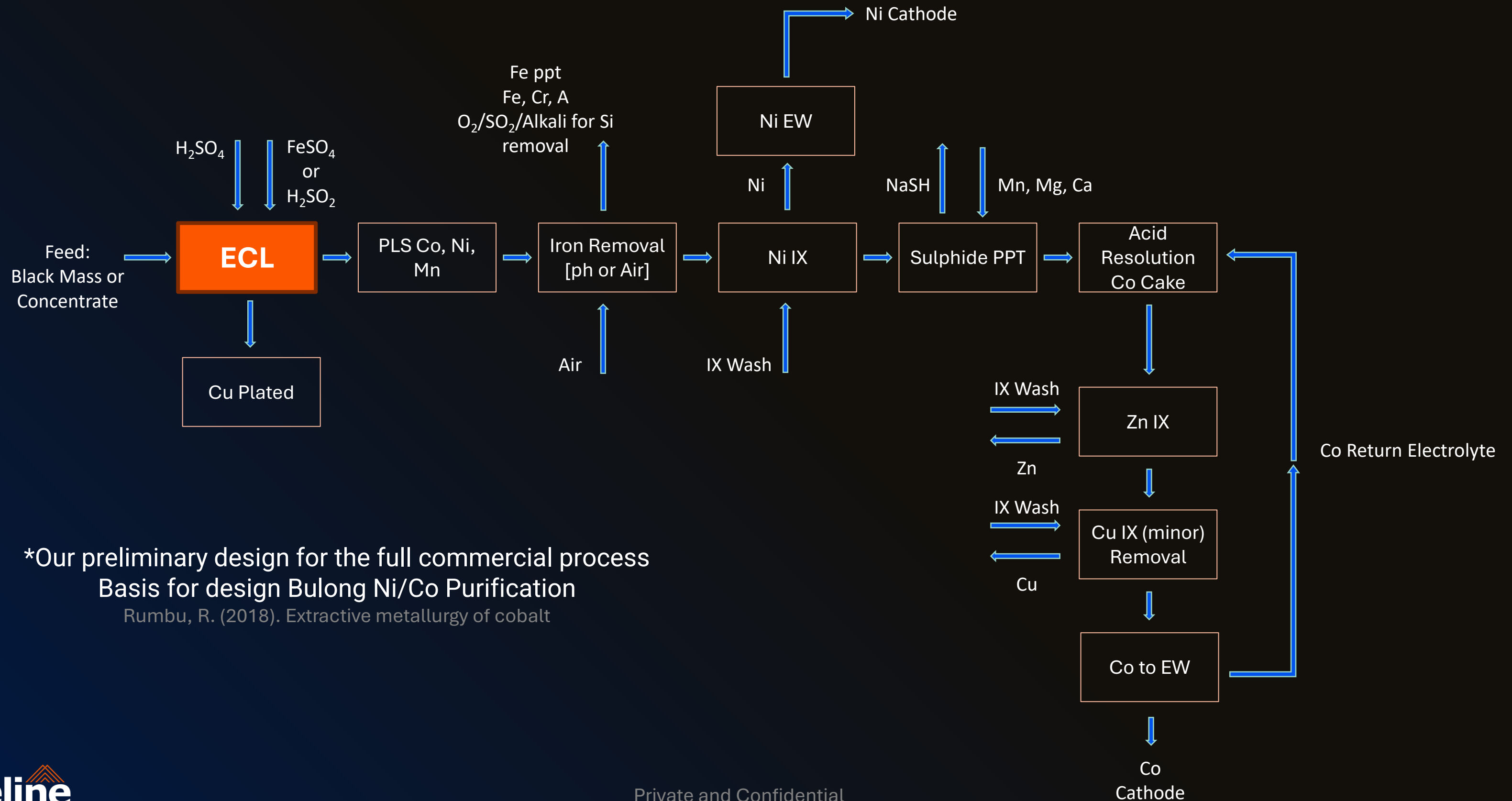
## CRITICAL PARAMETERS TO MAINTAIN

- ◆ Ratio of cathode to anode area
- ◆ Proximity of cathode to anode
- ◆ Ratio of the effective slurry volume to the cathode area

## COMMERCIALIZATION HURDLES

- ▶ **Cell Design:** Ensure current distribution, mass transfer efficiency maintained.
- ▶ **Mixing Efficiency:** Validate impeller geometry and flow dynamics with CFD modeling
- ▶ **Electrode Durability:** Evaluation of electrodes under constant load, scaled flow rates & slurry abrasiveness
- ▶ **Membrane Integrity:** Evaluate sourcing, lifespan, fouling potential, and cleaning demands
- ▶ **Fe<sup>2+</sup> Regeneration Rate:** Ensure minimal parasitic reactions and regeneration rate can match throughput in a continuous flow system
- ▶ **Slurry Handling:** Validate agitation & solid suspension systems

# Process Flow Diagram (PFD)\*



\*Our preliminary design for the full commercial process  
 Basis for design Bulong Ni/Co Purification  
 Rumbu, R. (2018). Extractive metallurgy of cobalt

# Feasibility Studies

## SCOPING

- ▶ 3-4 months
- ▶ \$45K
- ▶ Refine the business case, assess process options and potential sites
- ▶ Following tasks will be conducted:
  - ▶ Conceptual engineering design and initial metallurgical test work
  - ▶ Site analysis, initial capital cost estimate
  - ▶ Detailed financial model, preliminary project execution schedule
  - ▶ Preliminary environmental impact report with corresponding permitting process map, waste disposal plan



## PRE-FEASIBILITY

- ▶ 6-7 months.
- ▶ \$300K
- ▶ Following tasks will be conducted:
  - ▶ In depth metallurgical testing, final process flow, and Initial plant layouts will be developed
  - ▶ Final site selection, corresponding environmental impact report, refined capital cost estimate
  - ▶ Financial model and project execution schedule further refined
  - ▶ Detailed Initial Procurement Operating Plan (POP) and shipping options will be developed
  - ▶ Risk analysis

## PILOT & DEMO

- ▶ Pilot
  - ▶ Contracted lab(s)
  - ▶ \$4M
  - ▶ Approx. 2-month lead time
  - ▶ Approx. 24 months execution (all 3 phases).
- ▶ Demo Plant
  - ▶ \$15M Capex + working capital
  - ▶ Approx. 12 months construction
  - ▶ Approx. 12 months operation
  - ▶ Facility will be scaled during commercialization

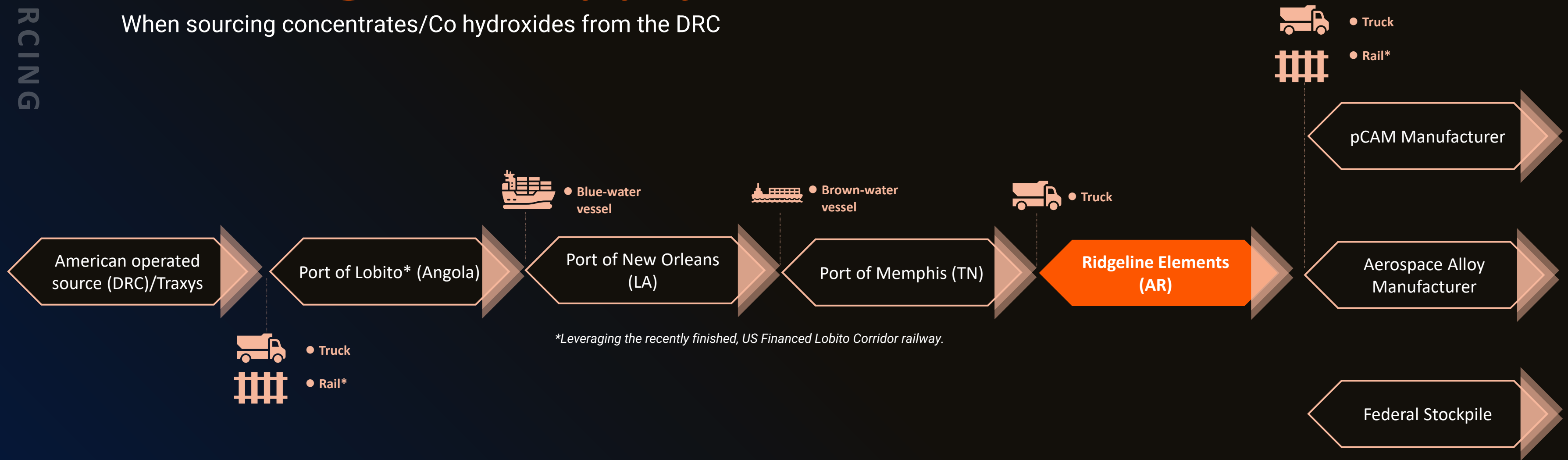


## DEFINITIVE FEASIBILITY

- ▶ Approx. 12 months.
- ▶ \$1M
- ▶ Report is granular and focuses on the engineering and process design.
- ▶ Following tasks will be conducted:
  - ▶ Advanced plant layouts developed with utility service points will be clearly defined, environmental permitting submitted.
  - ▶ Capital cost estimate finalized
  - ▶ Financial model refined and project execution schedule finalized
  - ▶ Waste disposal plan finalized
  - ▶ Procurement Operating Plan (POP) and shipping options will be finalized
  - ▶ Risk analysis refined

# Building the Supply Chain

When sourcing concentrates/Co hydroxides from the DRC












- ◆ Concentrate transported via Flexible Intermediate Bulk Container.
- ◆ Hydroxide transported via palletized drums



# Aerospace And Defense In Arkansas

Aerospace/Defense is Arkansas' leading export. In 2023, aircraft & aircraft parts were Arkansas's largest category of export with over \$850M dollars in goods exported. **Ridgeline Element's cobalt production** is a pivotal piece in securing the supply chain by creating a truly regional economy to produce batteries and aerospace alloys. With most of the required components already being produced locally; **opportunities for further growth abound...**

## Arkansas Defense Contracting Ecosystem

	- <b>Battery &amp; Defense:</b> Lithium hydroxide monohydrate (LHM)
	- <b>Battery &amp; Defense:</b> Lithium hydroxide monohydrate (LHM)
	- <b>Electrical &amp; Transportation:</b> High-performance steel production
	- <b>Battery &amp; Defense :</b> Specialty Graphite, carbon fiber, composites
	- <b>Defense:</b> High-cetane synthetic fuel – Aircraft and ground vehicles
	- <b>Defense:</b> High Mobility Artillery Rocket System (HIMARS) & Fire Control (MFC)
	- <b>Defense:</b> Solid Rocket Motors (SRM) & Multiple Launch Rocket Systems (MLRS)
	- <b>Defense:</b> Air defense missiles: Tamir (Iron Dome) Skyhunter
	- <b>Defense:</b> SRMs: Stinger, Javelins, Patriot, THAAD



# Cobalt in Defense Applications

APPLICATION	COMPONENT	SEGMENT	MATERIAL
AIRCRAFT	Combustor	Superalloys	Ni/Co Superalloy
	Sensors/Avionics	Magnets	SmCo
MISSILES	Propulsion system	Magnets	SmCo
	Control Actuator	Magnets	SmCo
AIRCRAFT CARRIERS	Integrated full electric propulsion	Superalloys	Ni/Co Superalloy
	Propulsion with outboard electric motors	Magnets	SmCo
CORVETTES/FRIGATES/SUBMARINES	Electric motors	Magnets	SmCo
UNMANNED ASSETS	Batteries	Batteries	LCO/NCM

Source: The Hague Center for Strategic Studies

## TRENDS

The use of cobalt in defense applications – particularly in the form of superalloys and magnets – is of increasingly visible importance. In 2024, NATO endorsed a supply-chain security roadmap **listing cobalt as being of high supply risk for military applications.**

### Growing use of EVs

- ◆ Tactical & non-tactical vehicles
- ◆ eMicromobility (Bikes)
- ◆ Backed by USA Climate Strategy & DoD Battery Strategy

### Other uses - portables

- ◆ Communications devices - radios and tablets.
- ◆ Wearable electronics - night-vision goggles, helmet-mounted displays, bodyworn sensors.
- ◆ Unmanned systems hardware – goggles and control systems.
- ◆ Optics - smart optics and scopes and directed energy weapons.

# Incentives

## STATE

Cumulative income tax credits may be used to offset **50% of the Arkansas income tax** liability in the tax year the credit is earned.








- ◆ Sales And Use Tax Refund - provides **5.5% tax refunds** on the purchase of building materials, machinery, and equipment.
- ◆ ArkPlus - provides **tax credits of 10% of the total investment** in a new location or expansion project. Requires both a minimum investment and a minimum payroll of new, full-time, permanent employees hired for the project.
- ◆ **Infrastructure Grants** - Share the cost of project infrastructure needs by committing grants from state and federal infrastructure funds. The amount of assistance committed is dependent upon the strength of the company, of jobs, average wage, project investment and costs associated with facility/site improvements.
- ◆ Equity Investment Incentive Program - The income tax credit/credits issued under this program are equal to **33 1/3% of the amount invested by an investor** in an eligible business. Targeted toward new, technology-based businesses paying wages in excess of the state or county average wage. Allows an approved business to offer an income tax credit to investors purchasing equity.

## FEDERAL

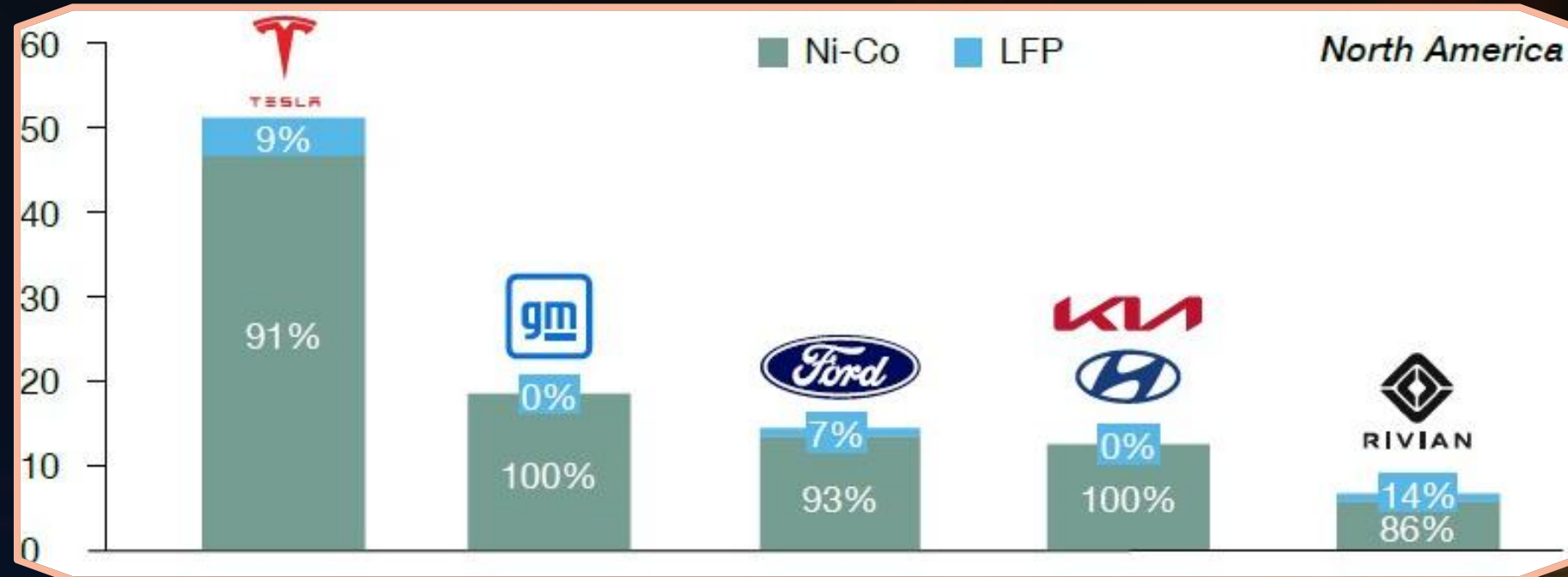
To qualify for the credit, each eligible component must be “produced by the taxpayer” and “sold by the taxpayer to an unrelated person.” A component will be considered produced by the taxpayer when it **conducts a process “that substantially transforms constituent elements**, materials, or subcomponents into a complete and distinct eligible component...”

- ◆ Credit Amount: 45X (b)(1)(M) in the case of any applicable critical mineral, an amount equal to **10 percent of the costs incurred** by the taxpayer with respect to production of such mineral.
- ◆ Eligible Component: 45X(c)(6)(H) Cobalt which is –
  - ◆ (i) converted to cobalt sulfate, or
  - ◆ (ii) purified to a minimum purity of 99.6 percent cobalt by mass.

# Cobalt Landscape

							
<b>Location</b>	Arkansas	Alberta	Ontario	Arizona	Idaho, Finland	Missouri	Switzerland / DRC
<b>Primary product/service</b>	Copper/cobalt refinery	Nickel/cobalt Processing	Cobalt Hydroxide Processing & Recycling	Cobalt Hydroxide Processing	Mining, processing	Mining, Concentrate Production	Mining, trading
<b>Proximity to customers</b>	5	2	4	4	2	4	3
<b>Political climate</b>	5	5	3	5	3	4	3
<b>Market Position</b>	1	3	2	1	1	3	5

# Cobalt Replacement in Batteries



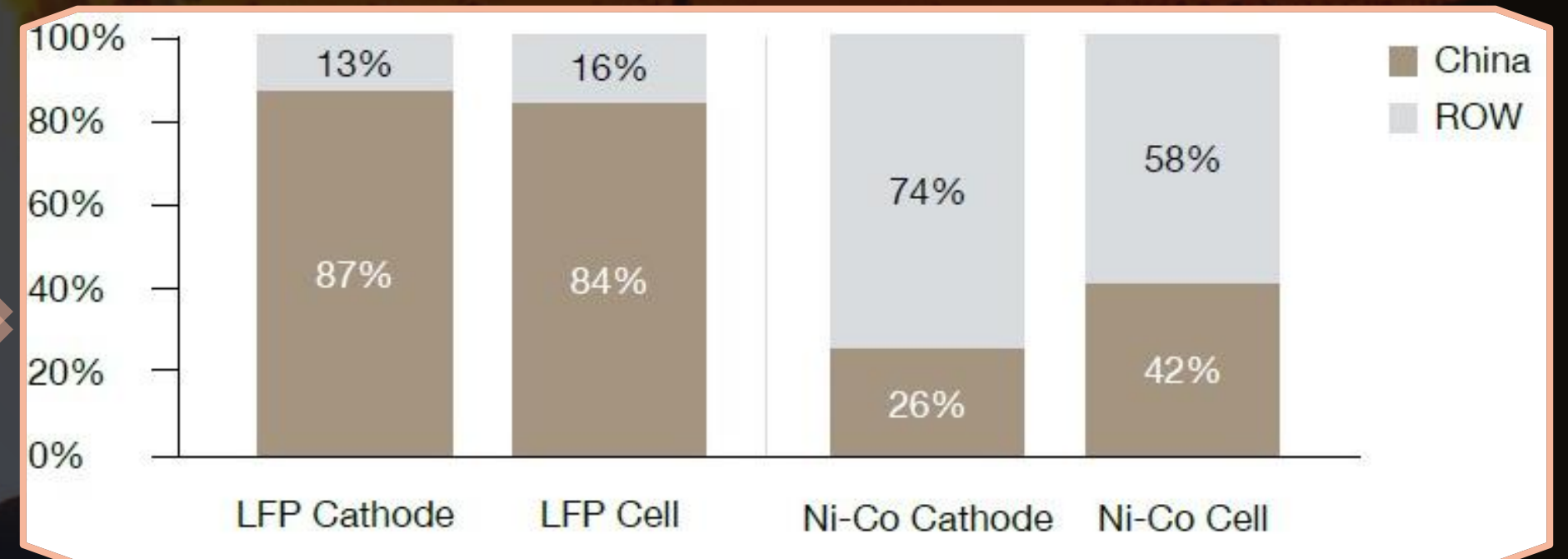
2024 Cell chemistry demand, top 5 OEMs – North America, GWh

Source: Cobalt Institute, Cobalt Market Report 2024

**Cobalt chemistries remain important in the west.** Nickel-Cobalt-Manganese (NCM) has been favored by OEMs with higher performance and higher range EVs, finding an optimal balance between energy density, power output and cost efficiency. This is particularly the case for North America where range is a higher priority.

Cobalt remains an important battery raw material globally but faces pressure in the battery supply chain from the following:

- ◆ Cost – The **most expensive battery raw material on a unit basis**. However, declining cobalt prices have supported cell cost competitiveness in the last year.
- ◆ Energy density – Efforts to increase energy density, primarily by shifting to higher nickel intensity. However, there has been a shift in this trend, as **Cobalt has proven vital for long-term safety and stability**.
- ◆ Responsible sourcing and sustainability considerations – particularly from DRC and increasingly Indonesia.



Share of 2024-30 cathode and cell growth by region, %

Source: Cobalt Institute, Cobalt Market Report 2024