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Perspective on Solutions for the Energy and Materials Transition

Draft document

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A number of solutions will need to be put in place to avoid large supply-demand imbalances

Supply-side enablers



~ **USD 3.3 tn**
investment until 2030¹

CAPEX

High levels of capital needed fast; Accessible project financing to be secured (many arrangements beyond Debt or Equity)



~ **500k FTEs**
additional in 2030²

People

Sufficient availability of contractors and specialists; social license to operate



6-16 years
from exploration to first production³

Lead time

Efficient regulation; shortened lead times; fast permitting



400 TWh
additional electricity requirement in 2030⁴

Electricity requirement

Sufficient electricity to support the pathway to net zero, including green electricity "Ultra Low Environment Footprint" for new projects

3 crucial elements

Speed – Investments, people, projects/ permitting, renewables

Agility – Strategic and operational agility and modularity for new metals/ technologies while solving issues (e.g., new battery chemistries)

Focus – Concentrated allocation of funding and resources; New green technologies and skills to ensure social acceptability

Demand-side enablers



Long term contracts

Long term contracts providing security of supply and funding, and derisking expansions and capex



Material substitution

Substituting materials for given applications/ technologies to enable more easy and less costly and risky access



Application substitution

Substituting or adapting applications in case selected high cost or high risk materials can not be substituted



Metal intensity reduction and recycling

Decreasing metal content without significantly affecting performance

1. Cumulative mining, refining, and smelting project, exploration and sustaining CAPEX over the period (excluding coal)
 2. Labor required for mining, refining, and smelting of copper, lithium, nickel, aluminum, steel/iron ore
 3. Across commodities
 4. For mining, refining, and smelting of copper, lithium, nickel, aluminum, steel/iron ore; calculated based on demand growth

CAPEX – Around 3.3 trillion USD of cumulative investments will be needed in 2020-30 to meet additional material demand

Estimate

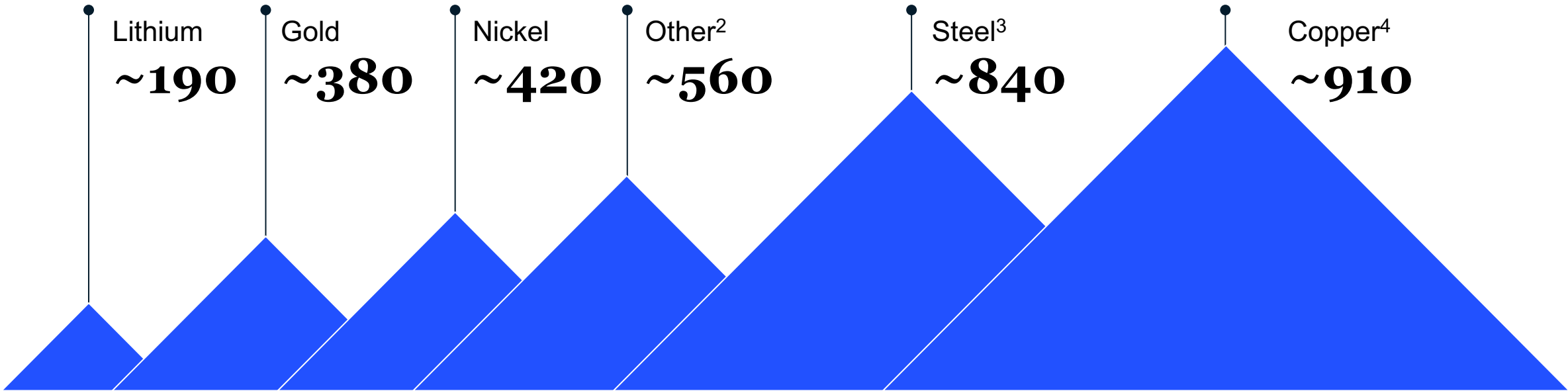


Global capex required to meet demand^{1,2} 2020-30, USD bn

Total CAPEX
~ **USD 3.3 tn**

Mining
~ USD 1.9 tn

Refining & Smelting
~ USD 1.4 tn







1. CAPEX estimate is based on global materials demand further acceleration scenario (incl. exploration, project and sustaining CAPEX); CAPEX includes mining, refining and smelting; Steel CAPEX considers decarbonization CAPEX; Closure rate of 2% p.a. assumed; Cost inflation of 10% p.a. assumed
 2. Other materials (~560 USD bn) include Antimony, Asbestos, Bauxite, Chromium, Lead, PGM, Phosphates, Potash, REE, Tar sands, Tin, Uranium, Zinc
 3. Incl. Iron ore and steel decarbonization (not including capex needed to produce Hydrogen used in DRI (~ 100-200Bn)) 4. Incl. Cobalt

CAPEX – Many alternatives possible to funding Mining projects beyond Debt or Equity (*Examples*)

Example of individual approaches to secure supply

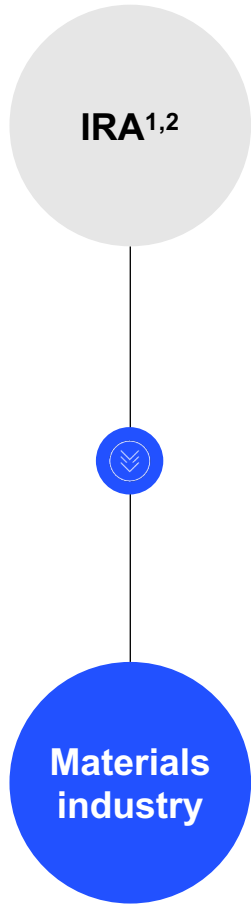
Approach	Examples for selected players
A Long term supply agreements for set volume and time	  <p>BMW Group signed supply contract with a forecast volume of EUR 540 mn with Ganfeng for sustainable lithium from mines in Australia</p>
B Co-funding/ownership through share in operations or JVs	  <p>BASF and Eramet signed agreement to assess development of nickel and cobalt refining with joint funding</p>
C Exploration JV and Strategic investment by Ma'aden and Ivanhoe Electric (electric and precious metals in KSA)	  <p>50/50 Exploration JV in the Kingdom of Saudi Arabia Ma'aden investing USD 126.5 mn in Ivanhoe Electric Common Stock</p>
D Streaming agreements with advance lump-sum payment in exchange for future production	  <p>Streaming agreement for Vale's Voisey's Bay cobalt mine with upfront cash of ~USD 390 mn and ongoing payments of 18% of cobalt spot price per cobalt delivered</p>

Example of alliances to secure supply

Options for collaborative approach	Rationale	Examples in other industries for alliances
Pool supply for large volume of European raw material demand	Increase negotiation power and potentially achieve preferential supply, price advantages etc.	 <p>Pooled procurement of health commodities esp. in low and middle income countries to jointly negotiate prices, & purchase and deliver products</p>
Jointly invest in exploration of existing mine	Limited total investment required per company and spreading of risk	 <p>Competitors Thales and Airbus Defense & Space jointly form JV UMS to secure access to semiconductor supply</p>
Jointly acquire mining companies or reservoirs	Limited total investment required per company and spreading of risk	 <p>Audi, BMW, and Daimler jointly acquired map service from Nokia for EUR 3 bn in 2015 with each player covering a third of total cost</p>
Jointly set up streaming agreement with advance payment	Limited total investment required per company, spread investment as well as price volatility risk	 <p>12 major Oil and gas companies set up an alliance including a Climate investment fund to jointly invest USD 1 bn into low carbon solutions</p>

CAPEX – Changing regulatory landscape is incentivizing the development of local downstream and refining– *Example: US IRA*

As of January 2023²



EV tax credits in the US depend on price caps, income caps, and **battery sourcing requirements**:

- **Battery materials:** To qualify for EV tax credits, an increasing share of battery materials must be extracted and processed in countries with active US free trade agreements (*see details in appendix*)
- **EV batteries:** By 2029, all EV batteries must be produced in North America²

Materials production expected to geographically shift for some materials, while meeting IRA requirements can be challenging for other materials (Mn, Co, Graphite)

Announced US investments³ since IRA:

~USD 30 bn

~USD 12 bn
for **cell manufacturing**
(~160 GWh)

~USD 9 bn
for **battery material manufacturing** (>400 kt)

~USD 8 bn
for **EV assembly**
(~450k units)

Technology
3 minutes read · December 12, 2022 11:01 AM GMT+1 · Last updated a month ago
U.S. finalizes \$2.5 billion loan to GM, LG battery joint venture
By David Shepperton

The new GM taken March

More electric SUVs, locally produced - that's what VW is planning in the USA
Volkswagen wants to double its market share in the USA by 2030. The new boss Pablo Di Si relies on new electric SUV models that are larger than in Europe.
Helio Hoteremann
12/12/2022 - 4:00 a.m. · Leave a Comment · shared twice

German car industry calls for European policy to counter US subsidies
Car lobby chief floats creation of EU agency focusing on supply of raw materials

China is becoming an Achilles heel for the German car industry, which relies heavily on the country's rapidly growing middle class for sales © REUTERS

1. IRA = Inflation Reduction Act, as of 1 Jan 2023

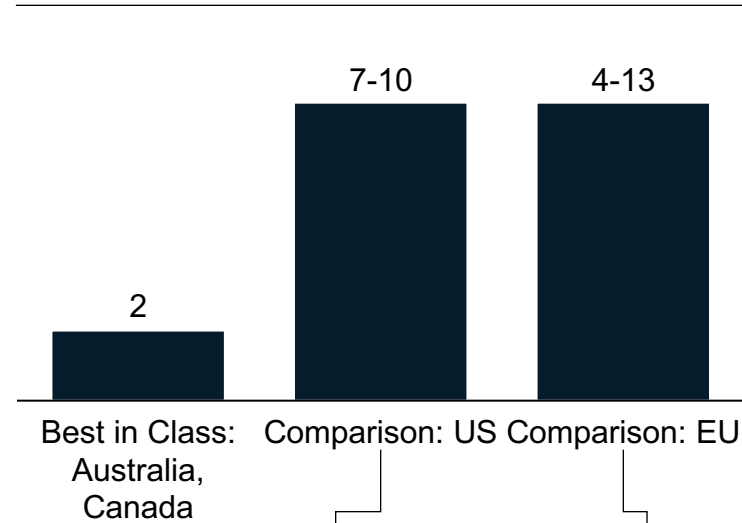
2. Treasury department issued interim clarification December 29, 2022, planned to issue final clarification in March 2023; Until guidance is finalized in March there are no battery content requirements applied

3. August 2022 - January 2023

Lead time – Importance of efficient regulation and permitting

Illustrative

Length of permitting process, years



Stringent environmental standards backed by an efficient process averaging 2 years

Can factor in 30 or more federal, state, and local regulatory processes

Large range, limited data Target of 3-5 years under the EU CRMA permitting framework¹

Examples

US: Taseko Mines' Florence Copper project in Arizona: >7 years to reach a permitting decision (Florence Copper, inherited by Taseko through its acquisition of Curis Resources in 2014, received final permitting approvals in 2022, with construction beginning soon thereafter)

US: Hudbay Minerals' Rosemont Copper project in Arizona: 12 years to reach a permitting outcome, running from 2007 to 2019 (project initially permitted in 2017, with those permits being overturned in 2019 and forcing a redesign of the operation)

EU: LKAB Rare Earths Oxides development (largest deposit in Europe) expected to take up to 15 years to launch²

Fraser Institute's 2021 survey of mining companies: Policy factors determine approximately 40 percent of respondents' investment decisions

"If a project starts with all the permits and three years later they stop it because someone else thinks differently, then there is legal uncertainty and it means that many projects are not going to be carried out." (Ricardo Ramos, CEO of SQM)³

"We know that permitting was instituted for good reasons and creates really valuable ways of improving and bettering the environment... One of the huge challenges to the energy transition is the barriers to deployment ... things like the length of time it takes to get a permit." (US Secretary of Energy Jennifer Granholm)⁴

"It's becoming more difficult around the world to get permits to mine or security for the large, upfront investments that are part of a mining operation." (Roland Harings, CEO of Aurubis)⁵

1. European Critical Raw Materials Act
 2. Reuters
 3. "Mining projects stuck in Chile's permitting bureaucracy", Bnamerica, March 13, 2023
 4. "Protracted permitting process at odds with energy transition", Andrea Hotter, FastMarkets, April 11, 2022
 5. "Protracted permitting process at odds with energy transition", Andrea Hotter, FastMarkets, April 11, 2022

Source: MineSpans, Press search; Company announcements

Long term contracts – Lithium examples ranging from long-term offtake agreements to full equity investments

	OEM/ cell manufacturer	Year of deal (start)	Location of asset	Source	Product	Agreement	Investment	Details	Estimated cost of asset, 2021 (2030)	Price for lithium product
Long-term offtake agreement	STELLANTIS CONTROLLED THERMAL RESOURCES	2022		Geo-thermal brine	Hydroxide	Offtake	None	25 ktpa over 10 years	(~6.5 USD/ kg)	N/a
	Ioneer Ford	2022 (2025)		Clay	Carbonate/hydroxide	Offtake	None	7 ktpa for 5 years	(~8 USD/ kg)	Price formula, adjusted quarterly
Long-term offtake agreement with prepayment	gm Livent	2022 (2025)		Brine	Hydroxide	Offtake with prepayment	198 mUSD	6 years, to be 100% sourced from US sites	~7.8 USD/ kg (~8 USD/ kg)	Price formula with the prepayment deducted
	EUROPEAN LITHIUM	2022 (2026)		Hard rock	Hydroxide	Offtake with prepayment	15 mUSD prepayment	9 ktpa for 6 years (50 kt total)	(~12.4 USD/kg)	Spot price (FastMarket) + discount
	TESLA Yuhua	2020 (2021)		Hard rock	Hydroxide	Offtake with prepayment	630-880 mUSD	12.6 – 17.6 ktpa for 5 years	~7 USD/ kg (~12.8 USD/ kg)	Indicating price of 8.4-11.7 USD/ kg
Investment plus offtake agreement	Ford Liontown	2022 (2024)		Hard rock	Spodumene	Debt facility	300 mAUD (now ~900)	150 ktpa (~22 ktpa LCE) for 5 years	(~7.3 USD/ kg) ¹	Price formula based on market prices for LiOH
	STELLANTIS VULCAN ENERGY	2022 (2026)		Geo-thermal brine	Hydroxide	Equity + offtake	76 mAUD (52 mUSD)	8% equity; 81 – 99 ktpa until 2035	(~6.5 USD/ kg)	Price formula
	gm Lithium Americas	2023 (2026)		Clay	Carbonate	Equity (in two equal parts depend. On court case)	650m USD	9.99% equity+ 100% offtake agreement (40 ktpa) for 10 years + ROFO for Phase 2	(~5.3 USD/ kg)	Price formula
Equity investment for ownership of supply	TOYOTA	2017		Brine	Carbonate (ARG), Hydroxide (JPN)	Equity + CAPEX investment	55 mUSD for equity 400 mUSD for CAPEX	25% ownership of volume <ul style="list-style-type: none"> Phase I. 17.5 kt (4.38 kt) Phase II. 42.5 kt (10.6 kt) 100% right as sales agent 	~8.5 USD/ kg (~6.2 USD/ kg)	Asset cost + ~3 USD/ kg for upfront investment ²
	BYD	2017		Brine - DLE	Carbonate	Equity + CAPEX investment	~365 mUSD CAPEX	49% ownership in 30ktpa asset	(~9.7 USD/ kg)	Asset cost + ~1.5 USD/ kg ²



Key takeaways

Amount of investment and resulting price impacts are different on a case-by-case basis

Most agreements will be based on price formulas with potential discounts given when prepayments or investments are part of the discussion

Negotiation power will vary depending on what type of supplier is being talked to

1. Assuming conversion to hydroxide at tolling refinery
 2. Assuming capex divided over 10 years

Long term contracts – Recent example: Mountain Pass and Sumitomo

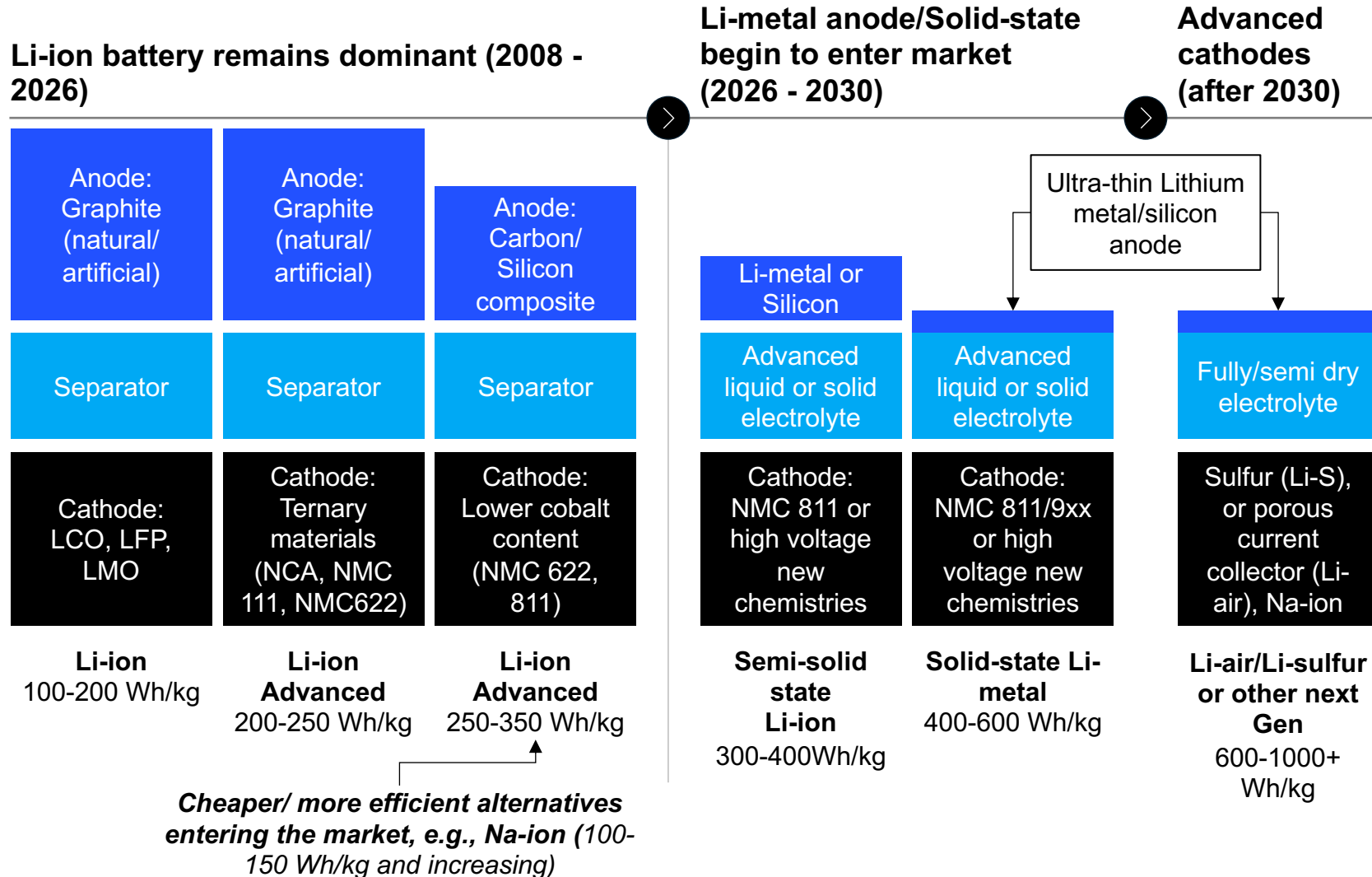
In **February 2023 Mountain Pass Materials and Sumitomo** announced an agreement under which **Sumitomo will be the exclusive distributor of NdPr oxide from Mountain Pass to Japanese customers** (key inputs to electrification including electric vehicles, wind turbines, other electronic devices). In addition, the companies will collaborate on the supply of rare earth metals and other products

This agreement will **diversify rare earth supply into Japan** away from only China, strengthening a critical supply chain into Japan's manufacturing sector

Sumitomo pioneered trading and distribution of rare earth materials in the 1980s, engaging in exploration, development, production, and trading activities globally

The Mountain Pass facility is the largest source of rare earth production in the Western Hemisphere, operating under U.S. and California environmental regulations. It is currently expanding its manufacturing operations downstream and this agreement helps to **stabilize funding and derisk expansions**

Material substitution – Example: Evolution of new battery chemistries (*Example high-level roadmap*)



Metal intensity reduction and recycling – Supply of recycled materials expected to increase significantly in the coming decade

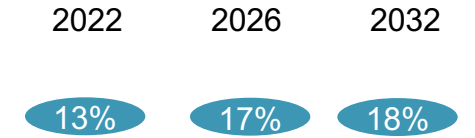
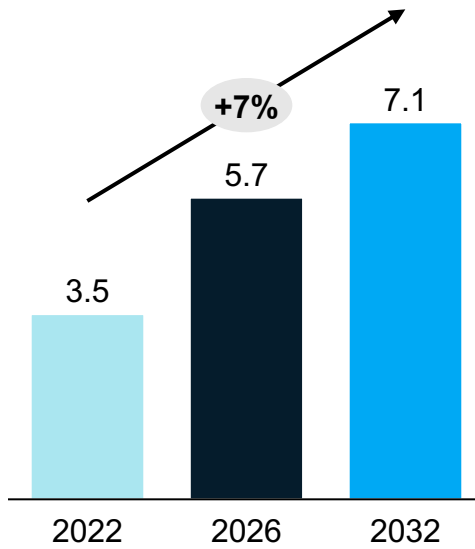
High Case Supply Scenario

CAGR

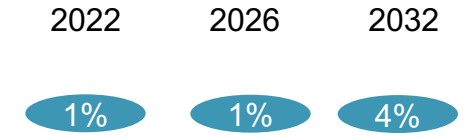
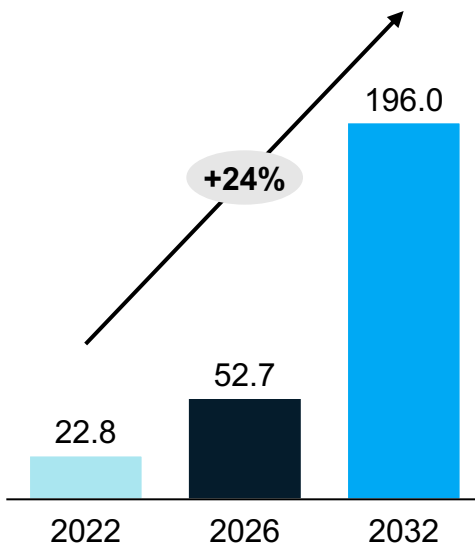


Recycled material, metal contained

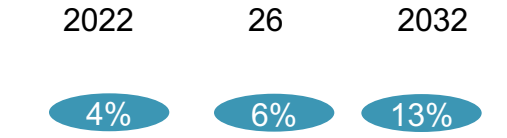
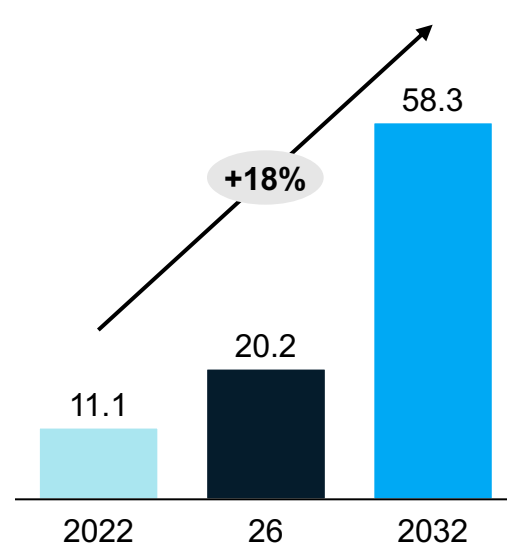
Copper, Mt



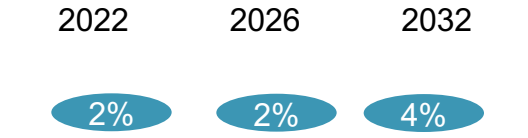
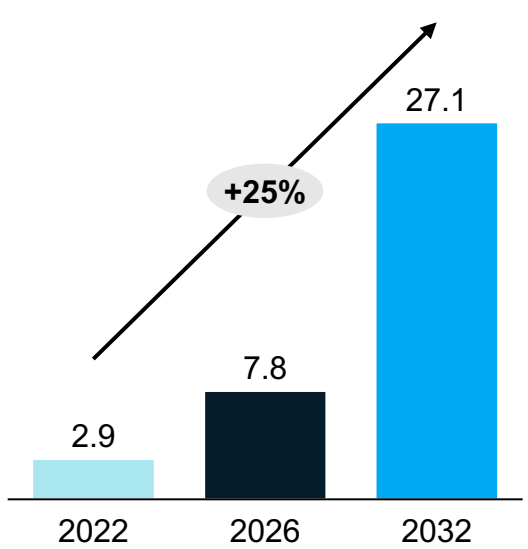
Nickel, kt



Cobalt, kt



Lithium¹, kt



Part of consumption covered by recycled volumes

1. Lithium LCE (Lithium Carbonate Equivalent)
Source: MineSpans