Minerais para Materiais Críticos e para Transição Energética

Tendências de Mercado e da Indústria

X SIMEXMIN

Jack Bedder, Nils Backeberg e Márcio Goto

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PROJECT BLUE

CRITICAL MATERIALS AND ENERGY TRANSITION INTELLIGENCE

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KEY CRITICAL MATERIALS COVERED IN THIS PRESENTATION

- **Outlook for demand:**
  - Niobium
  - Vanadium
  - Manganese
  - Fluorspar
  - Rare Earths
  - Iron ore
- **Short term analysis and prices:**
  - Graphite
  - Lithium
  - Cobalt
  - Chromium
- **Energy Transition Sectors:**
  - Batteries

THE NIOBIUM SUPPLY CHAIN IS EXPECTED TO DIVERSIFY AWAY FROM STEEL AS ITS MAJOR END USE, WITH CBMM COMMITTING TO EXTENSIVE R&D…

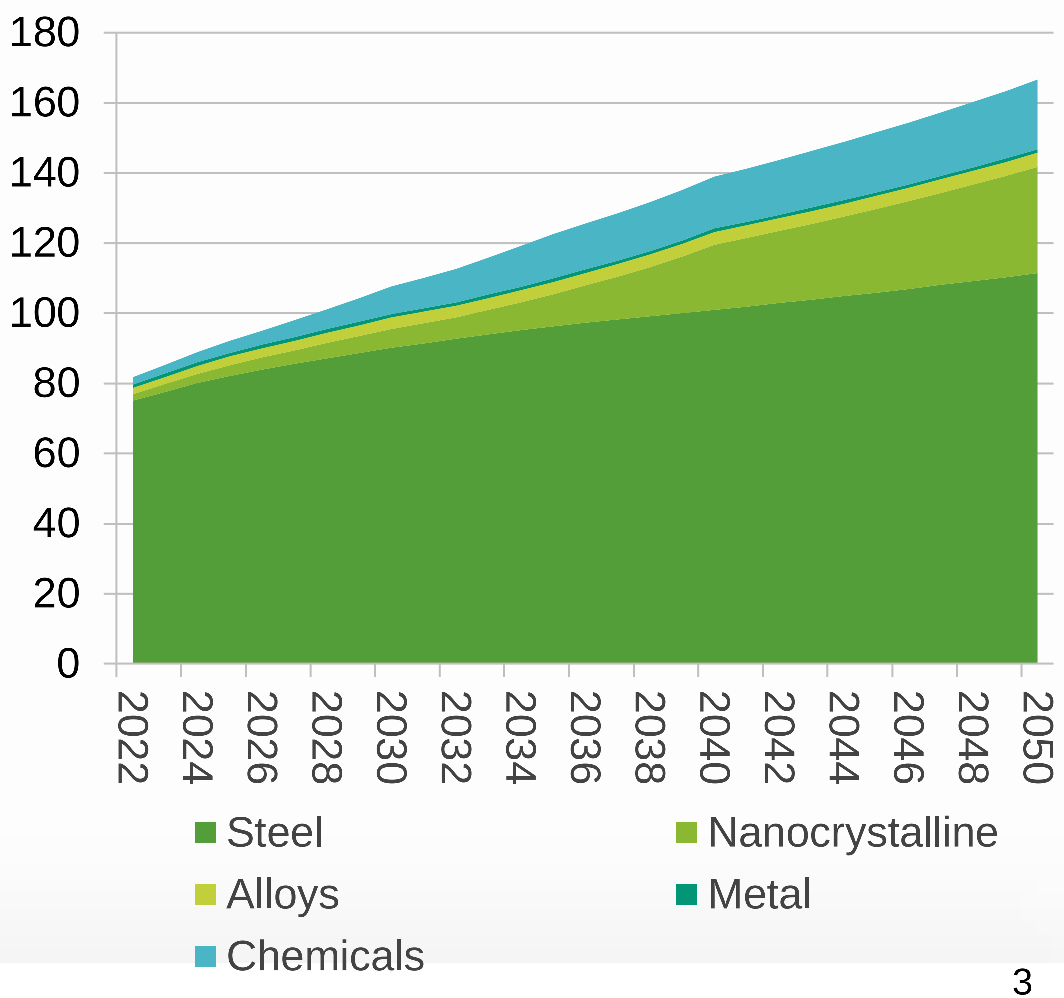
Simexmin X Simpósio Brasileiro de Exploração Mineral X Brazilian Symposium on Mineral Exploration

- Underpinned by long-term steel demand growth and increased intensity of niobium use in steel, niobium demand from the steel sector will increase steadily over the period to 2050.

- But upside comes from Nb's potential use in lithium-ion batteries – CBMM intends the battery market to account for as much as 25% of its revenue by 2030.

- Project Blue sees further upside in nanocrystalline materials, used to magnetically convert and control electricity. Here ferroniobium is used as a feedstock.

Outlook for niobium demand (kt)



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THE VANADIUM MARKET MAY BECOME A BIFURCATED MARKET OVER THE YEARS AHEAD, WITH DIVERGING STEEL AND BATTERY SUPPLY CHAINS

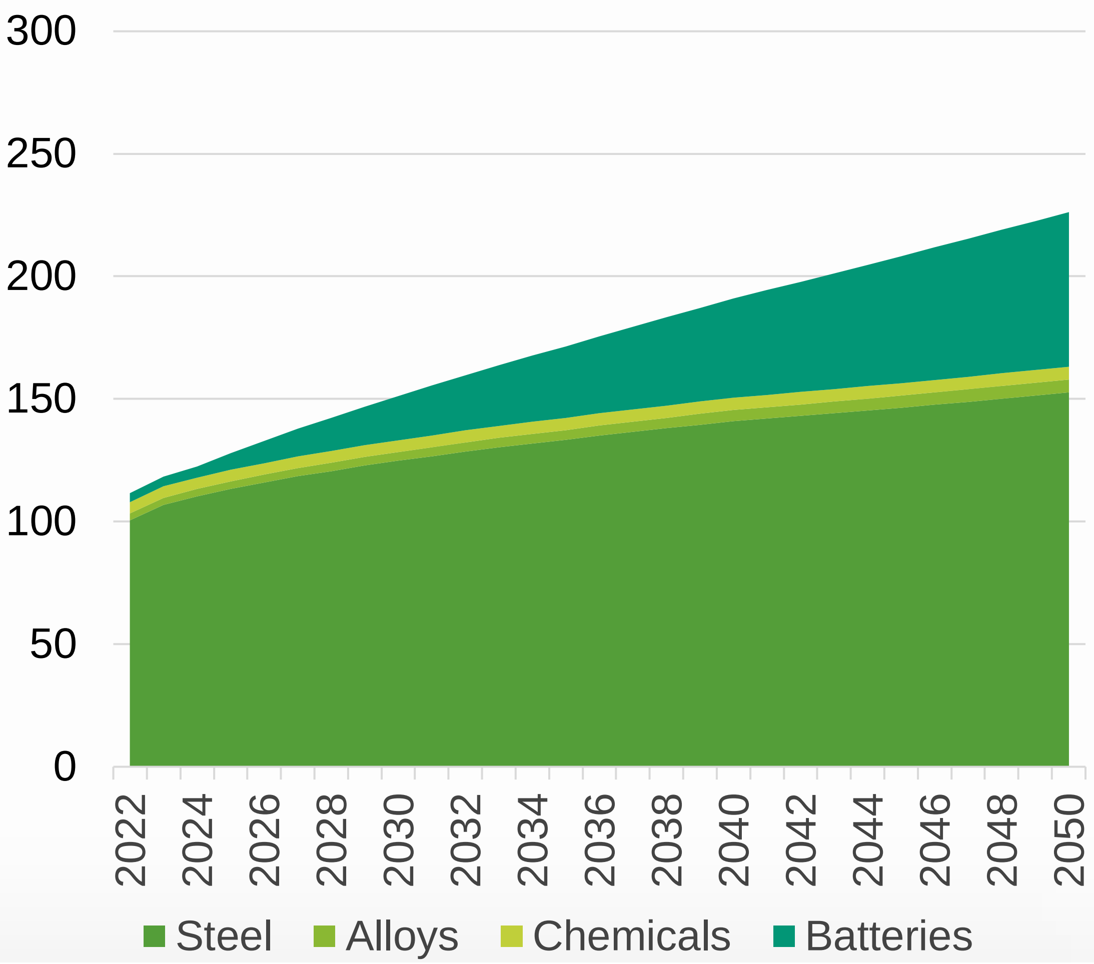
- Vanadium will see modest growth in demand from the steel sector through higher intensity of use.

- The growth of Vanadium Redox Flow Battery (VRFB) could see vanadium become a bifurcated market over the years ahead, with diverging steel and battery supply chains.

- By 2050, the VRFB market accounts for 30% of total vanadium demand in our base case. This new demand will require electrolyte from new projects, most of them unknown at this stage.

- Project Blue believes that the vast majority of the vanadium demand for VRFBs will come from China.

Outlook for vanadium demand (kt)

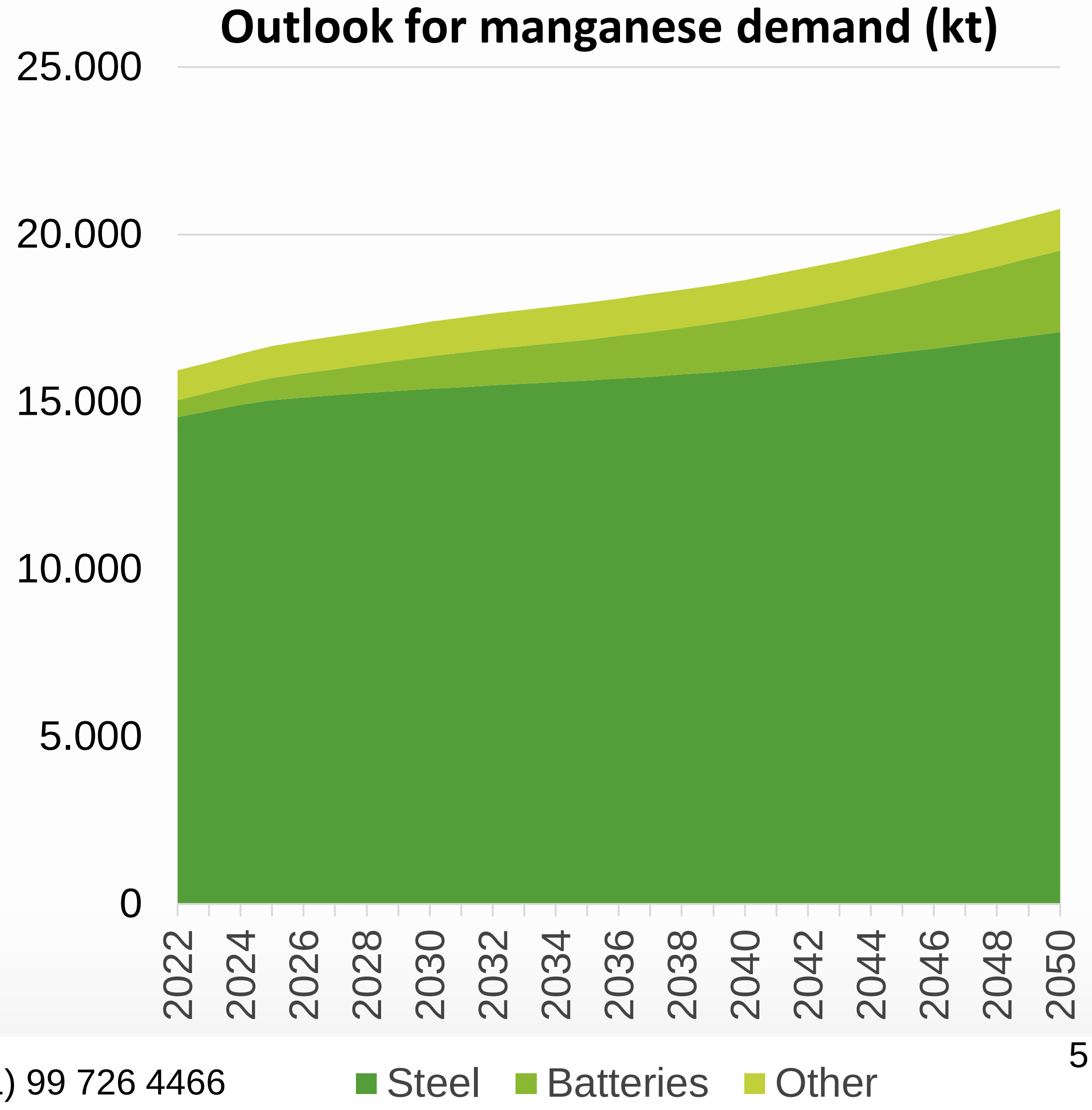


THE MANGANESE MARKET WILL ALSO BE RESHAPED BY BATTERY TRENDS, ALTHOUGH WILL REMAIN PRINCIPALLY A BULK STEEL MARKET

- All steel production uses manganese and steel will continue to be the main use for Mn over the years ahead.

- However, Mn is used in a wide number of important Li-ion cathodes used in EVs and energy storage. This includes the next-generation of high-nickel/manganese batteries which CATL, Tesla, VW etc. suggest will be critical to their output.

- At present most Mn sulphate (used in batteries) production is in China, so there is an opportunity for ex-Chinese projects to enter production and supply Western precursors and cathode plants.



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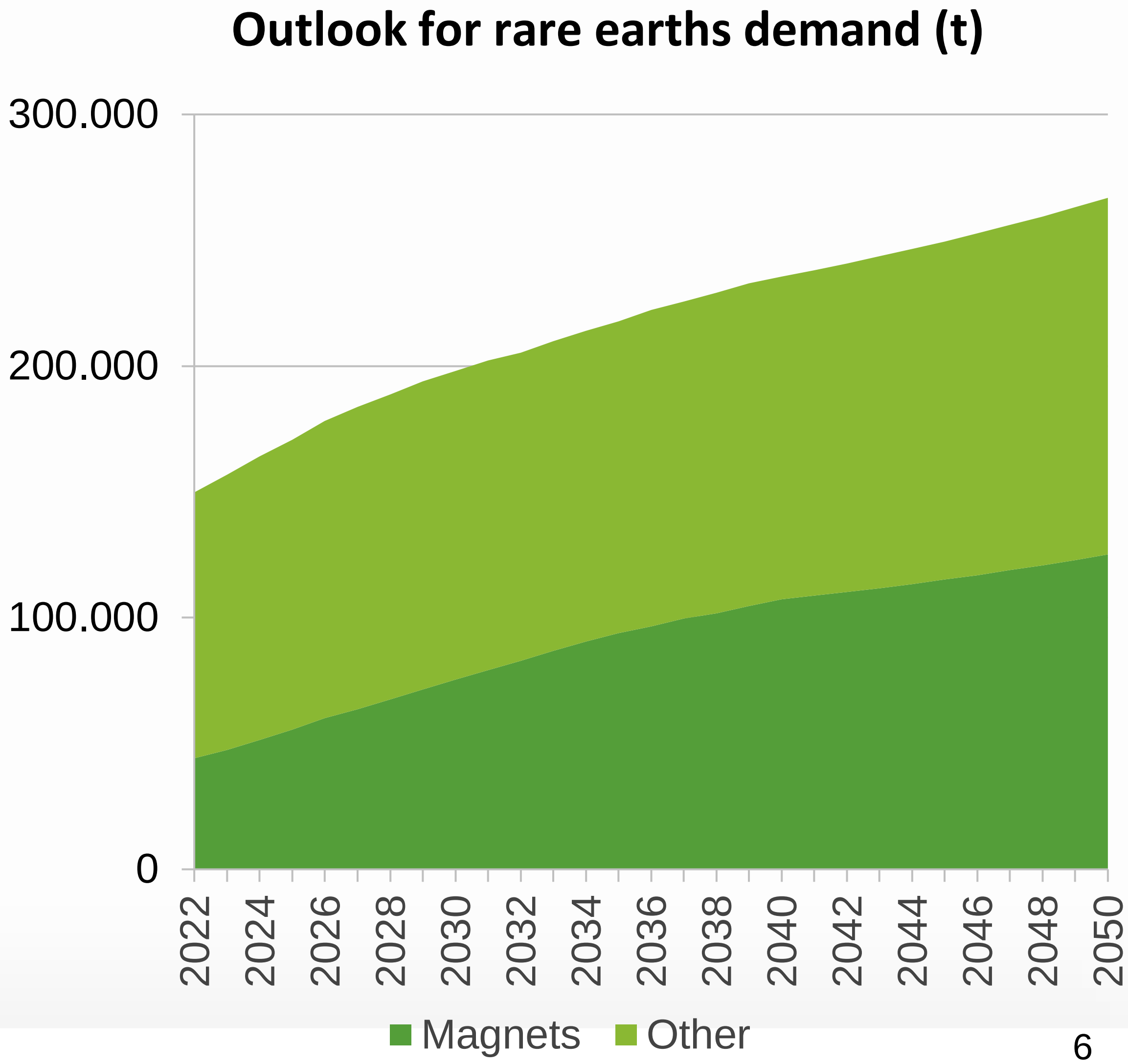
THE RARE EARTHS MARKET HAS PIVOTED TOWARDS HIGH-POWER MAGNETS USED TO IMPROVE ENERGY EFFICIENCY IN ELECTRIC VEHICLES, WIND TURBINES AND ENERGY-SAVING APPLICATIONS

- Rare earth elements (REEs) are a suite of 15 elements that naturally occur together and are difficult to separate. As a result, their supply-demand balances are uniquely intertwined.
- Some of the rare earths (mainly neodymium – Nd) have unique magnetic properties that have led to the development of high-power magnets, known as NdFeB permanent magnets. These magnets convert energy into torque (e-motor) or vice versa (generator) and there are currently no competitive technologies available to match the benefits gained from rare earth magnets.
- Growth in new energy technologies, both in energy consumption and energy generation are all driving strong growth for high-power magnets, and as a result, rare earths.

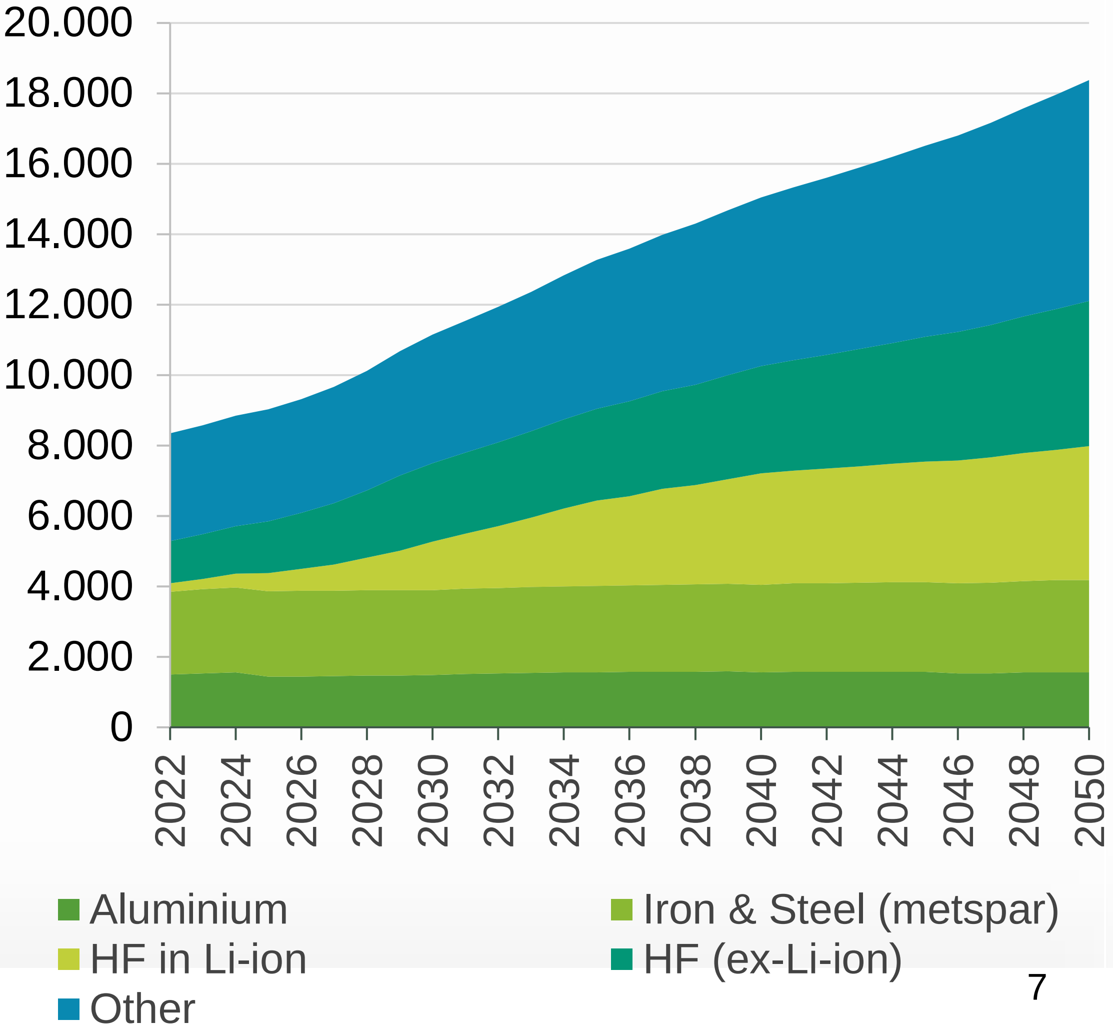


THE FLUORSPAR DEMAND IS SET TO DOUBLE OVER THE ENERGY TRANSITION PERIOD WITH COMPOUNDED EXPOSURE TO LI-ION BATTERY DEMAND GROWTH

- Fluorspar is split into metspar for metallurgical applications and acidspar for chemical applications. Generic industries for fluorspar include steel and iron (metspar) and aluminium and HF (acidspar). While each supply chain has gone through a period of tightening supply related to environmental suspensions in China, the interesting narrative for the compound has shifted to Li-ion batteries and EVs.

- HF is an essential feedstock for electrolytes and polyvinylidene fluoride (PVDF) used as binders, important components of Li-ion batteries. In addition, HF is used in natural flake graphite processing to produce a spherical graphite material, essential for manufacturing the current anode of lithium-ion batteries.

Outlook for fluorspar demand (t)

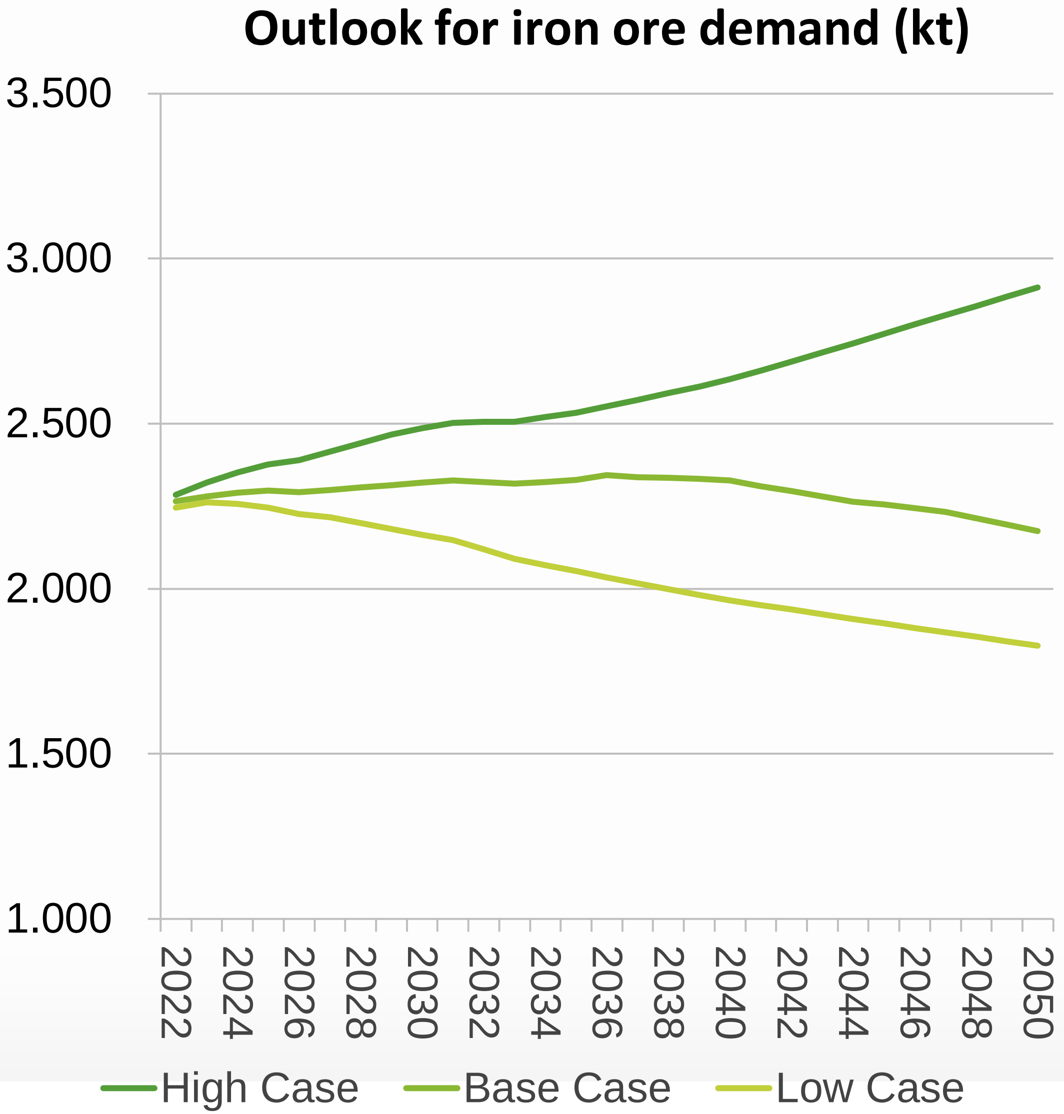


THE OUTLOOK FOR IRON ORE WILL DEPEND ON STEEL CONSUMPTION TRENDS AS WELL AS STEEL DECARBONISATION TRENDS, GREEN STEEL TRENDS ETC.

- Project Blue's base case for iron ore consumption assumes that the lobal BF/BOF to EAF ratio will gradually decline from 70:30 in 2022 to 50:50 in 2050. Iron ore consumption will drop s more scrap is used, although iron ore consumption from DRI will increase.

- The low case, besides taking into account a lower steel production scenario, assumes a faster shift to EAFs with a BF/BOF to EAF ratio of 45:55 in 2050. Iron ore consumption would drop to 1827Mt in 2050.

- Our high-case scenario, besides taking into account a higher steel production, assumes that the BF/BOF t EAF ratio drops only marginally to 65:35 level. he implied iron ore consumption would be 2,915Mt in 2050.



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SHORT TERM ANALYSIS AND PRICES

Graphite

C

Last month's graphite prices

	Oct-22	M-o-M	Y-o-Y
Amorphous 80% >200mesh China (USD/t)	377	0.6%	18.8%
Flake 190 EXW China (USD/t)	523	6.1%	41.4%
Flake 194 EXW China (USD/t)	708	2.5%	37.0%
Flake 194 FOB China (USD/t)	858	4.6%	51.2%
Flake 199 EXW China (USD/t)	952	0.5%	8.8%
Flake 895 EXW China (USD/t)	1,209	-0.7%	7.0%
Spherical 99.95% China (USD/t)	3,082	-0.2%	20.5%
Expandable Graphite EXW China (USD/t)	1,985	-1.5%	1.8%

Source: Asian Metal Prices

What happened last month?

- Australia's Syrah Resources announced plans to expand its Louisiana graphite anode plant fourfold after being selected for a US$219.8M grant as part of US drive to boost the domestic EV supply chain.
- Panasonic has signed an MoU with Nouveau Monde Graphite to establish a supply chain in North America for graphite as anode-active material used in Li-ion batteries. The new partners rely on Mitsui for a feasibility study on graphite production in North America to come to a firm offtake agreement in H1 2023. Panasonic has yet to detail supply volumes or the financial scope of a possible deal.
- Northern Graphite announced the completed option to acquire a 100% interest in the Mousseau West graphite project through the payment of US$500k in cash and the issuance of 900,000 common shares of the company to the owners of the property. Northern also has the right to acquire a 2% net smelter royalty retained by the owners at any time upon the payment of US$1M.

SHORT TERM ANALYSIS AND PRICES

Simexmin
X SIMPÓSIO BRASILEIRO DE EXPLORAÇÃO MINERAL
X BRAZILIAN SYMPOSIUM ON MINERAL EXPLORATION

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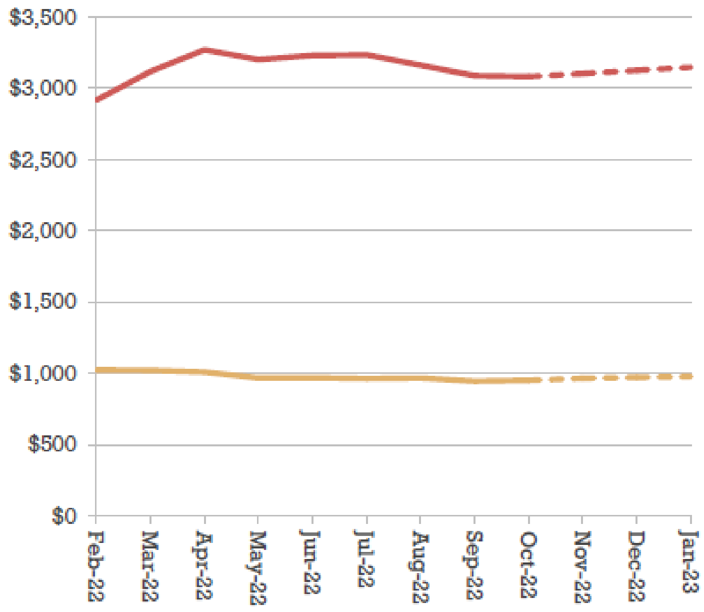
Graphite

C

Project Blue's three month outlook

	Nov-22	Dec-22	Jan-23
Spherical 99.95% China (USD/t)	3,104	3,126	3,147
Flake 199 EXW China (USD/t)	968	974	980

- Prices for spherical graphite (99.95%, EXW China) were roughly flat m-on-m for October in line with Project Blue's expectations. Prices are forecast to hold their own with modest price increases forecast over the next three months.
- Prices for flake graphite, 199, grade bottomed out in September and increased in October in line with cut output in China. Prices are forecast to increase modestly over the next three months, but sentiment in China remains weak with a downside to any short-term price recovery.



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SHORT TERM ANALYSIS AND PRICES

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Lithium

Li

Last month's lithium prices

	Oct-22	M-o-M	Y-o-Y
Spodumene Li2O 6% China (USD/t)	5,739	9.1%	359.1%
Lithium Carbonate 99% China (USD/t)	73,680	6.5%	171.6%
Lithium Carbonate 99.5% China (USD/t)	75,714	6.2%	164.3%
Lithium Carbonate 99.5% Europe (USD/t)	74,806	2.3%	174.5%
Lithium Carbonate 99.5% S. America (USD/t)	66,406	2.6%	188.1%
Lithium Hydroxide 56.5% China (USD/t)	71,020	6.5%	162.6%
Lithium Hydroxide 56.5% Magnet China (USD/t)	73,662	6.2%	161.6%
Lithium Hydroxide 56.5% Magnet Korea (USD/t)	77,644	4.1%	184.4%

Source: Asian Metal Prices

What happened last month?

- Lithium Americas will separate its North American and Argentine business units into two independent lithium-focused public companies by end-2023.
- Canada ordered three Chinese companies to divest their stakes in Canadian critical mineral companies after a defence and intelligence review concluded that the investments posed a threat to national security. Sinomine (Hong Kong) Rare Metals Resources has been told to exit its stake in Power Metals; Chengze Lithium International to divest its stake in Lithium Chile; and told Zangge Mining Investment (Chengdu) to unwind its investment in Ultra Lithium.
- Nio plans to invest US$82M in Greenwing Resources, an ore mining company headquartered in Australia which owns the San Jorge lithium project in Argentina.

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SHORT TERM ANALYSIS AND PRICES

Lithium

Li

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Lithium

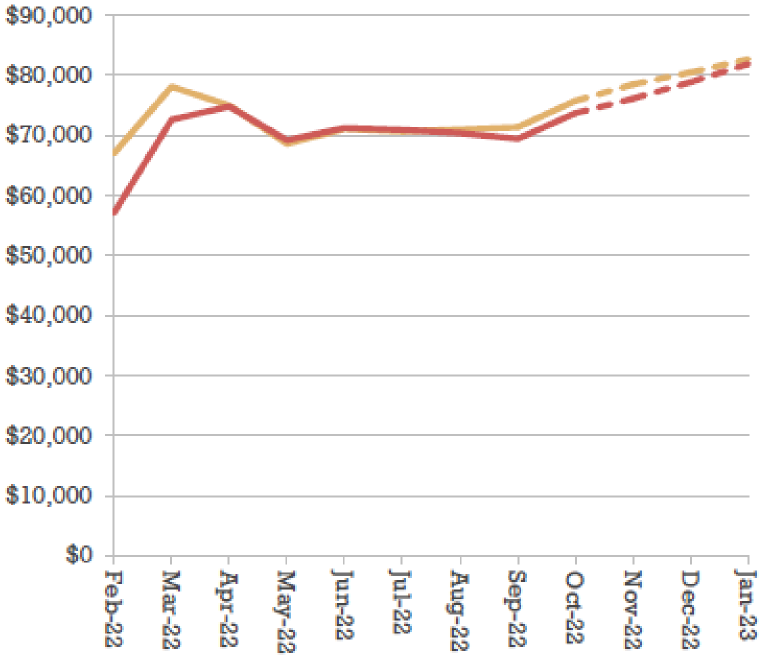
Li

Project Blue's three month outlook

	Nov-22	Dec-22	Jan-23
Lithium Carbonate 99.5% China (USD/t)	78,432	80,431	82,687
Lithium Hydroxide 56.5% Magnet China (USD/t)	76,079	78,822	81,860

- Lithium prices jumped higher in October having stayed in a narrow range between June and September. We expect more upside over the coming months with lithium bucking the trend seen across most raw materials.

- Elevated costs (especially spodumene) will continue to support prices, while royalties will play a considerable factor in Chile. On the demand side, growth forecast remain bullish and the scramble amongst buyers to secure access limited available units continues.



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SHORT TERM ANALYSIS AND PRICES

Cobalt

Co

Last month's cobalt prices

	Oct-22	M-o-M	Y-o-Y
Cobalt concentrate 6-8% CIF China (USD/lb Co)	13.05	-0.8%	-35.3%
Cobalt intermed. 20-30% CIF China (USD/lb Co)	15.35	-0.6%	-33.0%
Cobalt tetroxide 73.5% China (USD/lb Co)	20.79	-1.3%	-29.5%
Cobalt sulphate 20.5% China (USD/lb Co)	19.25	0.0%	-35.6%
Cobalt metal >99.8% China (USD/lb Co)	22.10	-1.3%	-19.8%
LME cobalt (USD/t)	51,510	0.0%	-6.1%

Source: Asian Metal Prices

What happened last month?

- In the USA, Jervois Global officially opened its Idaho Cobalt Operations (ICO) mine site near Salmon.
- Trafigura and EVelution Energy announced plans to build a 7ktpy facility for cobalt sulphate in Arizona.
- CATL will take a 24.68% indirect stake in CMOC via a capital boost and stake transfer, according to a company filing on the Shenzhen Stock Exchange. As a result, CATL would become CMOC's second-largest shareholder after Shanghai-based private equity firm Cathay Fortune Corp, which holds 30.19%.
- GM will invest up to US$69M in Queensland Pacific Metals for the development of its proposed Townsville Energy Chemicals Hub (TECH) Project in Northern Australia.

SHORT TERM ANALYSIS AND PRICES

Cobalt

Co

Last month's cobalt prices

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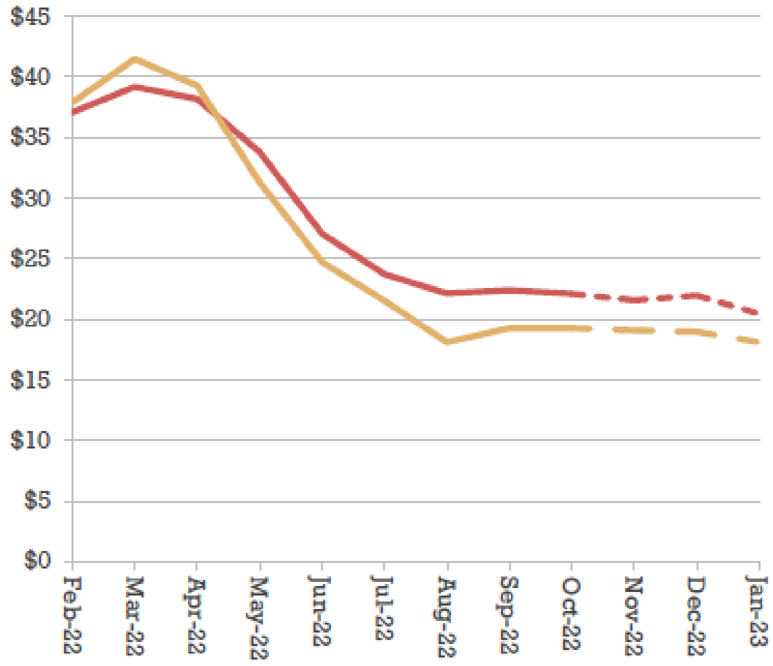
Cobalt

Co

Project Blue's three month outlook

	Nov-22	Dec-22	Jan-23
Cobalt metal >99.8% China (USD/lb Co)	21.55	21.96	20.44
Cobalt sulphate 20.5% China (USD/lb Co)	19.07	18.95	18.09

- Cobalt prices have been pretty flat for three months, hovering around US$22/lb in China for metal. LCO demand remains subdued and the market is comfortably supplied in terms of intermediates, metal and chemical. Payables sit at around 60%.
- We expect prices to trend slightly down to year end but for rising demand to gradually work through inventories and incentivise more output. Aerospace demand, in particular, seems to be picking up while demand from portables is expected to recover in 2023.



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Chromium

Cr

Last month's chromium prices

	Oct-22	M-o-M	Y-o-Y
Chromite conc. 42% FOB South Africa (USD/t)	166	6.2%	16.8%
Chromite conc. 40% FOB South Africa (USD/t)	158	9.6%	19.2%
RSA chromite conc. 40% CIF China (USD/t)	226	10.8%	39.0%
Turkey chromite lump 40% CIF China (USD/t)	278	-2.2%	-6.7%
Charge chrome 52% EXW China (USD/lb Cr)	1.07	5.5%	-31.9%
Charge chrome 50% CIF China (USD/lb Cr)	0.92	1.2%	-29.7%
HC FeCr 60% WHS EU (USD/lb Cr)	2.37	-0.5%	76.2%
HC FeCr 60% WHS USA (USD/lb Cr)	2.67	-0.5%	107.8%

Source: Asian Metal Prices

What happened last month?

- Tharisa released quarterly production data showing co-production of platinum group metal up 2.3% y-on-y to 45.3koz (up 7.6% q-on-q) and chromite concentrates up 5.1% y-on-y to 416.2kt (up 6.8% q-on-q).
- Glencore and Merafe Resources, 79.5:20.5 JV partners of Glencore-Merafe in South Africa, released its Q3 2022 ferrochrome production statistic of 408kt, down from Q1 and Q2 production levels, but up 8.9% y-on-y for the quarter.
- Outokumpu announced a prolonged delay until end-Q1 2023 in restarting its third ferrochrome furnace at its Tornio plant in Finland. The company stated exceptionally high electricity prices as an unsustainable situation as an underlying factor.

SHORT TERM ANALYSIS AND PRICES

Chromium

Cr

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RSA chromite conc. 40% CIF China (USD/t)			
Turkey chromite lump 40% CIF China (USD/t)			
Charge chrome 52% EXW China (USD/lb Cr)			
Charge chrome 50% CIF China (USD/lb Cr)			
HC FeCr 60% WHS EU (USD/lb Cr)			
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Source: Asian Metal Prices

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Chromium

Cr

Project Blue's three month outlook

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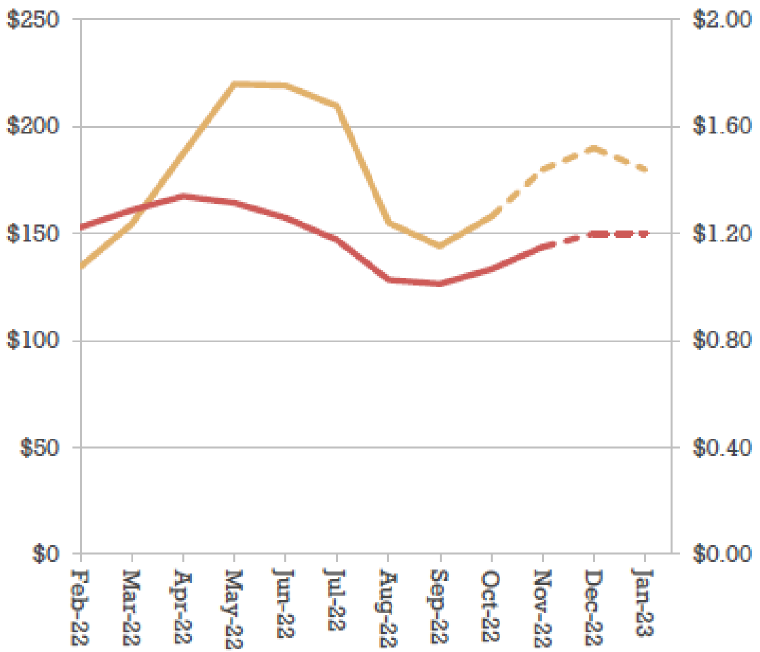
Chromite conc. 40% FOB South Africa (USD/t)	180	190	180
Charge chrome 52% EXW China (USD/lb Cr)	1.15	1.20	1.20



- Chromium prices have turned to an uptick. The uptick will be following some recovery in stainless steel demand in China, though prices are still far below the general cost structure.
- While European ferrochrome prices continue to decline, China's prices are below the cost of production, underpinning a sharp increase in prices over the last month. Prices could still rise further to equilibrate with the cost structure.
- Chromium ore prices have followed a more gradual uptick and with demand for ferrochrome returning will likely see further upside.

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Critical Materials Monthly

November 2022

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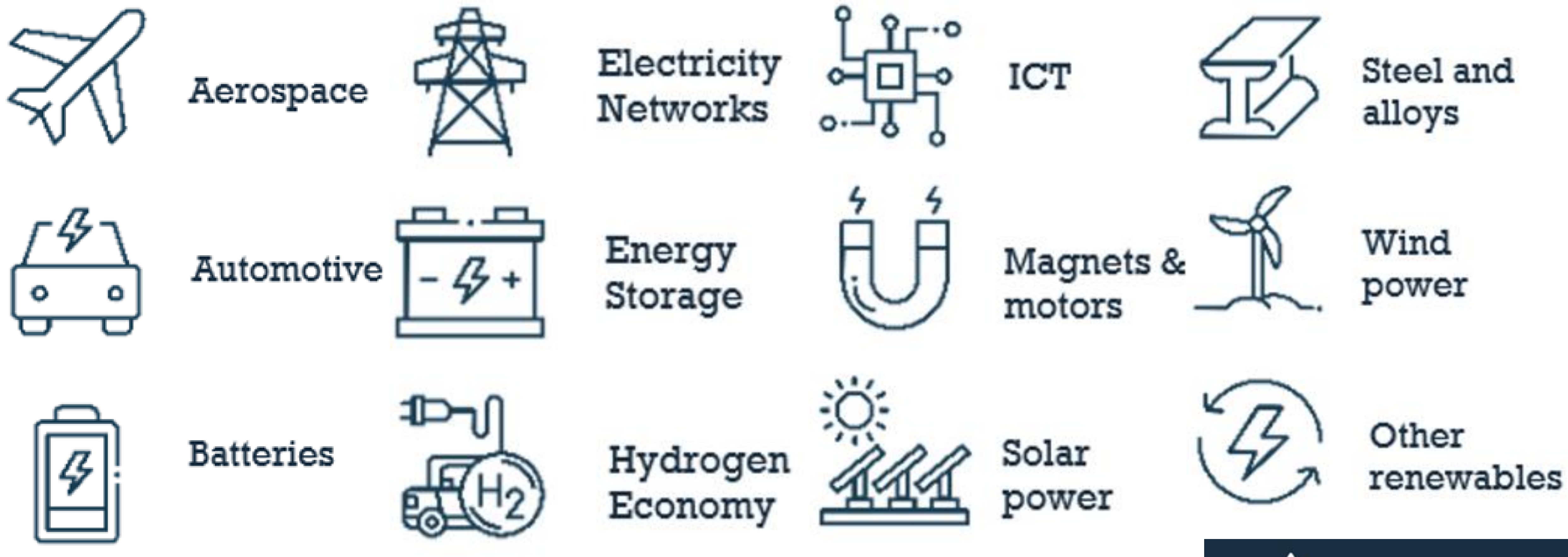
Table of Contents

Energy Transition Sectors



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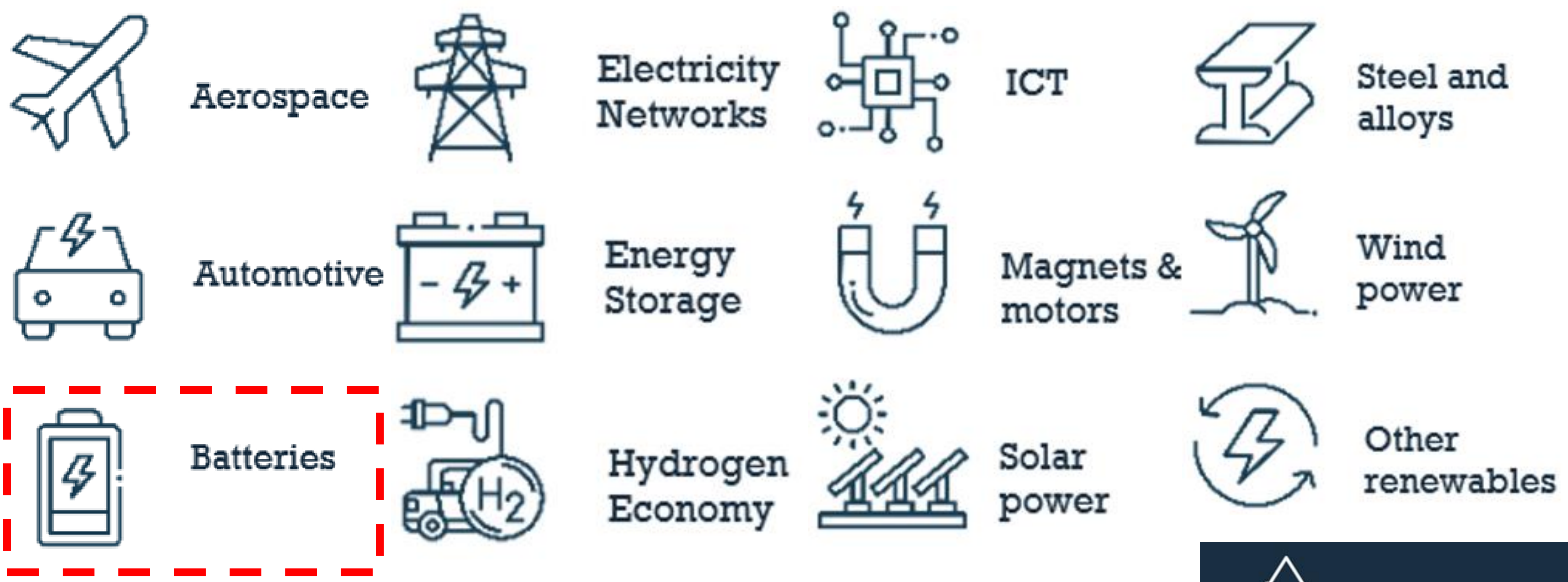
Energy Transition Sectors



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Batteries

What happened in October?

- Reports suggest that Britishvolt is in talks to divest its 93-hectare (230-acre) facility in Cambois, northern England, with Slovak battery manufacturer Inobat a potential suitor. Inobat has been evaluating European locations in the UK and Spain and may consider a merger or acquisition of Britishvolt as a potential route to secure new battery production capacity in Europe.

- Research from Pennsylvania State University has demonstrated a high-density electric vehicle battery that can be charged in around 10 minutes to offer a range between 200 and 300 miles. The latest battery prototype features an energy density of 265 Wh/kg, which could open up new possibilities in future electric vehicle design.

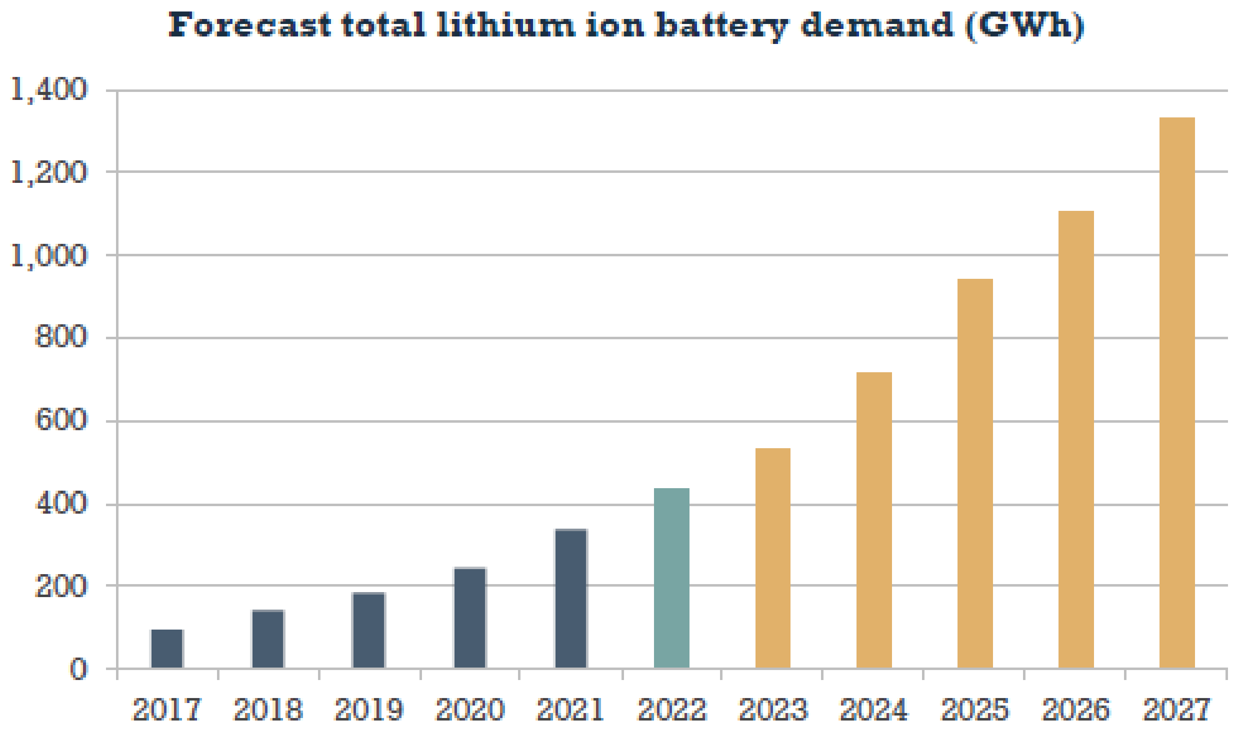
- Panasonic Energy began construction on a new lithium-ion battery manufacturing facility in De Soto, Kansas in the US. The faculty is focussed on accelerating manufacturing of "2170" cylindrical Li-ion batteries to serve domestic EV battery demand with a capacity of approximately 30 GWh per year.

Supply Chain Insight

US announces US$2.8Bn grants for EV batteries and materials

The Biden administration awarded US$2.8Bn of grants to boost domestic production of electric vehicle (EV) batteries and component materials across 12 states, in a bid to reduce the US reliance on supplies from China.
Albemarle is one of 20 manufacturing and processing companies receiving grants from the US Energy Department to boost domestic mining of lithium, graphite and nickel, and to build large-scale lithium processing, cathode and other battery material facilities, including recycling. These grants form part of the previously agreed 2021 US$1 trillion infrastructure bill.

Batteries



Lithium-ion battery demand is largely constrained by production capacity. Project Blue forecasts that total gigafactory production growth will allow demand to increase by over 200% between 2022 and 2027.

Critical Materials Outlook:

Key battery material demand challenges revert around constrained supply of battery-grade lithium in the medium term. Additional sourcing concerns relate to class I nickel, Russian nickel/cobalt, and DRC cobalt.

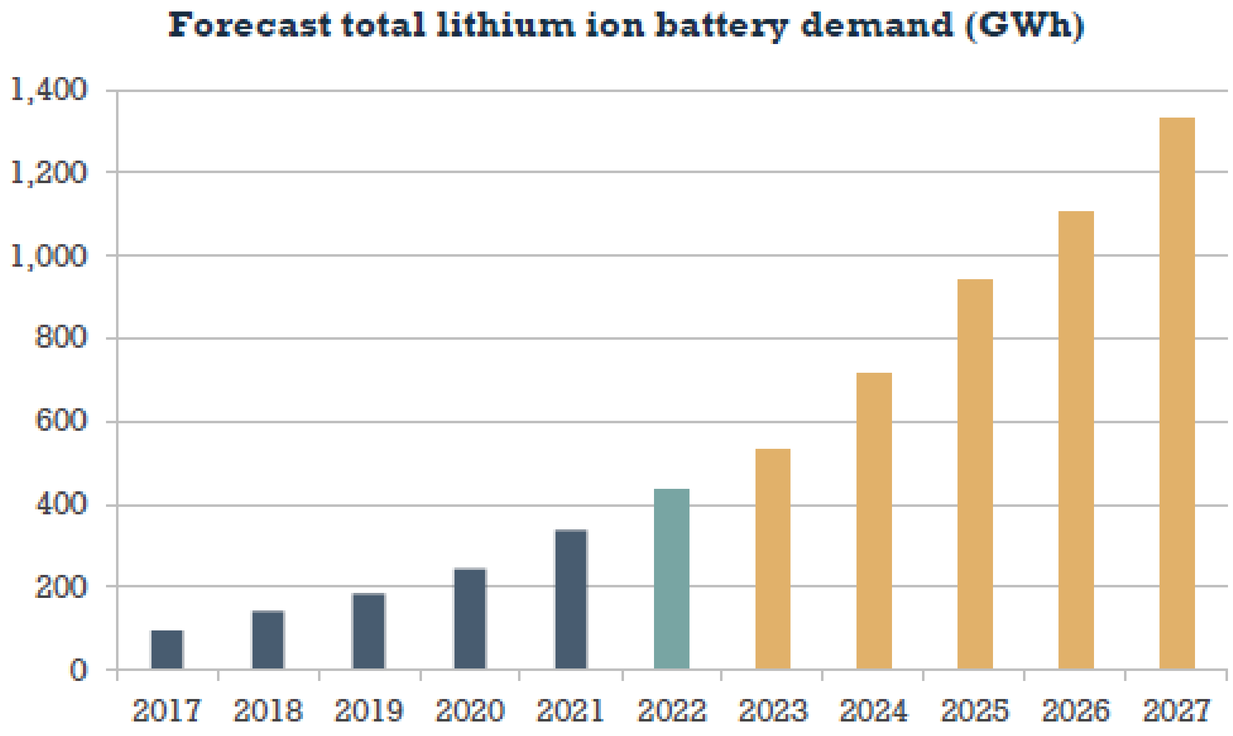
Geographical Outlook:

Battery/cathode production is concentrated in China, Japan and Korea. Future growth will be partly driven by new capacity in the USA and Europe, but questions remain as to where these plants can locally source feed.

Technology Outlook:

Key technology dynamics relate to anode/cathode chemistry technologies. Depending on EV type the high uptake LFP and concurrent move towards nickel-rich formulations remain the key short-term trends.

Batteries



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About Project Blue

Energy Transition will be raw material intensive. It will create unprecedented demand for critical materials, fundamental for renewable energy sources and other sustainable global sectors.

Project Blue provides market intelligence on energy transition supply chains and the critical materials that underpin them.

Our expert analysis is delivered through subscription services, consulting and events.

We are committed to analytical rigour, unbiased forecasting, and personal service.

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Government-focussed critical material strategy work

Events

"Blue Stream" videos available on Project Blue Online

"Blue Forum" networking events held around the world

marcio.goto@theprojectblue.com - (11) 99 726 4466

www.fla-conference.com

https://events.crugroup.com/copper/home

Acerto

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Agribusiness Intelligence for Latin America

www.acertolimited.com

Weekly Fertilizer Report | Brazil

INDEPENDENT MARKET ANALYSIS AND BENCHMARK PRICING

Consultor Economia Mineral
Treinamentos
Representações

Engenheiro de Minas (USP 1986) – MBA (FIA, 2004) -
Mestrando em Engenharia Mineral – PMI/EPUSP (2021>)

Especialista em Viabilidade de Minas (ENSM Paris 1999)

Ex-Multigeo, ex-Alcoa, ex-Camargo Corrêa, ex-ANM, ex-CRU e ex-Roskill (análises e projeções de mercado e custos)

Obrigado!

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