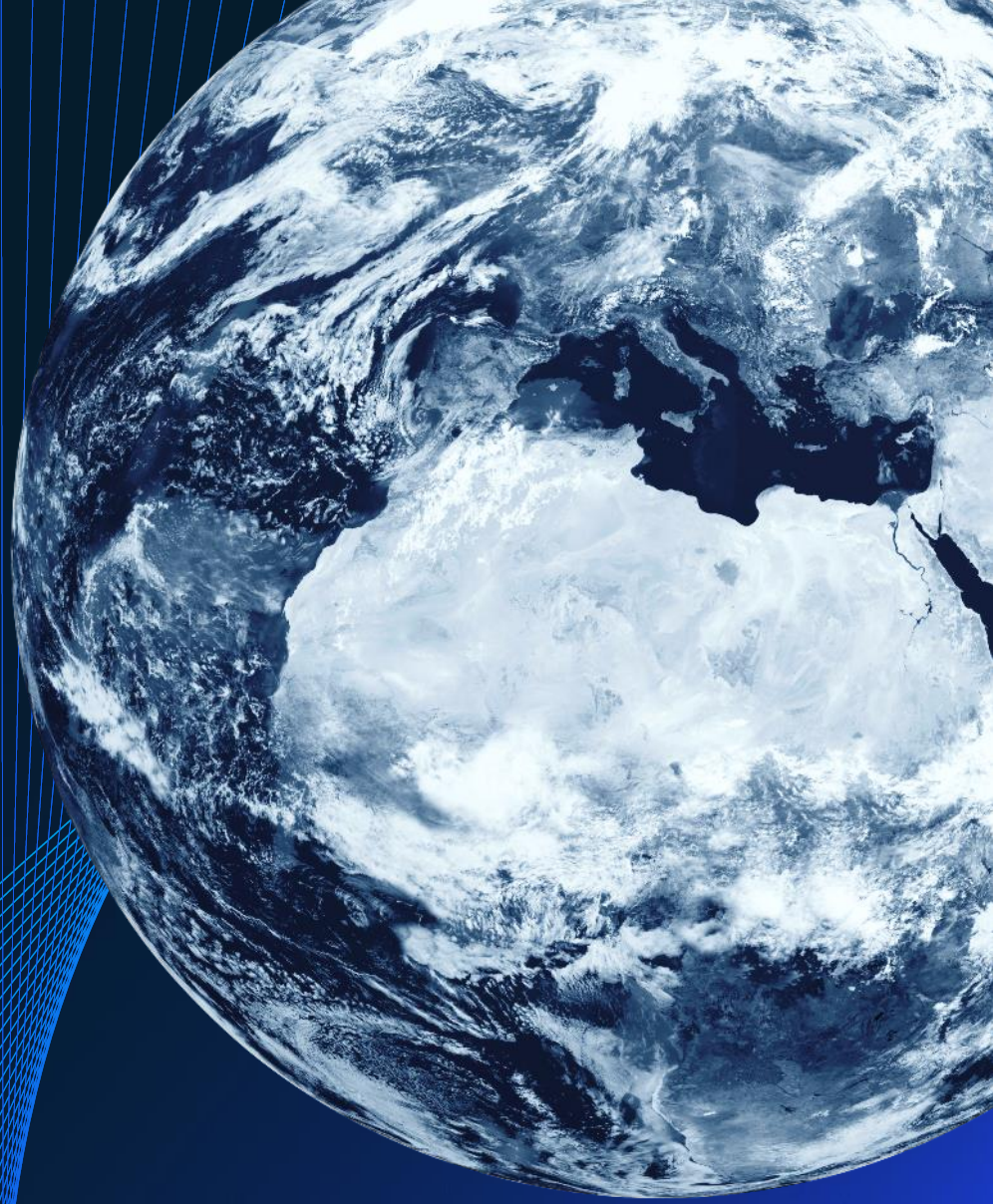
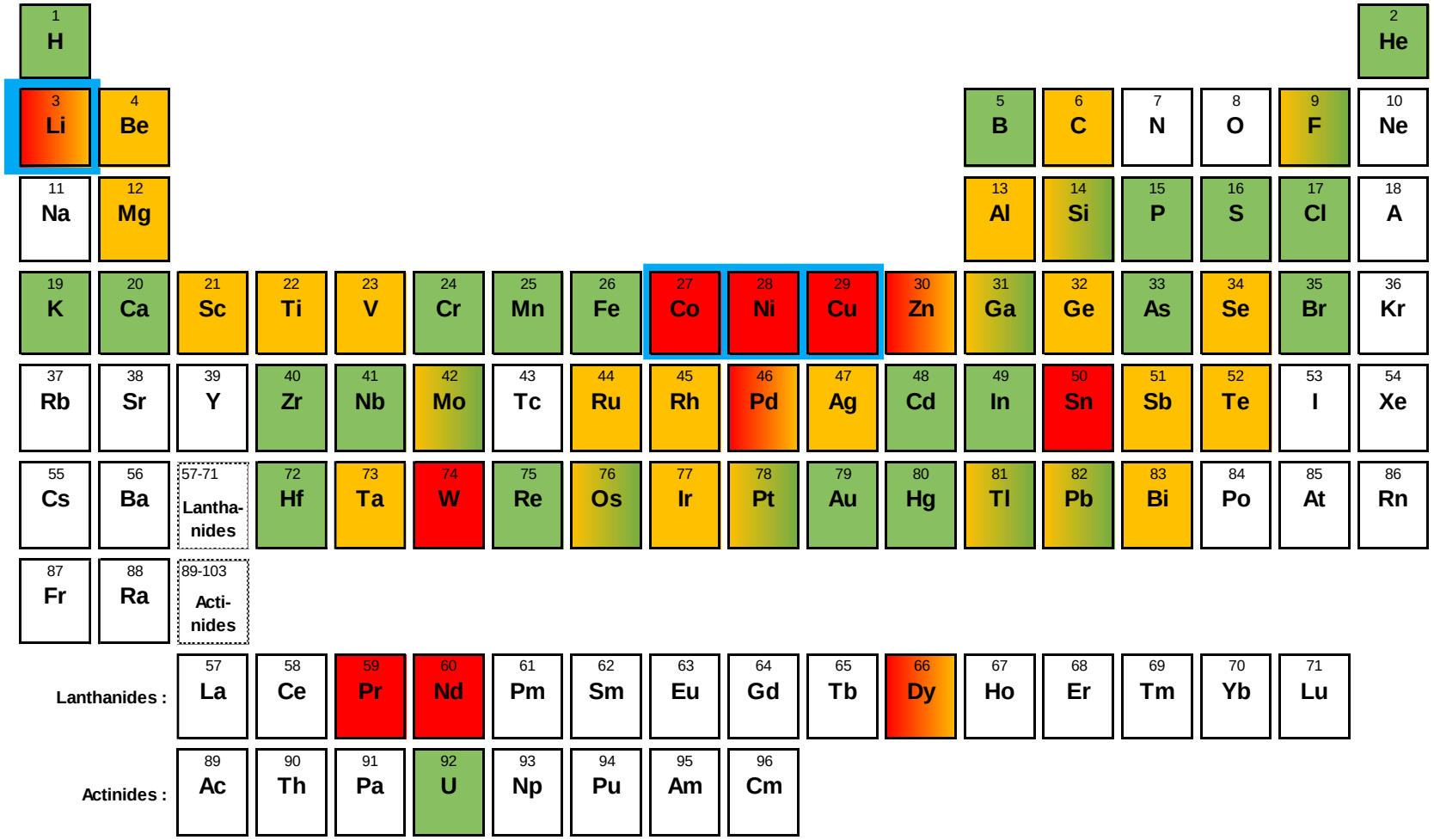
McKinsey & Company

Battery materials demand and supply perspective

World Materials Forum | Nancy, 16-18 June 2022

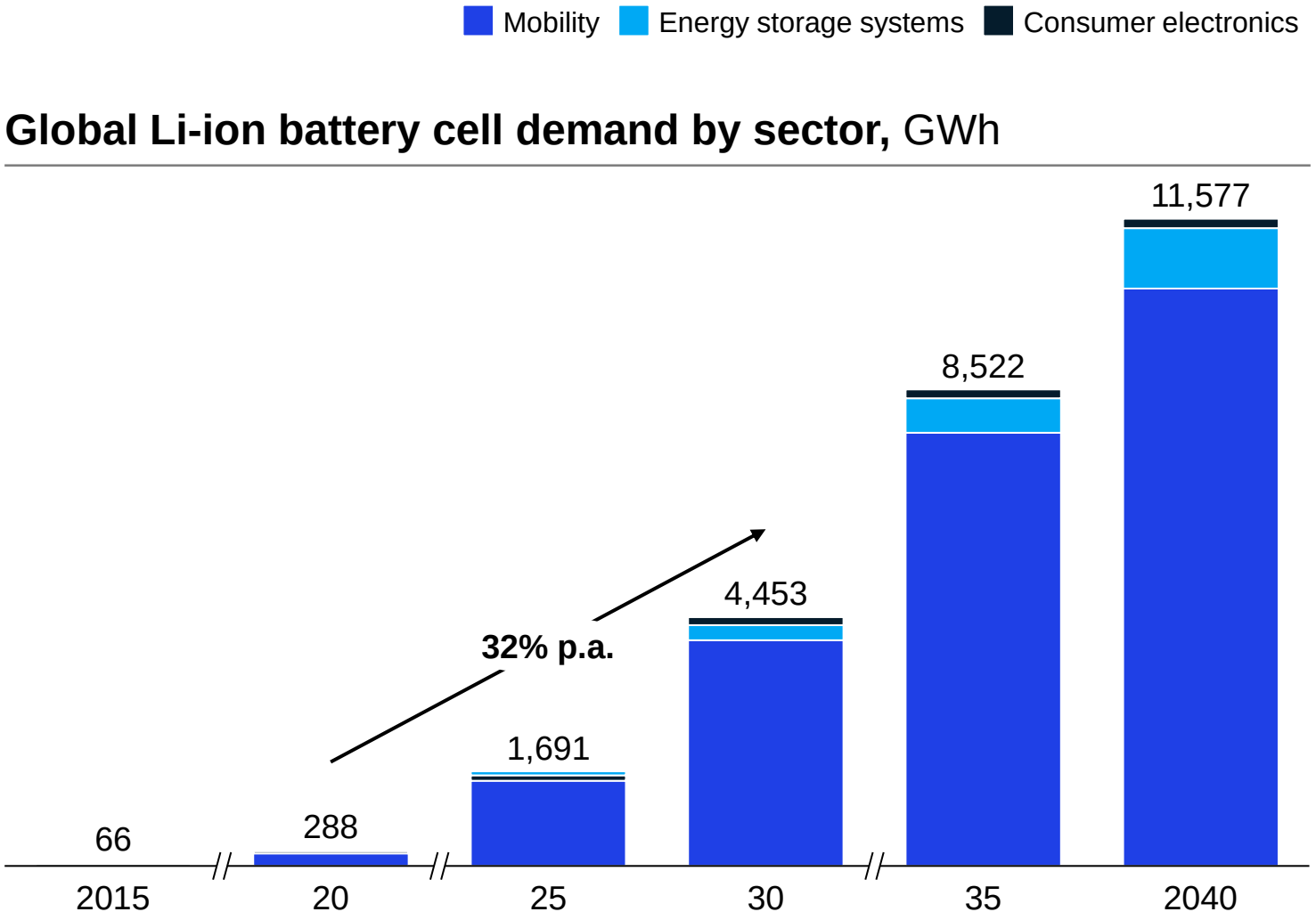


Criticality of battery materials and Copper as key metal for electricity infrastructure is very high



Source: WMF Criticality Assessment 2022

Li-ion battery cell demand growth driven overwhelmingly by the transition to EVs in the mobility sector



Source: Battery demand model Q1 2022, IHS; WEF

Key insights

- **Growth from 2020 – 30 expected to be strong at 32% p.a. CAGR**, underpinned by massive growth in mobility (breakdown follows) as well as growth in energy storage systems
- **Forecast continues to grow** as models are refreshed at a regular basis due to increased expectations of Electric Vehicle adoption

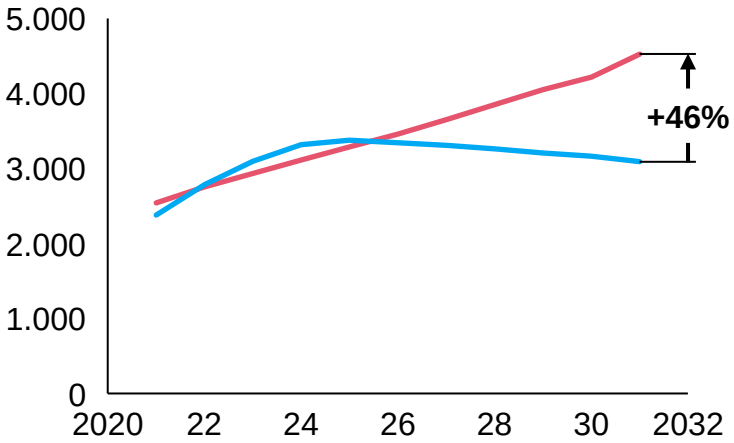
Battery mineral mining is at current pace to result in supply shortages towards the end of the decade

Focus on Ni in next pages (Li more globally available; Co being substituted away)

Base case scenario

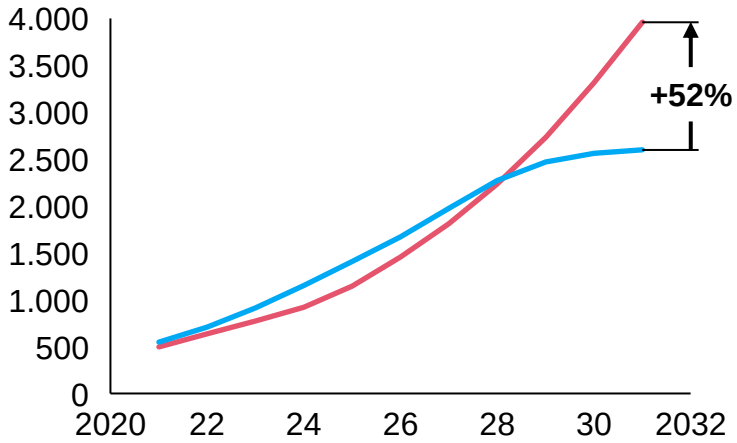
Demand Mine supply

Nickel
Metal, kt



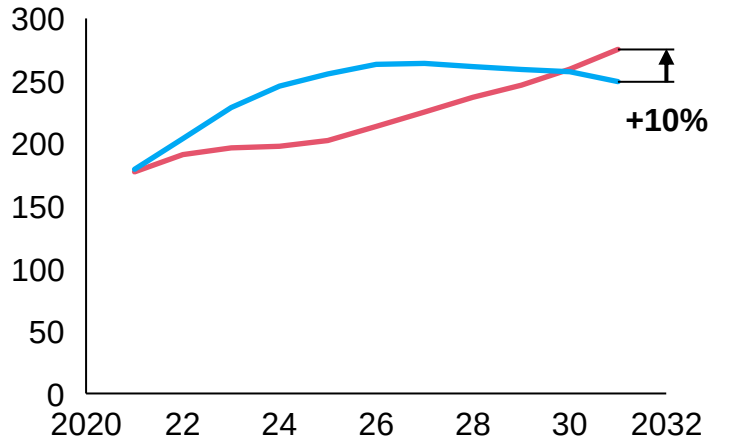
- Despite a decent project pipeline by 2030 there is a **likelihood for nickel Class 1 shortage of ~700 kt as battery nickel demand**
- Chinese, European and Indonesian companies are continuing the **development of facilities in Indonesia to upgrade low grade laterite ores** (Class 2) into Class 1 nickel products

Lithium
LCE, kt



- Driven by technology shifts, **lithium hydroxide and metal demand expected to grow at a faster pace than carbonate** over the next 10 years
- Largest Lithium producers are expected to **continue capacity expansions until 2026**, with **few advanced projects after that**

Cobalt
Metal, kt



- Long term nickel demand sparks initiative for **Indonesian laterite HPAL** projects that will **entail relevant cobalt co-production**
- Trend to **supply shortage on long term** by outpacing EV demand to **incentivize substitution and recycling**

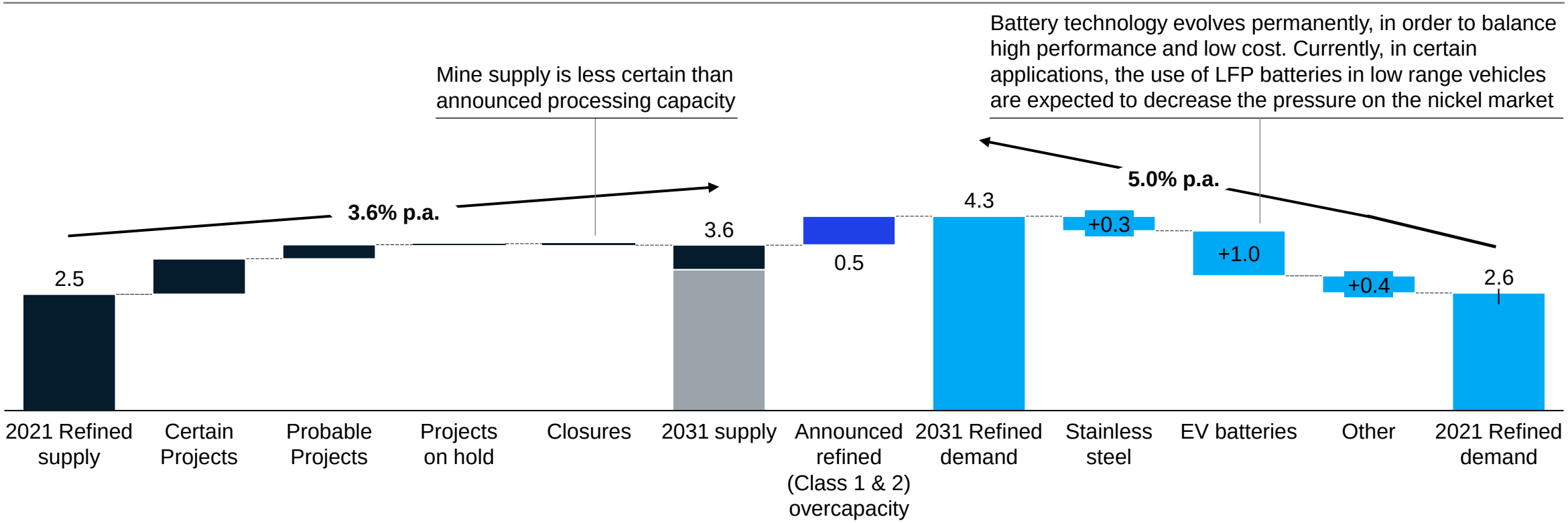
Source: Minespans

With current demand trends, a long-term shortage of nickel is expected, driven by EV growth

2022 Q1 Base case

Refined Supply Mine supply Demand

Refined primary nickel demand & supply[1,2], 2021-31
Mt

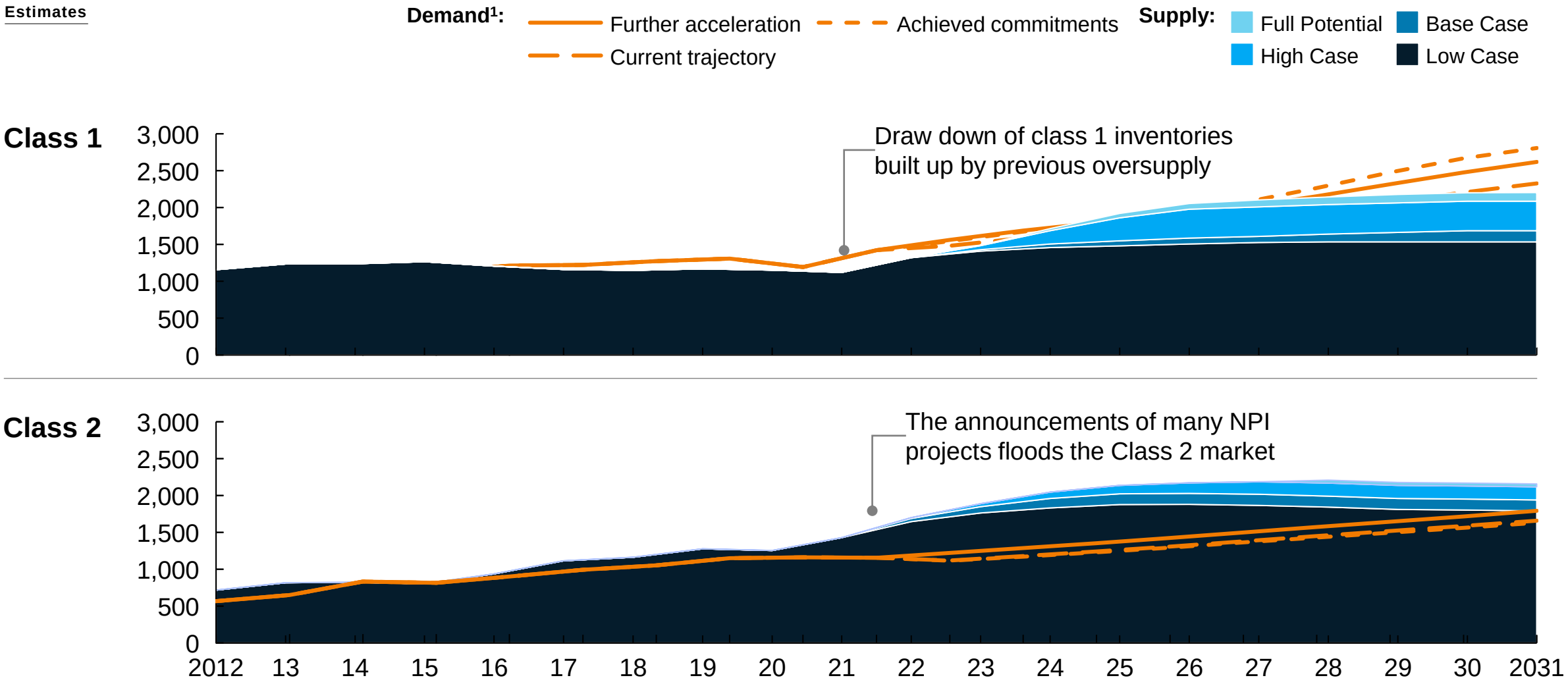


1. Base case scenario considering mill-head grade corrections;
2. Contained nickel in finished products, ready for end usage, such as FeNi, NPI, nickel sulphate or nickel metal, produced at the mine or in a refinery

Source: MineSpans

We expect a short-term Class 1 thightness, compensated by either significant supply pipeline growth via NPI conversion or substitution of nickel usage

Refined nickel supply capacity and demand by class of nickel, in kt Ni

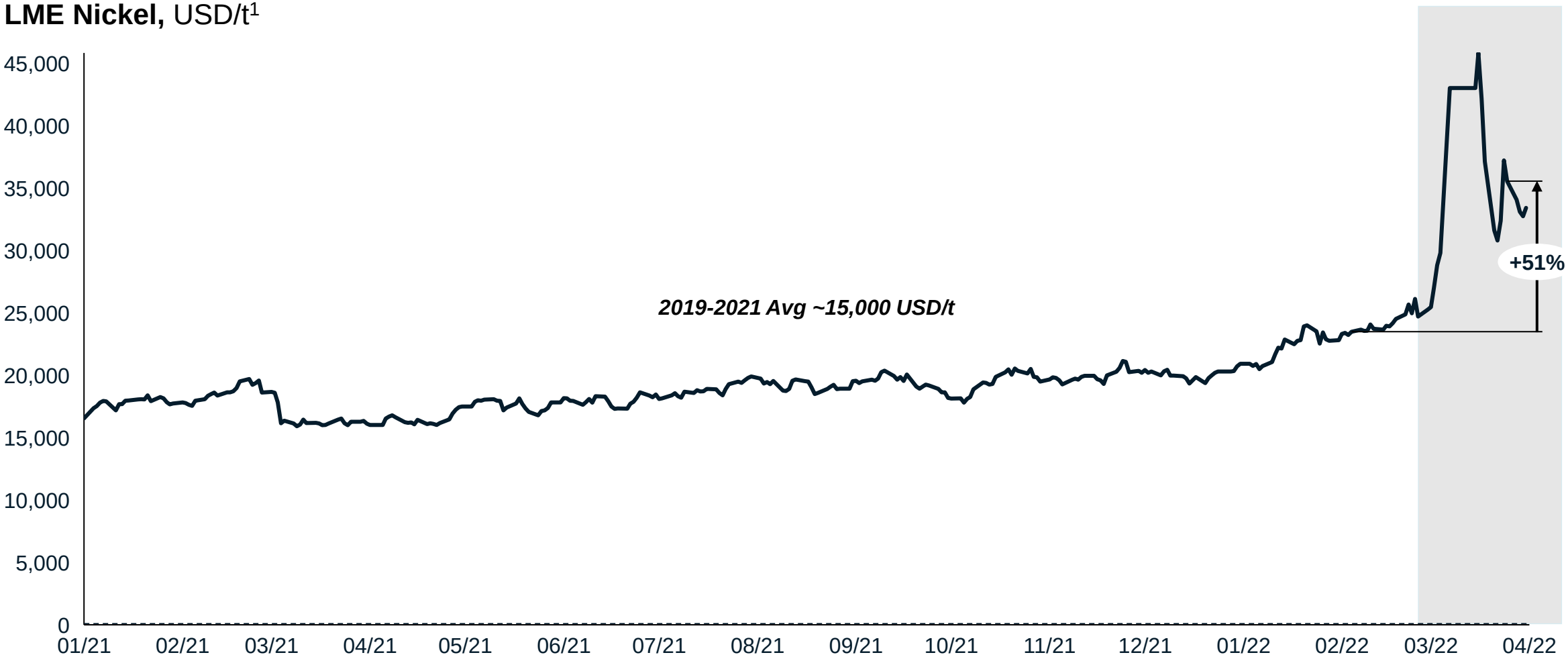


1. Class demand based on the current demand profile. Shifts in demand are likely to happen with evolving technology and price dynamics

Source: MineSpans, McKinsey Nickel demand model

The existing shortage in nickel supply combined with the consequences of the U/R conflict pushed nickel prices to historical highs

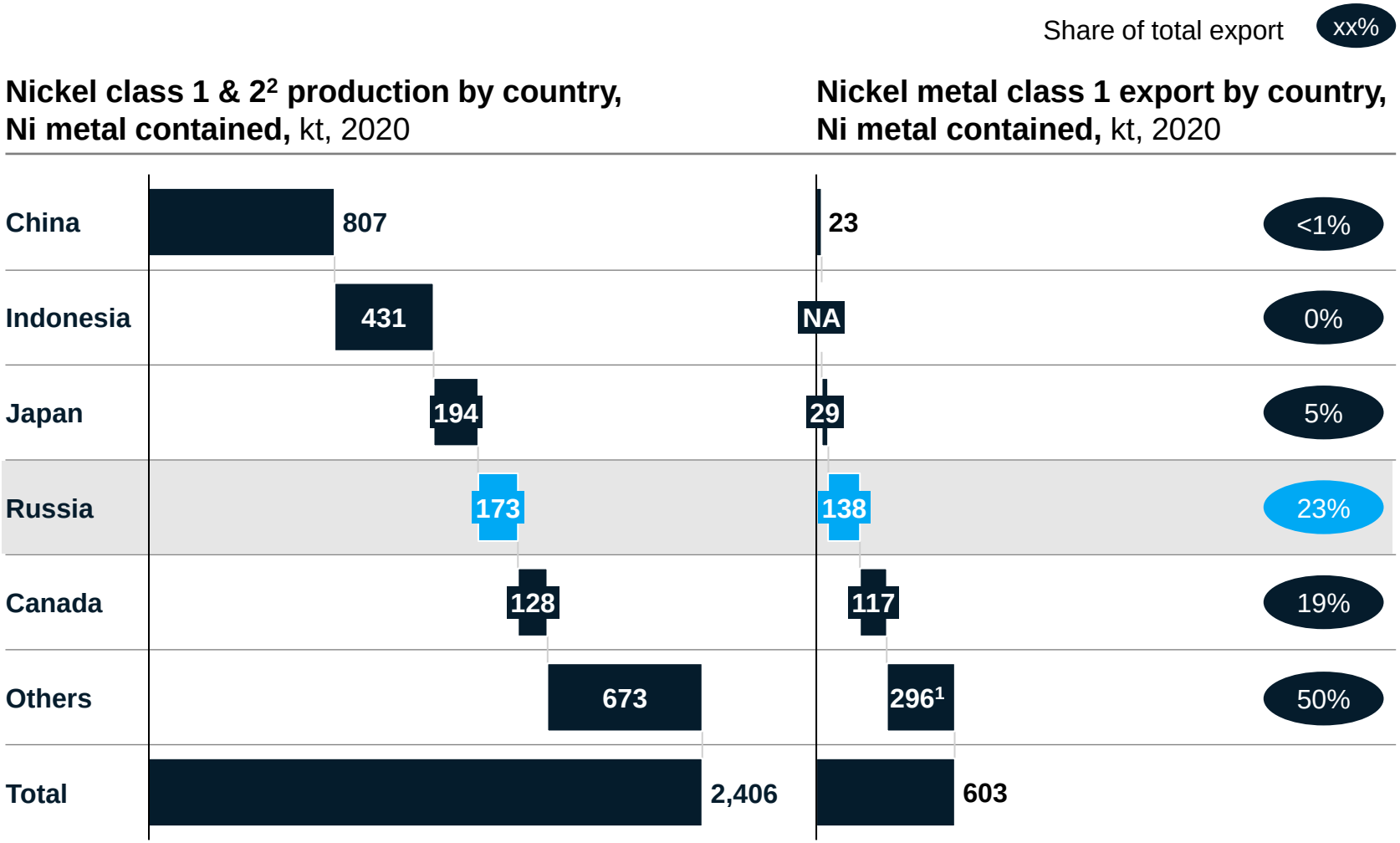
LME Nickel, USD/t[1]



1. Nominal prices

Source: MineSpans, Fastmarkets MB, McKinsey analysis

Russia is one of the largest Nickel class 1 exporters globally



1. Major export from producing regions as Oceania and Western-Europe
2. Nickel class 2 primary used for the production in stainless steel, class 1 used for both steel alloys and batteries

Source: Minespans, UN Comtrade

- Russian production of refined nickel metal is serving more than **20%** of the global nickel export market
- Russian export is currently mainly sent through the European market
- China and Indonesia are large producers of nickel pig iron (class 2)

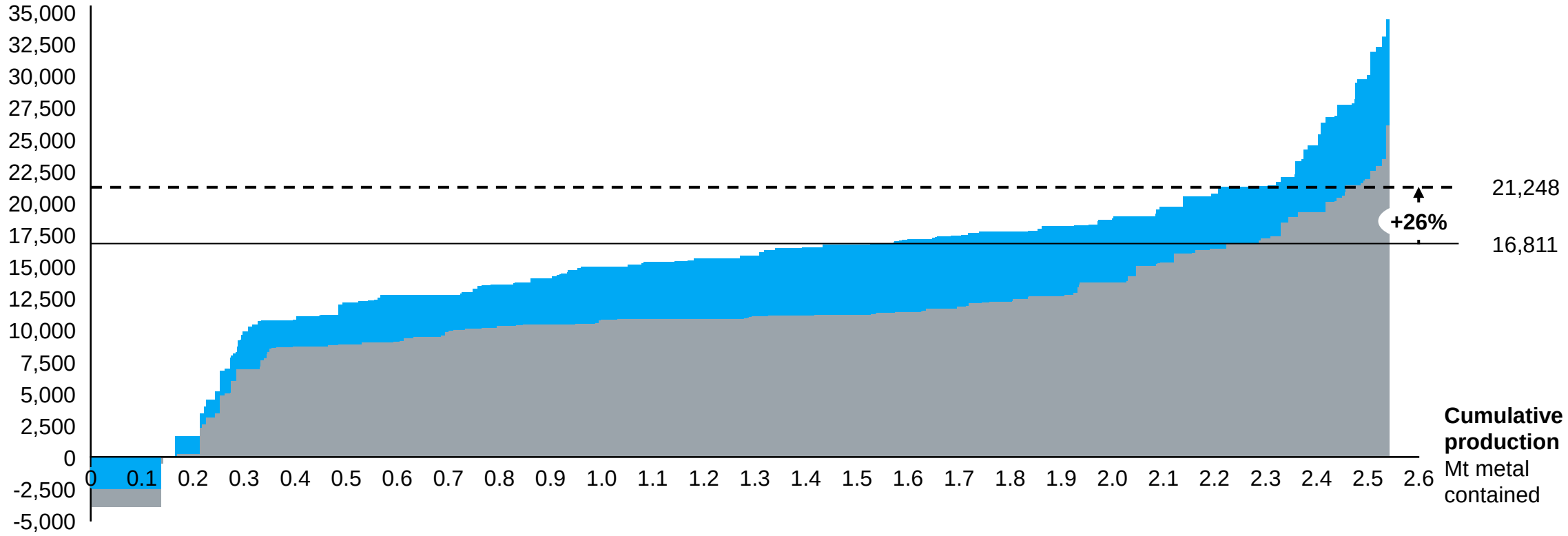
The nickel value chain is exposed to carbon pricing; a widespread 100 USD/t CO_2 penalty increases 2021 marginal cost by 26%

Carbon pricing landscape evolving; nickel market's exposure will depend on several variables

2022 Q1 **Sensitivity Analysis**

Finished nickel cost curve base vs 100 USD/t CO2 price, 2021

Cash cost incl. royalty, USD/t metal contained



1. CO_2 cost applies a standard 50 USD/t CO2e price to annual operational emissions, as well as the industry average carbon footprint of the operation's input product. Only CO_2 emissions are considered
2. Emissions Trading System
3. Sweden's carbon tax represents the higher end

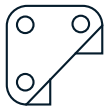
Source: MineSpans, World Bank Carbon Pricing Dashboard, press search, expert interviews

Several unknowns remain that may impact the Ni market

2022 Q1

Changes in demand patterns

Stainless steel



Steel mix: Decreasing production of 300 series resulting in decreasing demand for Ni

Raw material mix: Increasing use of scrap, particularly in China

EV batteries

Battery performance: Variable battery performance expectations regarding range, impacting nickel demand

Battery chemistry: Optimization of nickel intensity while maintaining performance

De-carbonization

Nickel customers in the automotive industry like BMW, Tesla, and Volkswagen aim to source zero or low-carbon raw materials

Increased supply

Technology

HPAL: Increasing prices confirm financial feasibility of new HPAL plants

NPI to matte[1]: Certain NPI plants, particularly in Indonesia are converted to matte smelters increasing supply of Class 1 Ni from laterite ores

Production

Restarts: Increasing prices have incentivized restarting mothballed assets

Projects & exploration: More expensive projects become economical and increased incentives for exploration, increasing availability of long-term supply

De-carbonization

The energy-intensive RKEF-matte from laterites may bridge the class 1 S/D gap, but will have challenges to **decarbonize its fossil-fuel consumption**

1. NPI Ni content: 2%-15%; Matte Ni content from Ni laterites: ~75%

Source: Nickel team analysis

Conclusion

Li-ion battery cell demand growing >30% per year over the next decade as the transition to EVs keeps on accelerating

This leads to **mining supply gaps for the main battery materials**

- **Nickel facing most severe gaps, with largest issue for Class 1 Nickel**, exacerbated by the Ukraine/Russia conflict (Russia exporting ~25% of Class 1 Nickel globally)
- **Lithium also facing supply gaps** but sources more globally available and technology evolving
- **Cobalt being substituted away**, avoiding severe future supply gaps

If and when clear **supply gaps would realize, expect more substitution** and/or **moves to other modes of propulsion**