



**COBALT
INSTITUTE**

enabling technology, advancing society

Cobalt Market Report 2021



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[CRU](#) was commissioned by The Cobalt Institute to prepare a summary report of the cobalt market in 2021, covering the key themes across demand, supply, trade and prices, as well as an overview of the market outlook.

The contents of this report have been produced from CRU's Cobalt Market Outlook Service which provides subscribers with a quarterly report on the market, including medium term forecasts and accompanying data, as well as access to in-house price assessments and CRU's central macroeconomic drivers.



1 | FOREWORD

TRANSPARENT AND ACCESSIBLE INFORMATION ON THE COBALT SUPPLY CHAIN FOR EVERYONE

**DAVID BROCAS, CHAIR OF EXECUTIVE COMMITTEE, COBALT INSTITUTE;
HEAD COBALT TRADER, GLENCORE**

Securing access to responsibly produced raw materials is key to ensuring the implementation of the Paris Accords. Cobalt is a critical part of the solution: it is crucial for ensuring durability and safety of lithium-ion batteries, it is integral to sustainable technologies such as energy storage and is infinitely recyclable.

These virtues make **cobalt a true enabler of the green economy and technological innovation of battery technologies.**

Nevertheless, the effects of the pandemic continue to place global supply chains under strain and the war in Ukraine is expected to have far reaching and long-lasting impacts on commodity markets and energy in particular.

The publication of the Cobalt Institute's "**Cobalt Market Report**" – **the most comprehensive market overview to date** – provides an in-depth analysis of the trends driving the demand for this unique commodity.

In 2021, the cobalt market showed unprecedented annual demand growth of 22%. This was largely due to the rapid growth of the lithium-ion battery market and strong sales of electric vehicles.

As electric vehicles continue to revolutionise the way we travel, **cobalt-containing batteries are a technology of choice for many car manufacturers in all of the major automotive markets** of China, Europe and North America.

Whilst I am optimistic about the future of cobalt, the industry faces a number of challenges to ensure its ongoing relevance in future technology. The debate around the substitution of this unique commodity can only be overcome through a continued focus on embedding transparent and responsible business practices across the supply chain.

The Cobalt Institute publishes this report to make the supply chain data accessible to everyone and to help underpin a broader approach to transparency.

2 | EXECUTIVE SUMMARY

After remaining flat during the first stages of the Covid-19 pandemic, the market rebounded in 2021 growing 22% year-on-year (y/y) to 175 kt. **Demand rose by 32 kt in 2021 alone compared to 51 kt in the 5 years from 2015-20.** Growth was led by lithium-ion battery applications, accounting for 63% of annual demand and 85% of y/y growth.

For the very first time in 2021, **cobalt demand from electric vehicles (EVs) overtook other battery applications to become the largest end use sector at 34% of demand**, totalling 59 kt. This was supported by EV sales doubling over 2020 levels, with China accounting for more than half of global sales and 64% of y/y growth.

The EV sector uses a combination of lithium-ion battery chemistries with **cobalt-containing cathodes maintaining the largest share due to their superior energy density and performance** – cobalt is particularly important for stability and safety. In 2021, 74% of global light duty EV battery demand was for nickel- and cobalt-based chemistries compared to 25% for lithium iron phosphate (LFP).

Supply also returned to growth in 2021, with mine supply rising 12% y/y to 160 kt, after falling in 2020. The Democratic Republic of the Congo (DRC) produced 74% of mined cobalt in 2021 and accounted for 87% (15 kt) of annual growth. Output from the artisanal and small scale mining (ASM) sector is estimated to have increased to 14.5 kt in 2021, 12% of the DRC's total supply. Primary refined supply increased 14% y/y to 144 kt; China remains the largest refined cobalt producer, providing around 70% of both 2021 refined supply and y/y growth. Finland, Indonesia and Madagascar combined provided 27% of refined supply growth in 2021.

A variety of factors constrained logistics and supply chains in 2020 and 2021, particularly impacting cobalt hydroxide exports from the DRC to China. As a result, increased mined output from the DRC has not translated to increased exports to China. Tight cobalt hydroxide supply lifted payables substantially from early 2021 and they remained close to 90% for most of the year, impacting the wider cobalt market. High payables put pressure on the margins of metal producers in China resulting in a 35% y/y fall in production in 2021. Alongside weaker European metal prices, China imported larger volumes of cobalt metal to supplement constrained hydroxide imports, with imports averaging 280% higher y/y in the period from 2020 Q3 to 2021 Q2.

Robust market performance and ongoing tight conditions were highlighted by cobalt's price growth in 2021 – European metal prices doubled through the year from \$16/lb in January to \$32/lb by the end of the year. Due to relative market weakness, European prices averaged \$2.5 below Chinese metal in 2021, with the discount persisting since mid-2020. Cobalt sulphate prices also maintained a premium over metal, averaging \$3.6/lb, due to very strong chemical demand growth from the lithium-ion battery sector.

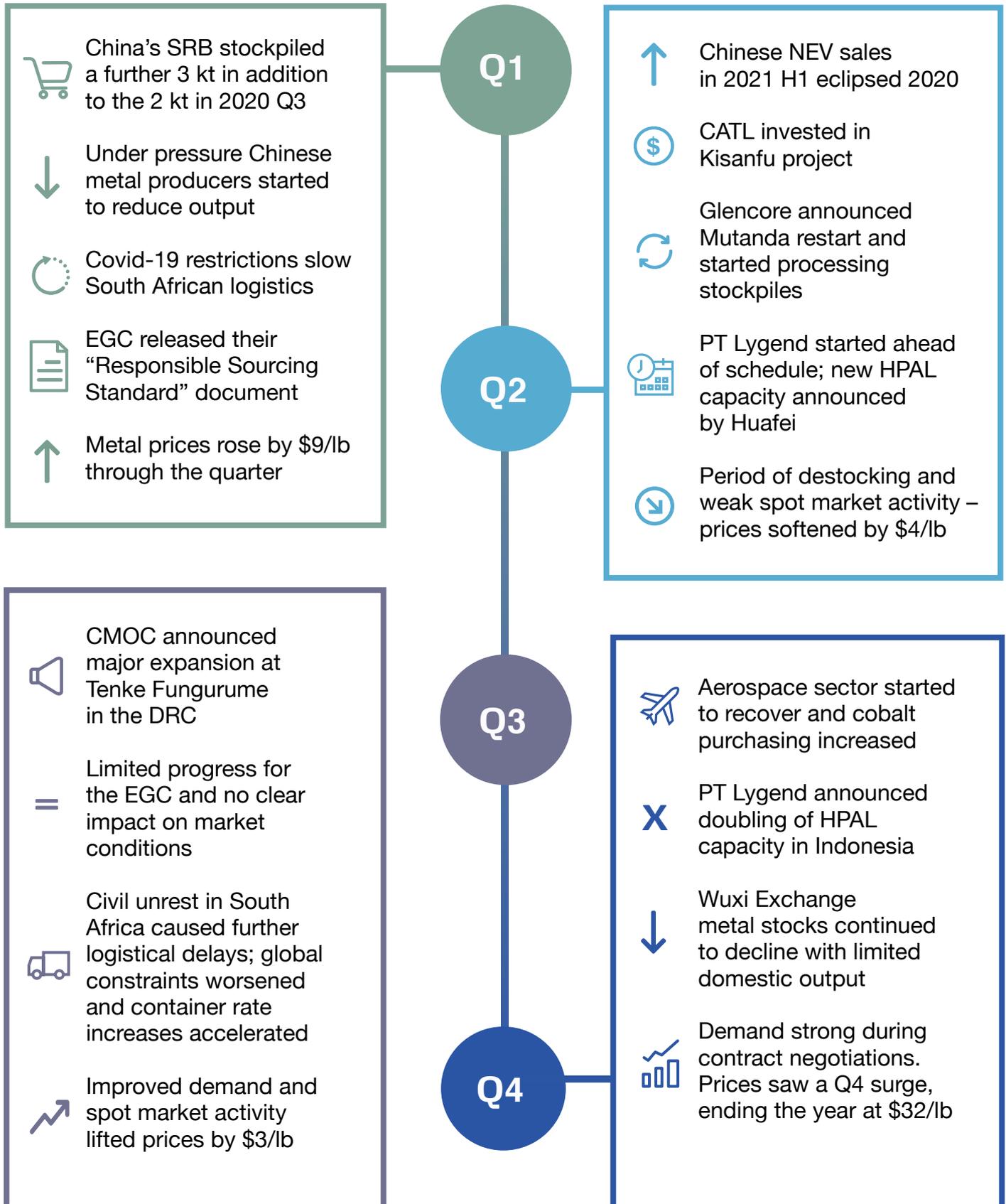


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Looking ahead, **cobalt demand is expected to continue rising rapidly as the EV transition gains pace** – demand is forecast to approach 320 kt in the next 5 years from 175 kt in 2021; 70% of growth will come from the EV sector. **Supply will keep pace with demand in the short term, however supply chain bottlenecks remain a key risk.** Freight routes were anticipated to begin to normalise from the second half of 2022, but this will likely be delayed due to impacts from the war in Ukraine and Covid-19 lockdowns in China. From 2024, the market is forecast to shift back into a deficit as supply growth fails to keep pace with demand. **Prices will remain elevated to incentivise further investment and prevent wide deficits developing.**



3 | 2021 AT A GLANCE...



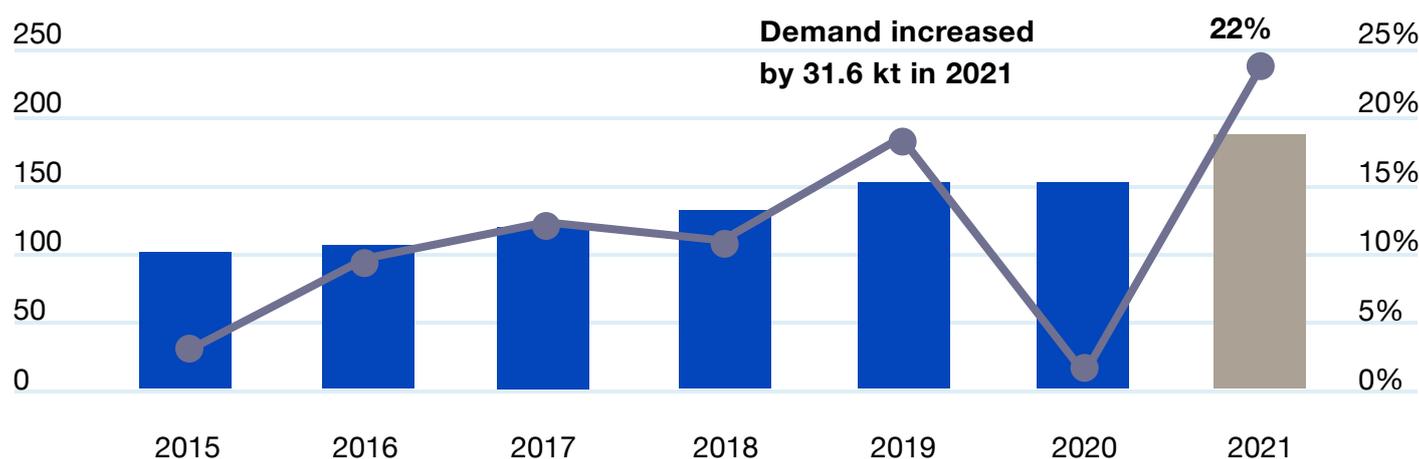
4 | RAPID DEMAND GROWTH RETURNS AFTER SLOW 2020

Cobalt demand grew at a compound annual growth rate (CAGR) of 9.2% from 2015-20, from less than 100 kt* in 2015 to 143 kt in 2020. Demand growth slowed to a halt in 2020 as the Covid-19 pandemic impacted most end use sectors, with the exception of lithium ion (Li-ion) battery applications.

However, as the global economy began to recover after the first phase of the pandemic and the Li-ion battery market maintained rapid growth, demand rose significantly higher in 2021 to 175 kt, up 22.1% y/y. In comparison, 2021 alone saw 31.6 kt of demand growth compared to 50.8 kt in the 5 years from 2015-20.

Figure 1: 2021 saw the cobalt market continue to grow rapidly after the slowdown of 2020

Cobalt demand, 2015-2021 (LHS: cobalt demand, kt Co; RHS; y/y growth, %)



Data: CRU

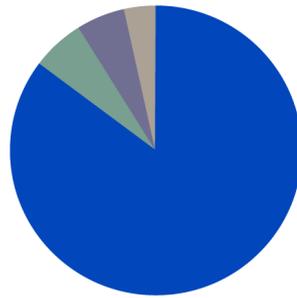
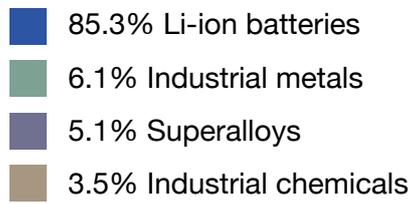
63% of total demand was from Li-ion battery applications in 2021. As a result, a large proportion of y/y growth was from this sector, as presented in the pie charts below. 85% of demand growth came from the Li-ion battery sector which translated into 70.5% of growth for cobalt sulphate. The next largest product type was cobalt oxide, primarily also for battery applications, and to a lesser extent in industrial applications.

* All mass units in metric tonnes. kt equivalent to 1,000 metric tonnes.

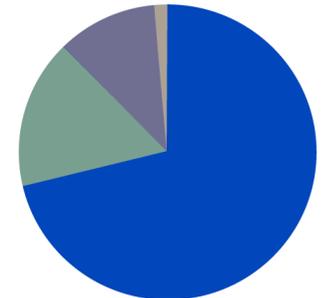
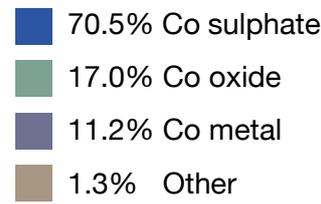


Figure 2: Li-ion batteries accounted for the vast majority of demand growth in 2021

Share of 2021 growth
by end use



Share of 2021 growth
by cobalt product

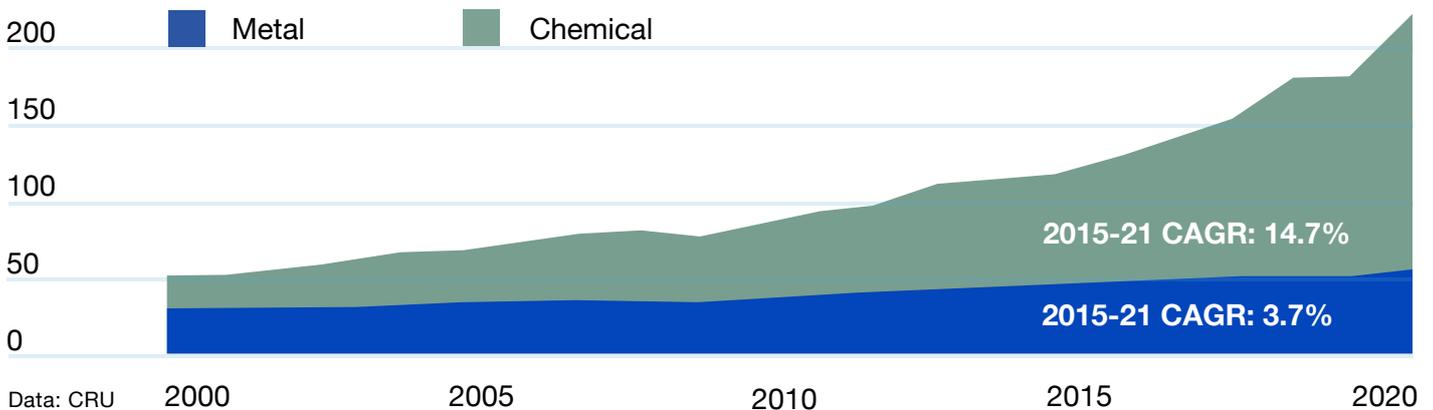


Data: CRU

Since overtaking the metal portion of the market in the early 2000s, cobalt chemicals have continued to gain share due to the rising importance of batteries to the demand landscape. In 2021, chemicals accounted for three quarters of the market. Since 2015, metal applications have grown at a CAGR of 3.7% compared to 14.7% for chemicals.

Figure 3: Chemicals continue to rise in importance in the cobalt market

Metal & chemical demand growth, kt Co



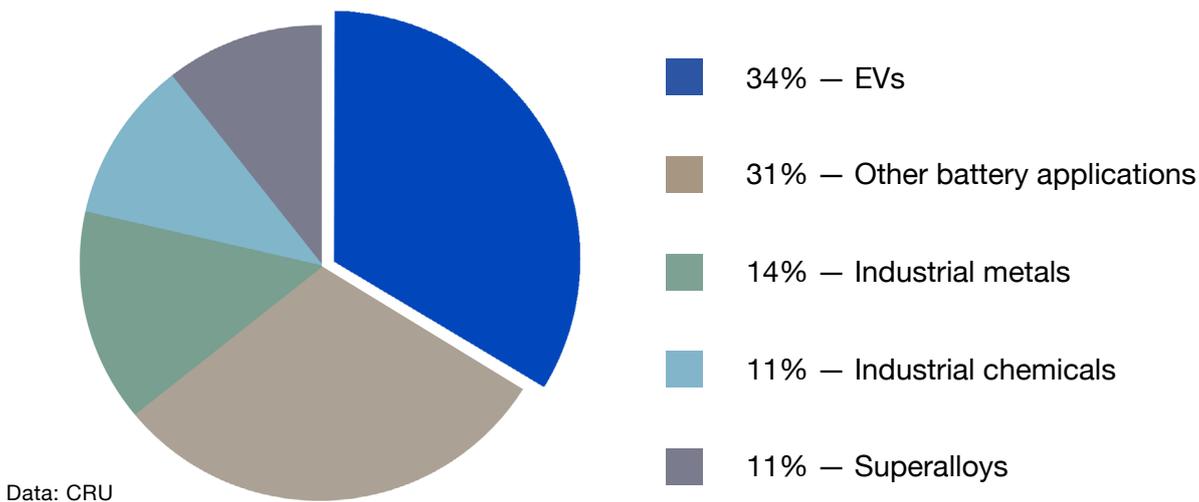
Data: CRU

With around 70% of the downstream Li-ion battery supply chain in China, regional cobalt demand growth was focussed in China in 2021, rising 28% y/y. China's share of global cobalt demand rose from 60% in 2020 to 63% in 2021. In the rest of Asia, with major precursor and cathode producers in South Korea and Japan for example, demand growth was 16% y/y, with the region losing some demand share, falling to 17% in 2021. The next largest regions, Western Europe and North America, with around an 18% combined share, have established cobalt metal markets, large scale aerospace manufacturing (Boeing & Airbus) and growing EV supply chains; combined demand grew 12% in 2021.

The remainder of the demand chapter will provide further details on the key end use sectors with particular focus on electric vehicles (EVs). EVs became the largest end use sector in 2021 and have the most growth potential.



Figure 4: For the first time, EVs became cobalt's largest end use sector in 2021



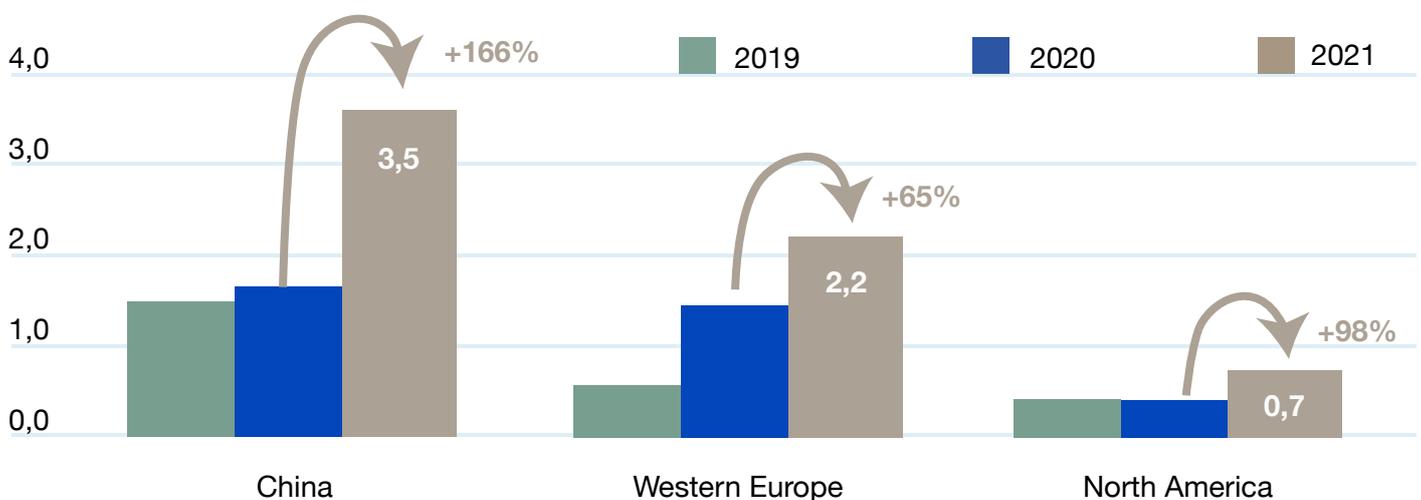
ELECTRIC VEHICLES

2021 had a lot to live up to in the EV space after strong sales growth of 36% y/y in 2020. This was supported by Covid-19 recovery policies (e.g. generous EV incentives in Europe), greater model variety/availability and major EV strategy commitments from most automotive companies.

2021 more than delivered with new energy vehicle sales (NEV, referring to battery electric and plug-in hybrid vehicles combined) rising by 3.4 million units to 6.7 million globally (102% y/y). China led the way with more than half of global sales and 64% of 2021 growth. Europe and North America followed with 26% and 10%, respectively, of global y/y growth.

Figure 5: Global EV sales reached new highs in 2021 with China ahead of the pack

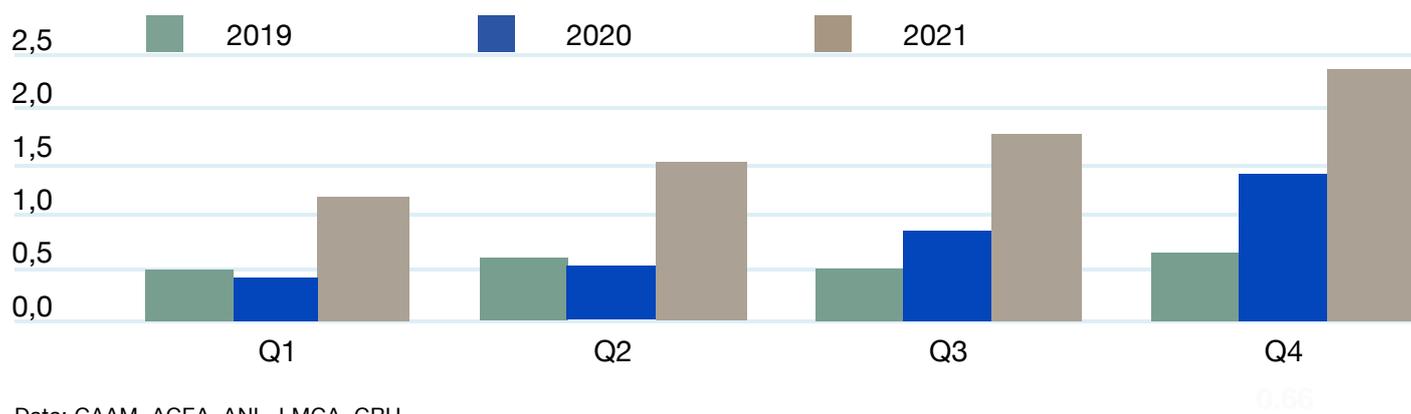
NEV sales, million units



Data: CAAM, ACEA, ANL, LMCA, CRU. Note: NEV refers to battery-electric (BEV) and plug-in hybrid (PHEV) vehicles. LDV (light duty vehicle) data presented, not including HDV and Buses.

Figure 6: The NEV market grew throughout 2021, far surpassing 2019 and 2020 levels

Quarterly NEV sales in China, Western Europe & North America, million units



EVs also bucked the trend of the wider automotive market as supply chain constraints and semiconductor/chip shortages continued to plague producers. 2021 was the third consecutive year of sales decline for non-NEV light duty vehicle (LDV) sales, albeit falling to a lesser degree than in the early stages of the pandemic. Since 2019, internal combustion engine (ICE) and hybrid (HEV) annual sales have fallen from 87.7 million units to 75.2 million in 2021 (-15%). This is in comparison to NEV sales rising from 2.4 to 6.7 million units (+175%) over the same period.

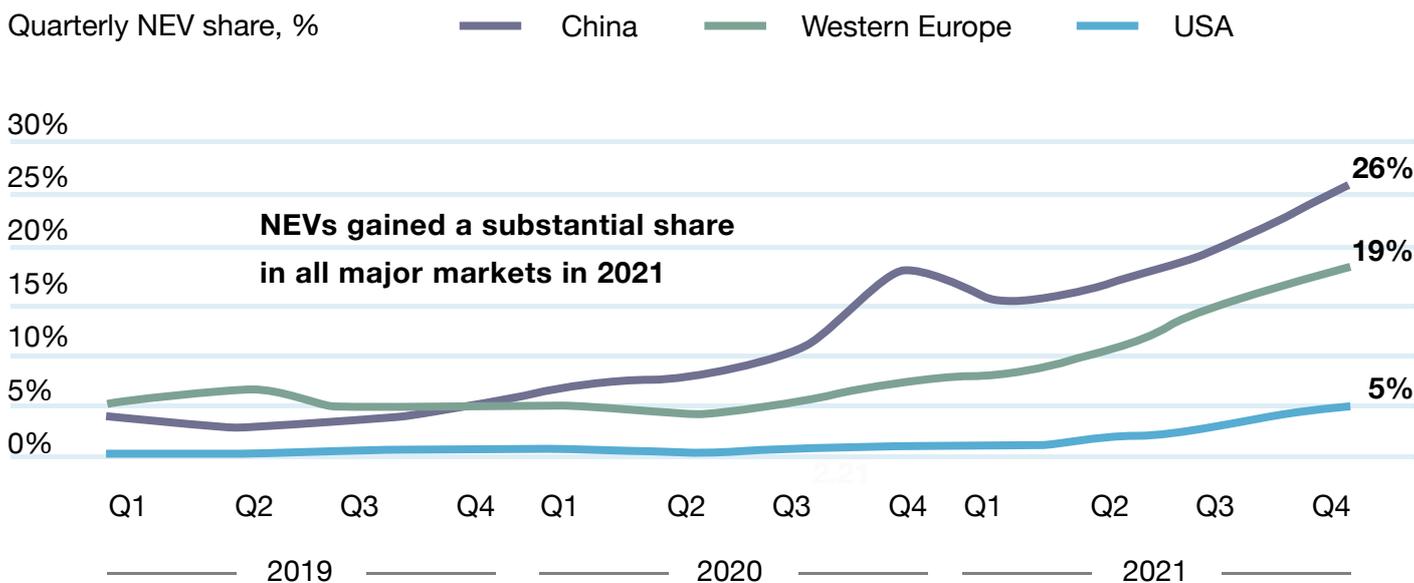
EV production has faced pressure from chip shortages, particularly due to being on average more chip-intensive than ICEs. However, the sector has remained relatively well insulated from any major impact:

- Automotive OEMs are facing tightening fleet emissions standards, particularly in the EU and China, meaning they are prioritising chip availability for EVs to avoid fines.
- Aside from pure plays such as Tesla, EVs still remain a small share of fleet production for many OEMs, meaning it is more straightforward to shield this part of the business.
- Electrification strategies are becoming increasingly important for shareholder value and EVs have been protected at the expense of ICE production.

The momentum of NEV demand continued to gather pace with market penetration rising in all of the major markets throughout 2021. Western Europe's NEV share was the highest of all regions at 26% in 2021 Q4, up from an average of 11% in 2020. China followed at 19% in Q4, up from 6% in 2020. The US lagged the two other major markets at just 5% in Q4, albeit up from 2% in 2020.



Figure 7: NEVs are gaining share in all of the major markets



Data: CAAM, ACEA, ANL, LMCA, CRU.

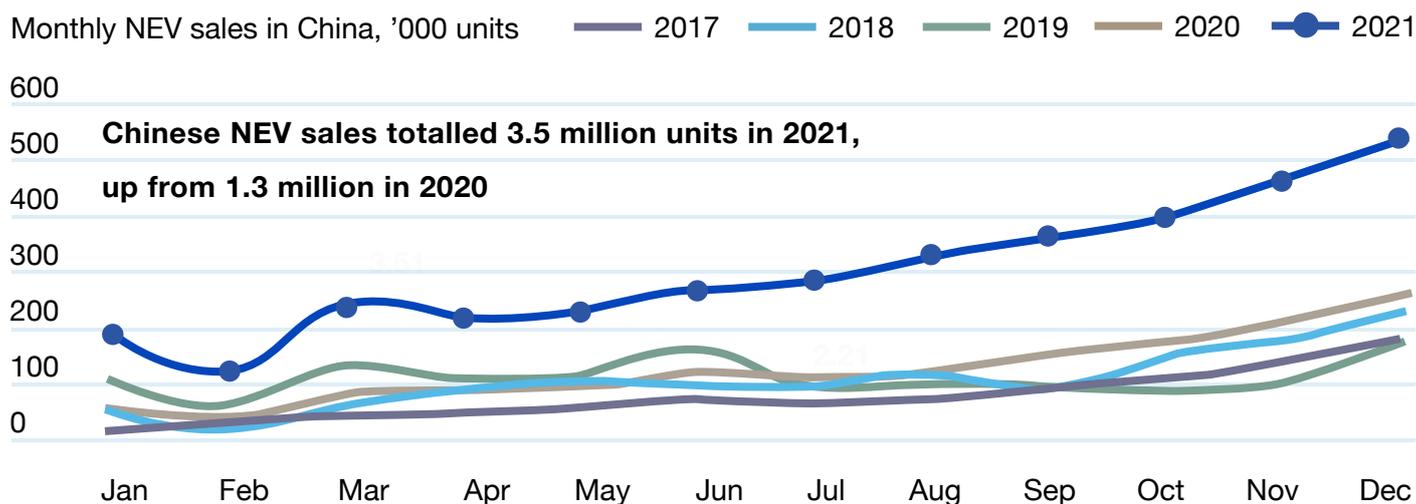
CHINA'S NEV MARKET GREW 166% Y/Y

After being neck and neck with Western Europe in 2020, Chinese NEV sales surged ahead in 2021. A key feature of the surge in sales in 2021 (and late 2020) was the popularity of mini EV models which are substantially more affordable than other larger models. The Hongguang Mini EV, with a starting price of around \$4,500 in 2021, was the best-selling NEV in China in 2021 with close to 400,000 models sold and a 14% share of BEV sales. This is in comparison to the Tesla Model 3, the best-selling NEV of 2020, which retailed for around \$40,000 in China in 2021. Of the top ten best-selling models in 2021, three were mini EV models accounting for around 20% of total BEV sales.

The Hongguang Mini sold more than twice as many units as the second best-seller, the BYD Qin EV (6% of BEV sales). Tesla now produce larger volumes from their Shanghai factory and have been exporting to Europe since late 2020. The Model Y and Model 3 were in 3rd and 4th spot, respectively, with around 11% BEV share combined.



Figure 8: NEV sales grew rapidly in China in 2021, well ahead of previous years



Data: CAAM, CRU. EV refers to battery-electric (BEV) and plug-in hybrid (PHEV) vehicles.

In addition to the three mini EVs, a further five top-10 models had LFP battery options for standard range models in 2021. LFP cathodes have been critical to the recent mini EV thematic in China by enabling competitive pricing with ICEs and supporting improved EV market accessibility.

LFP batteries are generally lower cost than other nickel- and cobalt-based chemistries (e.g. NMC, NCMA, NCA) but have inferior range and performance. Although, lithium carbonate spot prices doubled from September to December 2021, and increased even further in early 2022; this is alongside price rises for cobalt and nickel sulphate. These factors will impact the relative cost competitiveness of the cathode chemistries and may impact future market shares if battery raw materials prices remain elevated. Although it is worth noting that downstream producers in the battery supply chain primarily purchase raw materials on a contract basis so have lower exposure to the spot market. Nickel and cobalt chemistries will be discussed further in the cathode chemistry section below.

After losing share in 2019, LFP technology has developed and regained market share. For example, Cell to Pack (C2P) technology and BYD's Blade Cells are allowing improvements to pack-level energy density and longer driving ranges for LFP models. That being said, similar mechanical cell- or pack-level improvements will also likely be possible for the nickel and cobalt chemistries as they are increasingly adopted and developed.

In addition, charging infrastructure improvements have reduced range anxiety and NEVs have been particularly popular in major Chinese cities which has meant that travel distances are shorter than average. Vehicle affordability has therefore been more important than range.



Figure 9: Top 10 NEV models in China in 2021



Model	Cathode chemistry
Hongguang mini EV	LFP & NMC
BYD Qin EV	LFP
Tesla China Model Y	LFP, NMC811, NCMA
Tesla China Model 3	LFP, NMC811, NCMA
BYD Han EV*	LFP
BYD Song Plus	LFP
LiXiang One	NMC
Cherry eQ	LFP & NMC
CCAG Benben EV	LFP
GAC Aion S	NMC

■ The chemistries highlighted are those of particular relevance to the cobalt outlook

Note: Mini EV models in bold; LFP battery options highlighted; * PHEV model also available.

Due to the rising popularity of affordable NEV models and much greater model variety, policy and subsidy changes in China did not have a negative impact on demand in 2021. We do not expect further subsidy cuts to damage sales in 2022 and beyond. China's Technical Roadmap 2.0 and the Dual Credit Policy* will increasingly encourage OEMs to switch production to NEVs, and particularly full battery electric (BEV) models. The current government target is for a 20% NEV share by 2025, which we expect to be achieved as early as 2022, and for BEVs to make up 90% of NEV sales.

* China's Technical Roadmap 2.0 was released in October 2020 to detail the plan for electrifying the passenger car fleet. This was an update on the previous version of the roadmap (1.0) from 2016. The Dual Credit Policy is part of the roadmap and is designed to incentivise the phase out of ICEs and shift to NEVs. It uses a Corporate Average Fuel Consumption (CAFC) and NEV dual credit system. The policy is structured to increase the NEV share of OEM fleets and therefore the share of total NEV sales over time. Each year, the threshold for the share of NEVs and the value of credits increases.

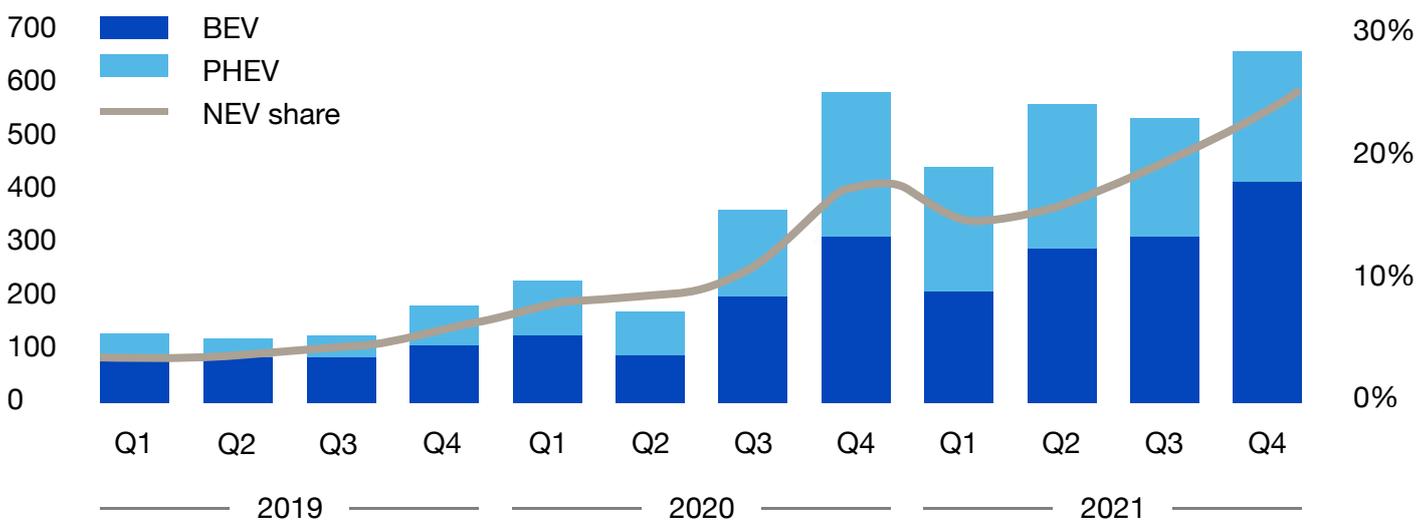


MORE THAN 1 IN 3 VEHICLES SOLD IN WESTERN EUROPE WERE xEVs IN 2021

The introduction of subsidies in five of the six biggest EV markets in Europe provided a substantial boost to NEV sales in Western Europe in 2020 H2. Aside from some minor adjustments, these subsidies remain in place and continue to support strong sales. 2021 sales reached 2.2 million units, up 65% y/y. The rise in Q4 sales was less pronounced than in 2020 as the rush to meet emissions targets was reduced due to a greater EV share of fleets, and also due to chip-related issues in the broader automotive market.

Figure 10: The NEV share continued to rise higher in Western Europe in 2021

LHS: Quarterly BEV + PHEV sales in Europe, '000 units; RHS: NEV share, %



Data: ACEA, CRU. Note: NEV refers to battery-electric (BEV) and plug-in hybrid (PHEV) vehicles. LDV (light duty vehicle) data presented, not including HDV and Buses.

Alongside much improved policy support, European OEMs are continuing to develop their electrification strategies with new commitments and model releases as NEV penetration rates rise quickly. Many are aiming to end combustion engine sales in Europe in the next 5-10 years. This has led to much greater model variety and availability with a large number of new and improved models released over the last two years. To support this transition, European battery capacity has the potential to increase by more than 10 times over the next 5 years.

Fleet CO2 emissions compliance remains a key driver of sales and is likely to become more important over time in line with the EU's emissions ('Fit for 55') and ICE phase out targets (currently new sales banned from 2035). As a result, BEVs are likely to take further market share of the total NEV market. PHEVs began 2021 well with a 52% share of NEV sales in H1, up from 45% in 2020, but BEVs regained share in H1 with 59% of sales. BEVs are expected to move further ahead as PHEVs lose policy support and BEV quality, choice and availability improves.



POLICY CHANGES IN THE US LOOKING LESS LIKELY BUT REMAIN KEY FOR FASTER UPTAKE

North America (primarily the USA) has previously lagged China and Europe due to limited model variety and a lack of policy support, with EV sales declining for two consecutive years from 2018-20. However, this has started to shift since mid-2020 and sales have rebounded due to EV commitments from the OEMs, leading to greater model variety and availability, as well as some supportive policy from the Biden administration.

A number of flagship models have been released that are well suited to US consumers which has helped to kick start the American EV market. These include Tesla's Model Y, the Mustang Mach E and Ford's F-150 Lightning pickup, which has reimagined the best-selling vehicle of all time and seen high pre-orders since its release.

Despite US EV sales close to doubling in 2021, it was hoped that pandemic-related recovery spending would provide a more significant boost to the market, with \$174 billion initially assigned to EVs as part of the American Jobs Plan (AJP) in March 2021. However, the proposed spending was slashed to only \$15 billion (for charging networks and electric public transport) by the time it was passed.

The outstanding spending was then included in Biden's 'Build Back Better' Act which passed through the House of Representatives before hitting opposition at the Senate. The key areas of relevance are an increase in federal tax credits from \$7,500 currently to a maximum of \$12,500 (up to 2027) and importantly the removal of the incentive cap at 200,000 vehicles for OEMs. Tesla and GM have already reached the cap so this is key for these two major players, and for EV penetration overall. It is looking increasingly unlikely to pass the Senate, particularly in its current form, with the requirement for EV plants to be unionised to be eligible for tax credits appearing to be a key sticking point.

Further policy support is important for the US market to start to catch up with China and Europe, the other major automotive markets. Upfront incentives have been critical for both regions, particularly as EVs are still on average more expensive than ICEs and are facing ongoing pressure from high raw materials prices. In the US, Florida is a prime example of the efficacy of supportive policies and incentives with the state alone accounting for 42% of total NEV sales in the US in 2021.

SUMMARY OF THE KEY EV MARKETS

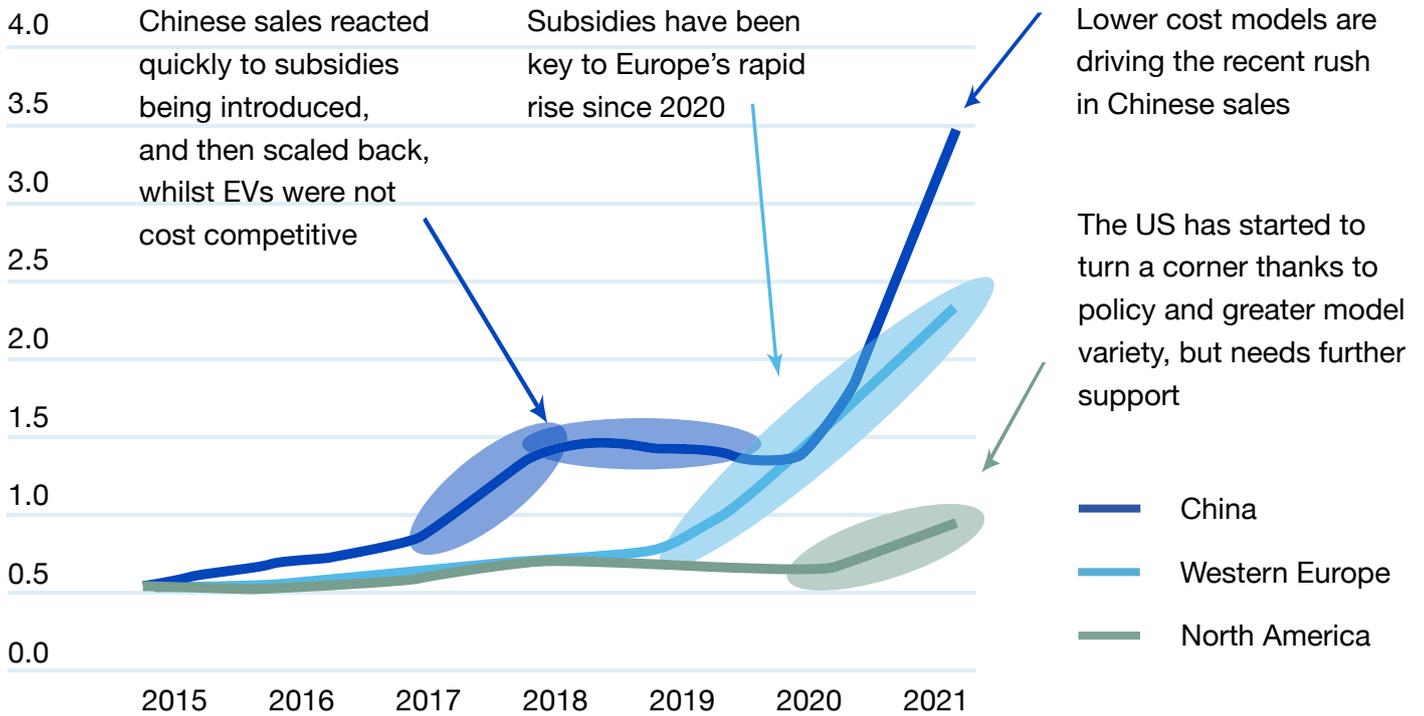
Prior to 2020, China was the driving force of the EV market – annual sales rose from 0.2 to 1.2 million units from 2015-19, contributing 46% of all global sales during this period. To 2019, sales in Europe and North America averaged around 300,000 units per year.

Since then, the EV market has turned a corner and is now growing at pace, with the share rising to 8% of total LDV sales in 2021, doubling from 4% in 2020. Despite the US sitting behind China and Europe in terms of EV market share, all three major markets are now contributing towards this rapid transition.



Figure 11: NEV trend now being driven by all three major automotive markets

LDV NEV sales in the major auto markets, million units



Data: CAAM, ACEA, ANL, LMCA, CRU. Note: NEV refers to battery-electric (BEV) and plug-in hybrid (PHEV)

CATHODE CHEMISTRIES & EVS

Nickel- and cobalt-based cathodes dominate the landscape for EVs due to their superior energy density, performance and recyclability. The NMC, NCMA and NCA chemistries accounted for three quarters of global demand in 2021. Up to recently, medium nickel NMC chemistries (NMC 532 and 611) and NCA (used by Tesla) have dominated with 53% of the market in 2015, rising to 79% in 2019.

In recent years, there has been a gradual shift towards higher nickel intensities with superior energy density to enable improved driving range and vehicle performance. In 2021, high nickel chemistries (NMC 721, 811 and NCMA) accounted for around 15% of light duty EV demand, up from 5% in 2018; this trend is expected to continue. Despite the lower intensity compared to medium nickel cathodes, cobalt remains a critical material for the stability and safety of high nickel chemistries.



Figure 12: The top EV models in Europe and the US are still dominated by nickel-cobalt chemistries



Model	Cathode chemistry
Tesla Model 3	NCA & LFP
Renault Zoe	NMC 721
VW ID.3	NMC 721
VW ID.4	NMC 721
Kia eNiro	NMC 622
Ford Kuga PHEV	NMC 532
Fiat 500 Electric	NMC 622
Skoda Enyaq iV	NMC 721
Hyundai Kona Electric	NMC 622 / NCMA
Volvo XC40 PHEV	NMC 532



Model	Cathode chemistry
Tesla Model Y	NCA & NCMA
Tesla Model 3	NCA & LFP
Mustang Mach-E	NMC 811
Chevy Bolt	NMC 721
VW ID.4	NMC 721
Nissan Leaf	NMC 532
Audi E-tron	NMC 622
Porsche Taycan	NMC 622
Tesla Model S	NCA
Hyundai Kona Electric	NMC 622 / NCMA

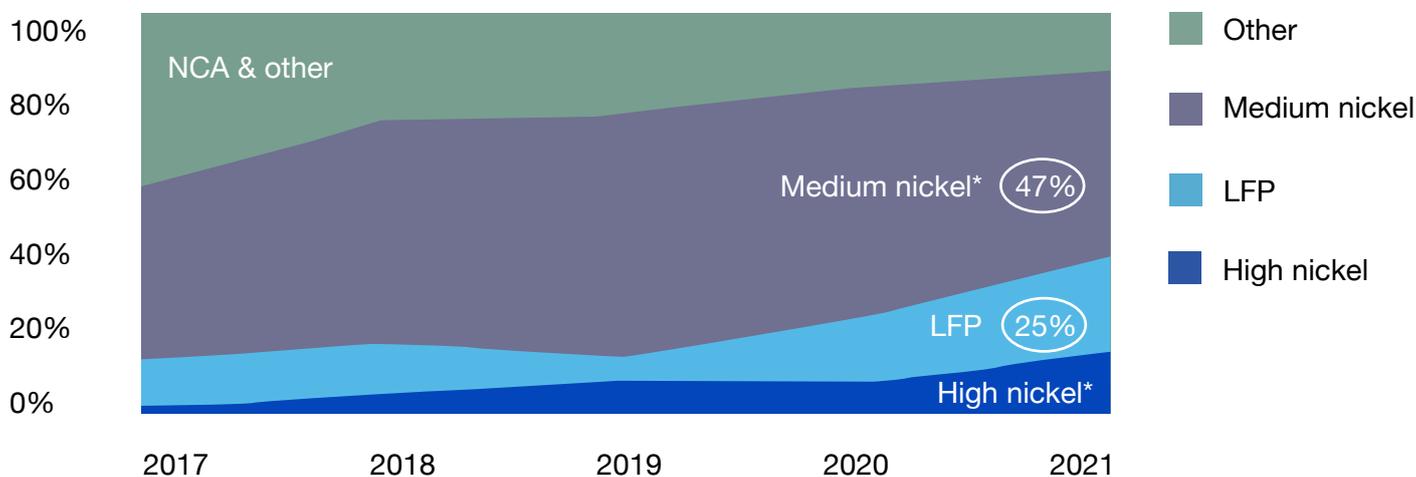


As discussed in the China section above, LFP batteries rose in popularity in China in 2020 and 2021 alongside more affordable mini EV models. Tesla’s Made in China Model 3 vehicles also use LFP batteries, including those being exported to other regions from Shanghai. LFP has a substantial market share in China but remains limited in Europe and North America where nickel- and cobalt-based chemistries dominate. A number of OEMs, including VW, Tesla and Mercedes-Benz have recently committed to using LFP cathodes in standard range batteries indicating that LFP’s share will likely rise outside of China in the years to come.

In 2021, 74% of global light duty EV battery demand was for nickel and cobalt chemistries (medium and high nickel combined), with 25% for LFP. In China, LFP accounted for half of the market.

Figure 13: The EV sector is shifting preference from medium to high nickel chemistries, alongside LFP

Global light duty EV cathode chemistry share (GWh), %



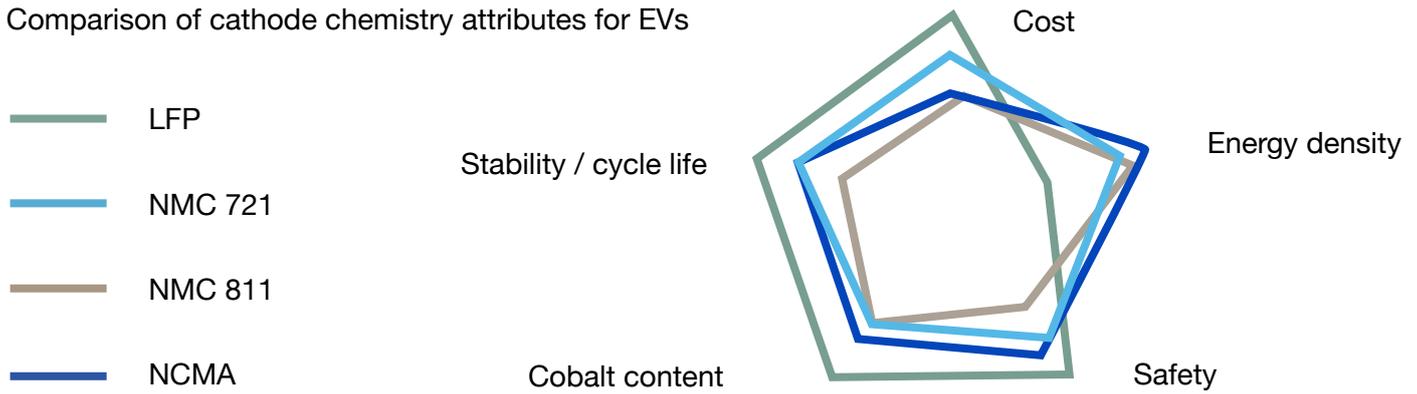
Data: CRU. Note: * High nickel chemistries include NMC721, NMC811 and NCMA; medium nickel chemistries include NMC532 and NMC622.

The figure below compares the attributes of the major emerging chemistries. These are the attributes that to date have been considered as most important to EV producers and consumers, and referenced when discussing future preferences. However, ESG (Environmental, Social and Governance) considerations such as emissions and end of life recycling will become increasingly important to technology adoption as the EV transition continues and legislation, such as the EU Battery Regulation, develops.



Figure 14: The market is finding a balance between cathode chemistry attributes

Comparison of cathode chemistry attributes for EVs



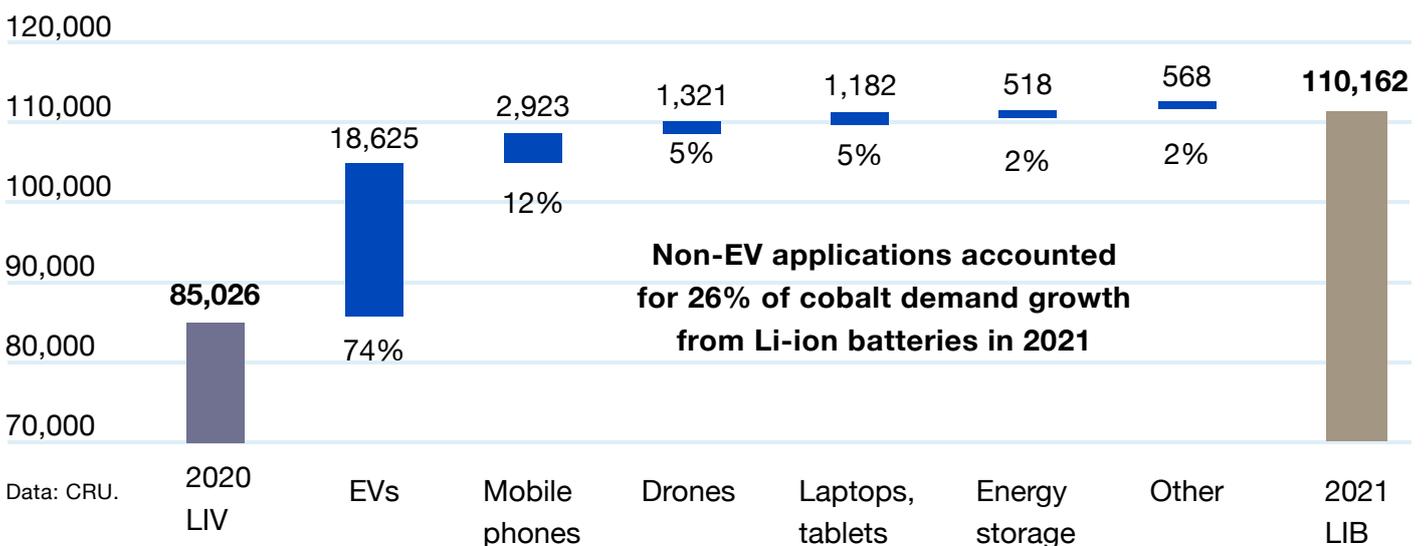
OTHER LI-ION BATTERY APPLICATIONS

Li-ion batteries accounted for 65% of 2021 demand and 85% of y/y growth. EVs are the largest part of this sector (34%) with non-EV applications making up the remaining 31% of 2021 demand, totalling 52 kt of cobalt.

Importantly for cobalt, many of the major non-EV segments rely on cobalt-containing chemistries such as LCO (lithium cobalt oxide) and NMC (nickel-manganese-cobalt). LFP, containing no cobalt, is used in segments such as energy storage and e-bikes.

Figure 15: Cobalt demand from Li-ion batteries grew by 25 kt in 2021

2021 cobalt demand growth from Li-ion batteries, tonnes Co (share of Li-ion growth, %)



Of the non-EV applications, mobile phones are the largest end use with around 26 kt of cobalt demand in 2021 and 12% of y/y Li-ion battery growth. Battery demand from mobile phones is supported by an increasing shift to 5G models with larger battery sizes, with around 40% of new models in 2021 being 5G compared to 25% in 2020. Mobile phones primarily use LCO batteries.

The next largest segment is laptops and tablets with 16 kt of cobalt demand in 2021, increasing by around 1.2 kt y/y. Alongside rising demand globally for portable devices, battery sizes are also increasing as they are for mobile phones. Laptops and tablets use a combination of LCO and NMC batteries with a declining share of NCA.

The second fastest growing non-EV sector is for drones which are increasingly being used for a number of recreational, industrial and military applications – accounting for 5% of cobalt demand growth from Li-ion batteries in 2021. The sector is dominated by LCO batteries, with a smaller share for NMC.

The use of batteries in energy storage has significant growth potential but remains a relatively small segment, with only 2.2 kt of cobalt demand in 2021 across both residential and grid applications. LFP is expected to build a strong share of this sector, with NMC and NCA maintaining a smaller share at present.

INDUSTRIAL APPLICATIONS

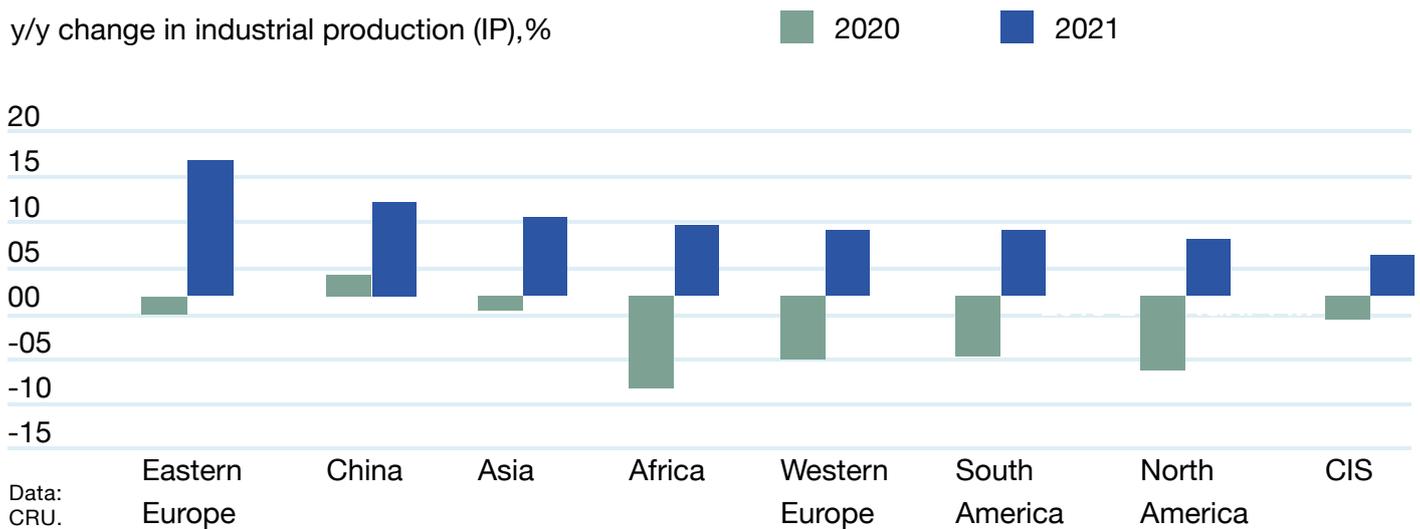
A quarter of total cobalt demand in 2021 came from industrial uses which span a large variety of both metal and chemical products. Metal applications include cemented carbides, diamond tools, alloys and magnets; chemical applications include pigments, catalysts, tyres, inks and driers. Industrial metal accounted for 57% of total industrial demand in 2021.

Cemented carbides are the largest industrial metal application, with 37% of 2021 demand. For chemicals, polyester production is the largest application (31% of 2021 industrial chemical demand), closely followed by ceramics and dyes with 28%.

The trend of cobalt demand from industrial applications is linked to industrial production (IP) in the mechanical and electrical engineering sectors. Following weak macroeconomic conditions in 2020 at the start of the pandemic, all regions experienced a substantial decline in IP, except for China. In 2021, all regions saw a rebound as the recovery from Covid weakness began. Eastern Europe, China and Asia saw the highest levels of y/y growth after also performing the best y/y in 2020.



Figure 16: Industrial production swung back to positive territory in all regions in 2021



AEROSPACE

The aerospace sector was one of the hardest hit during the pandemic and this has been acutely felt for cobalt demand from the sector, one of the largest individual metal applications. Cobalt demand for aerospace superalloys fell 19% y/y in 2020 at the start Covid-19, following a 13% fall in 2019 due to Boeing's 737 MAX aircraft being grounded for safety concerns following two crashes.

Demand recovered slightly in 2021 rising 6% y/y but remained far below previous levels – 4.2 kt in 2021 compared to 5.6 kt in 2018. Despite levels of flight activity and aircraft manufacturing improving through 2021, the industry was sitting on a large backlog of commercial aircraft inventories from 2020. This meant that cobalt purchasing has lagged the industry's recovery, with a more marked return to purchasing interest from 2021 Q4 onwards.

Aircraft production remained slow in 2021 due to the backlog from 2020, although Airbus and Boeing's (ex. 737) annual aircraft deliveries did rise. Business jet deliveries also grew 10% y/y after a fall of 20% in 2020; military demand rose by around 3.5%.

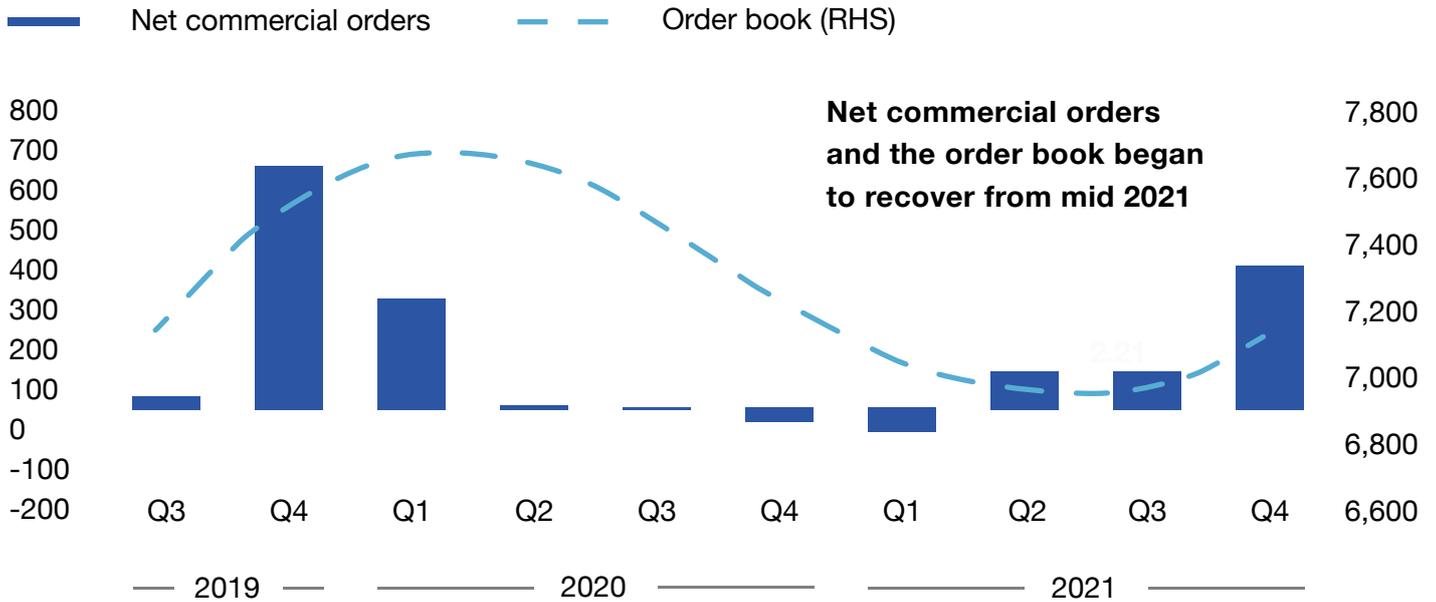
Commercial flight activity has been a key metric of industry health during the pandemic. Average flight activity fell 42% in 2020 due to travel restrictions and lockdown measures during the first phase of the pandemic. Flight activity rebounded in 2021, initially for short haul and increasingly long haul, growing 24% y/y. This occurred alongside economies adjusting to Covid-19 and travel restrictions being lifted. However, activity still remained 28% below pre-Covid-19 levels indicating the magnitude of the recovery still required. We do not expect demand to recover until at least 2023, with Boeing not expecting activity to fully normalise until 2023 or 2024.

Airbus' performance was a useful indicator of industry recovery through 2021. Net orders swung into positive territory from Q2 and the order book plateaued after a steady decline since the start of the pandemic.



Figure 17: Airbus are seeing a turnaround in aircraft demand following the peak of the pandemic

Airbus commercial aircraft demand, units



Data: CRU, Airbus.

SIZE OF THE COBALT MARKET

The cobalt market was worth approximately \$8.4 billion in 2021, up 90% y/y from \$4.4 billion in 2020.

It is complex to calculate an accurate value of a global commodity market due to regional and product-specific price differentials and spot vs. contract transactions. This estimate is for the primary refined cobalt market only (not including secondary material sources), using CRU’s refined production data. For simplicity it uses the market price benchmarks for cobalt metal (Europe) and cobalt sulphate (China) for each segment of the market. It does not take into account the location of refined production, other regional price differentials or specific product types that are produced at various assets. The prices used are those assessed in-house by CRU, on an annual average basis.



5 | THE DRC CONTINUES TO BUOY SUPPLY GROWTH

MINED SUPPLY REMAINS DOMINATED BY THE DRC

After minimal growth in 2019 and falling 6% in 2020, growth of global mined supply continued in 2021 rising 12% y/y, by 17.4 kt. The DRC accounted for 15 kt of growth, with Indonesia and Madagascar each contributing 1.6 kt as Indonesia's mined supply ramped up alongside new HPAL capacity and Ambatovy in Madagascar restarted following a Covid-19 imposed closure for much of 2020.

Figure 18: Majority of mined growth from the DRC in 2021

Mined supply growth in 2021 by major country, tonnes Co



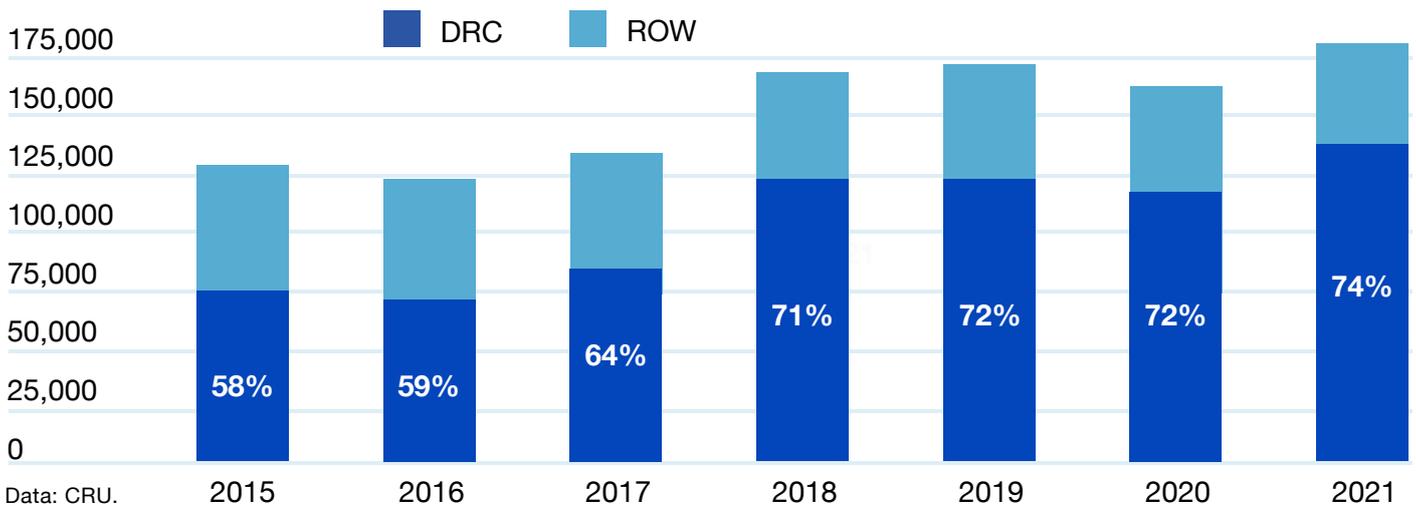
The DRC continues to dominate mined supply, with 74% of global output in 2021. The country produced 118 kt (up from 103 kt in 2020) with the next largest producer, Australia, producing 5.6 kt (3% of global supply). Cuba, the Philippines, Russia, Canada and Papua New Guinea each produced 3-5 kt in 2021, accounting for a combined 13% of supply.

With rising supply expected from countries such as Indonesia, USA, New Caledonia and Canada, the DRC will lose a small amount of global share in the coming years, albeit still remaining in the high 60s%.



Figure 19: The DRC remains the dominant mined producer in the cobalt market

Mined supply, tonnes Co

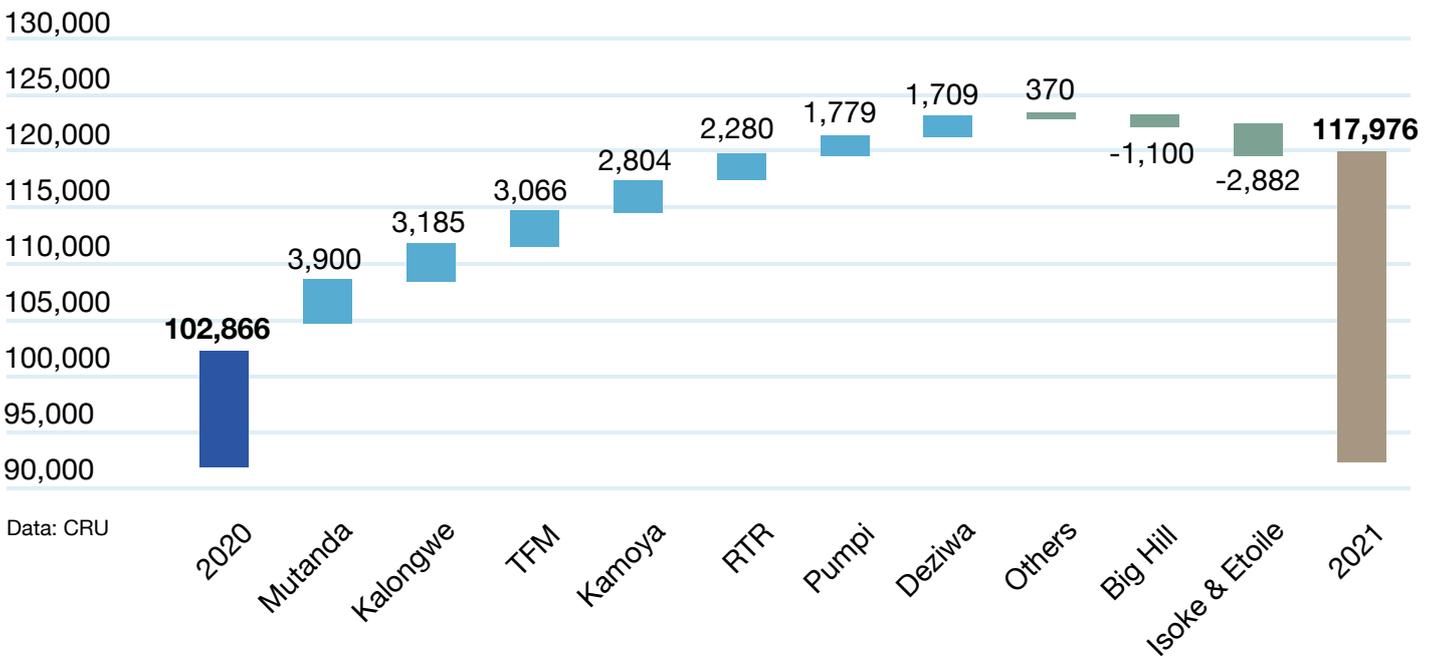


MINED OUTPUT FROM THE DRC IN 2021

Mined supply from the DRC increased by around 15 kt in 2021 from a number of key operations as described below.

Figure 20: A number of operations increased mined production in the DRC in 2021

Mined supply changes in the DRC in 2021, tonnes Co



INCREASES IN 2021

MUTANDA – GLENCORE:

- After being placed into care and maintenance in November 2019, Mutanda did not produce in 2020. In May 2021, Glencore announced that the operation would be restarted in late 2021 with stockpile volumes being processed from Q2 onwards. A total of 3.9 kt was produced in 2021.
- The processing plant restarted in October and will continue to process oxide stockpiles until 2025. Glencore plan to invest \$250 million to transition to the sulphide part of the deposit from 2028.
- Elsewhere for Glencore, Katanga had power supply issues in Q4 resulting in lower than expected annual production of 23.8 kt.

KALONGWE – CHENGTUN MINING:

- The operation continued to ramp up after starting in 2019, with 2021 production 3.2 kt higher than in 2020.
- It is understood that the current operation has capacity of approximately 7 kt/yr so we expect minimal additional volumes at present.

TENKE FUNGURUME – CMOC:

- In August, CMOC announced a \$2.5 billion expansion which aims to double production volumes. The expansion was split into two phases, the first of which ('10K project') was trialed before being fully implemented in Q4.
- The feasibility study for the second phase ('Mixed mine project') has been completed and construction is reportedly progressing well. The start of a gradual ramp is expected from 2023.

KAMOYA – WANBAO MINING:

- After successfully trialing a Phase 2 expansion in 2020 to enable higher production volumes, Wanbao's Kamoya operation has ramped up to capacity of around 5 kt of cobalt per year. 2021 production was 2.8 kt higher than in 2020.

RTR – ERG:

- The Roan Tailings Reclamation (RTR) site is now close to full production rates of 18-19 kt per year. There is potential for further output additions but this is yet to be confirmed.



PUMPI – WANBAO MINING:

- Pumpi continues to increase production after starting in 2020, with 2021 increasing by 1.8 kt.
- The ramp up is expected to be complete in 2022 to reach around 4.5 kt per year of cobalt production capacity.

DEZIWA – CNMC:

- Deziwa has completed its ramp up with around 9 kt per year of capacity. There is potential for a Phase 2 expansion, although further details have not yet been released.

DECREASES IN 2021

BIG HILL:

- Unless the operation receives further investment, we expect that it will close in the coming years. It is one of the only operations to still sell alliage blanc rather than the typical cobalt hydroxide product from operations in the DRC.

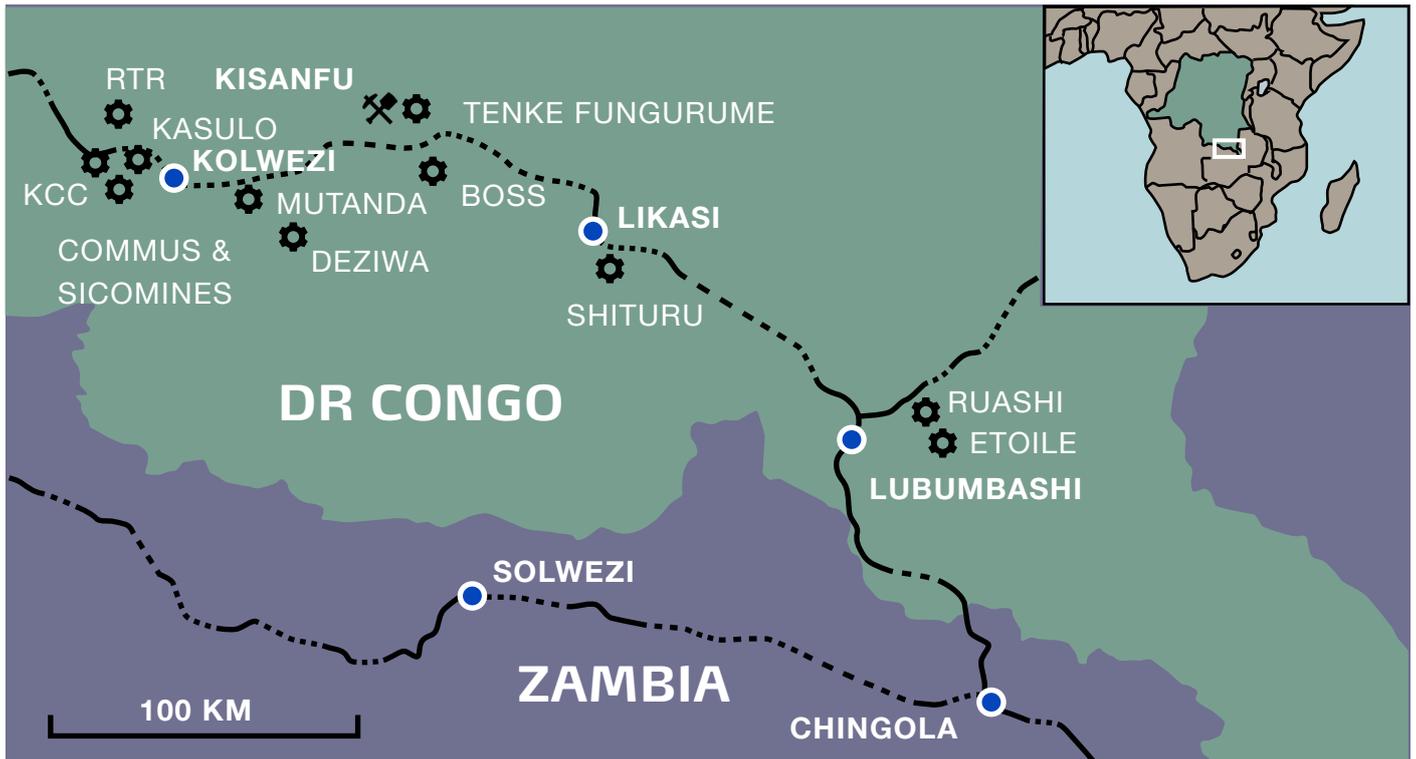
USOKE & ETOILE:

- Usoke remains closed since halting production in 2020, with Etoile continuing production. Trafigura's recent investment in Etoile (and Mutoshi) will allow a 2nd phase of production at Etoile with around 4 kt per year of cobalt capacity.

Elsewhere in the DRC, the major Chinese battery producer, CATL, acquired a 23.75% stake in the Kisanfu project in April 2021, alongside the existing shareholders of CMOC and Gécamines. The Kisanfu project is around 30 km Southwest of Tenke Fungurume and close to other major operations, so is likely to benefit from logistical synergies in the area. The deposit, discovered by Freeport before selling their stake to CMOC, has around 3.1 million tonnes of cobalt resources and 6.2 million tonnes of copper. The project is not expected to begin production until the mid-2020s. The battery industry has seen other similar investments for lithium projects but importantly this is the first time a battery maker has invested in a cobalt mining project.



Figure 21: The Kisanfu project is located close to other major operations around Kolwezi



ARTISANAL MINING OUTPUT INCREASED FOLLOWING STRONG PRICES

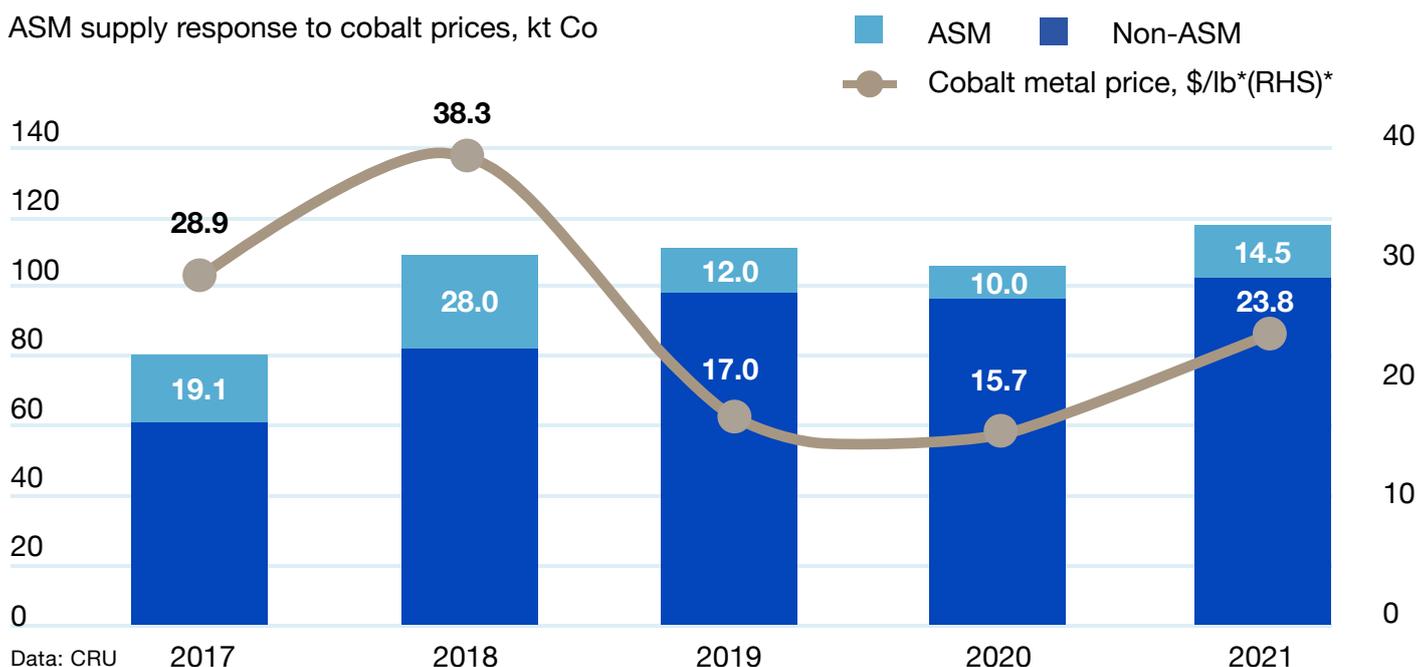
Artisanal and small scale mining (ASM) activity increased in 2021 in response to rising prices through the year. Swing ASM supply continues to react quickly to price dynamics.

CRU estimate* that ASM mining in the DRC accounted for around 14.5 kt of production in 2021 – this equates to 12% of mined supply from the DRC and 10% globally. This rose 45% y/y from 10 kt in 2020 when annual prices averaged \$8/lb lower.

With prices continuing to rise in early 2022, we expect ASM supply to be even stronger and account for a larger share of both DRC and global mined supply.

* Due to the nature of the artisanal and small scale mining (ASM) sector in the DRC, it is currently very difficult to determine exact volumes of production. CRU has developed a methodology for estimating the approximate volume of cobalt produced by ASM in the DRC. This is based on statistics published by the DRC Ministry of Mines and CRU's understanding of individual mining operations. Annual estimates are also cross-checked with other industry sources.

Figure 22: The ASM sector continued to react to cobalt prices in 2021



ASM DEVELOPMENTS – THE EGC AND THE RMI

The Entreprise Générale du Cobalt (a subsidiary of Gécamines), the EGC, was formed in 2019. In March 2021, the entity released a new ‘Responsible Sourcing Standard’ document which outlined their planned formalisation of the ASM sector in the DRC. As stated in the document, the EGC “holds the monopoly for the purchase, treatment, transformation, sale and export of cobalt extracted by artisanal miners”. Trafigura will assist with the traceability of production and identifying potential buyers. The not-for-profit PACT are responsible for continuous improvement of the standards.

The new standards appeared to be a positive step towards ensuring ethical and traceable cobalt supply from the ASM sector, albeit with uncertainty around the enforcement of the standards and the EGC’s control due to the large size and disperse nature of the ASM sector. There have been announcements since in relation to operating guidelines, ASM formalisation and pricing mechanisms, but no significant changes in production or market conditions.

The Kasulo site is currently a semi-formalised ASM operation run by Congo Dongfang International Mining (CDM) which has been a focus of the proposed changes by the EGC. Prior to 2012, Kasulo was a residential area until cobalt was discovered and it was then quickly mined by large numbers of individual artisanal miners and small cooperatives.

It appears that there are a number of political, governmental and commercial barriers remaining before the EGC has a material impact on the ASM sector in the DRC. For example, CDM has the rights to Kasulo and has been operating this as an ASM site since 2012. The EGC announced that this would be their first ‘official site’ although it is understood that CDM or the local cooperative were not consulted and the EGC have no rights to this site. If the EGC do operate this site in future then this will not result in any additional cobalt units as production is already taking place.



The Agency for Regulation and Control of Strategic Mineral Substance Markets (ARECOMS) will regulate any of the EGC's proposed changes to the structure of the ASM sector, although this agency is also only in the early stages of development. It is therefore unlikely that the EGC will be able to enforce any significant short term changes. We continue to monitor developments but currently expect the ASM sector to continue as normal, with no material impact on production volumes.

The Responsible Minerals Initiative (RMI), an initiative of the Responsible Business Alliance (RBA), has also confirmed its next steps in supporting the responsible sourcing of artisanal cobalt from the DRC. A memorandum of understanding (MOU) between the RMI and the Global Battery Alliance (GBA) was signed in February 2022 to define the next phases of the work that was initially undertaken by the GBA's Cobalt Action Partnership (GBA CAP). The new agreement recognizes the need for greater market clarity regarding ASM cobalt sourcing expectations and the roles of initiatives working in this space. The MOU outlines the RMI's specific role in developing clear sourcing expectations for ASM cobalt that promotes improved conditions at mining sites and acceptance into global supply chains. It further highlights that the sovereignty of the government of the DRC is paramount, and engagement with the DRC government and stakeholders is necessary for progress.

REFINED METAL AND CHEMICAL MARKETS FAR APART IN 2021

Primary refined supply, including both metal and chemical products, grew by 17.9 kt in 2021 to 144 kt. The market rebounded after less than 1 kt of growth in 2020 at the start of the pandemic. With 72% of total primary production (104 kt in 2021), China is by far the largest refiner of cobalt globally. The next largest is Finland with 14 kt, or 10% of supply.

As the largest contributor, China also provided a significant share of growth in 2021 – 71%, or 12.8 kt. Finland, Indonesia and Madagascar combined provided 27% of 2021 growth. Growth in Finland came from the Kokkola refinery where Jervois acquired Freeport Cobalt in July 2021. In Madagascar, Ambatovy's refinery restarted alongside the mine operation in April 2021. China and Indonesia will be discussed in more detail below.

In 2020, the metal market was particularly impacted by the start of the pandemic, due to a number of its industrial end uses, and as a result refined metal production fell by 2.9 kt. Due to margin pressures (discussed further below), the metal market continued to struggle in 2021 resulting in a further 2.3 kt (-7% y/y) decrease in global refined production. The chemical market, on the other hand, saw a significant rebound after limited growth in 2020 due to much more favourable market conditions – refined chemical production grew by 20.2 kt (22% y/y) in 2021.



Figure 23: China provided 71% of global refined supply growth in 2021

Primary refined supply (metal & chemical) changes in 2021, tonnes Co

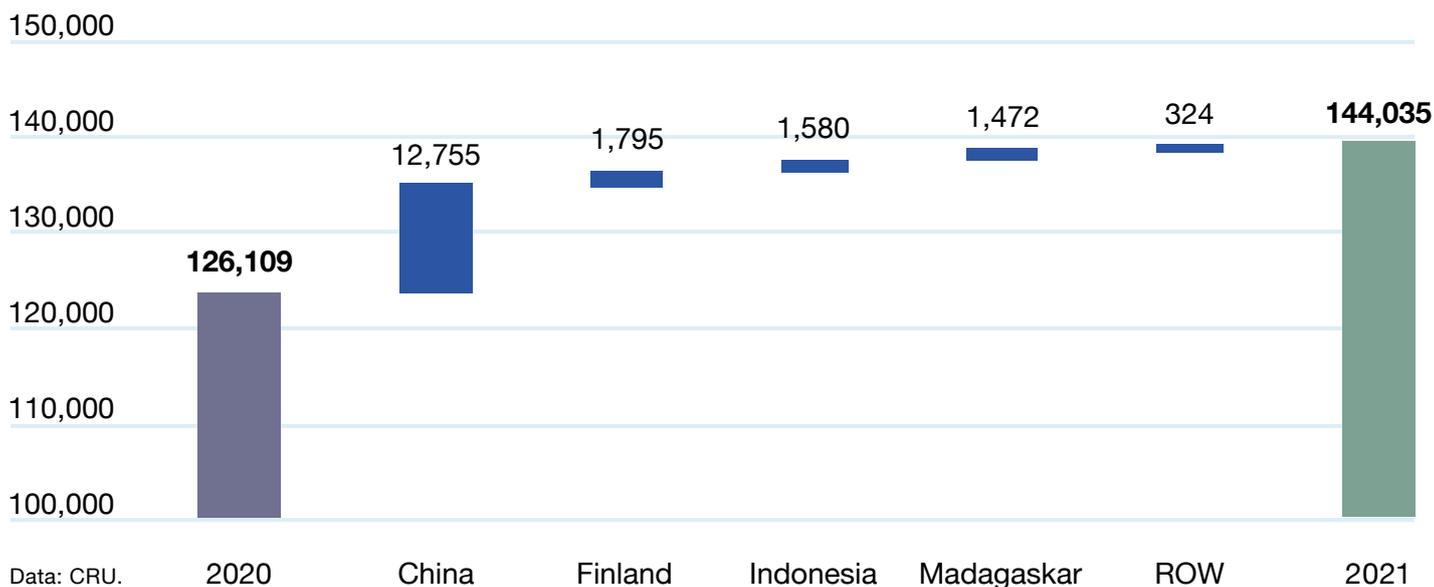
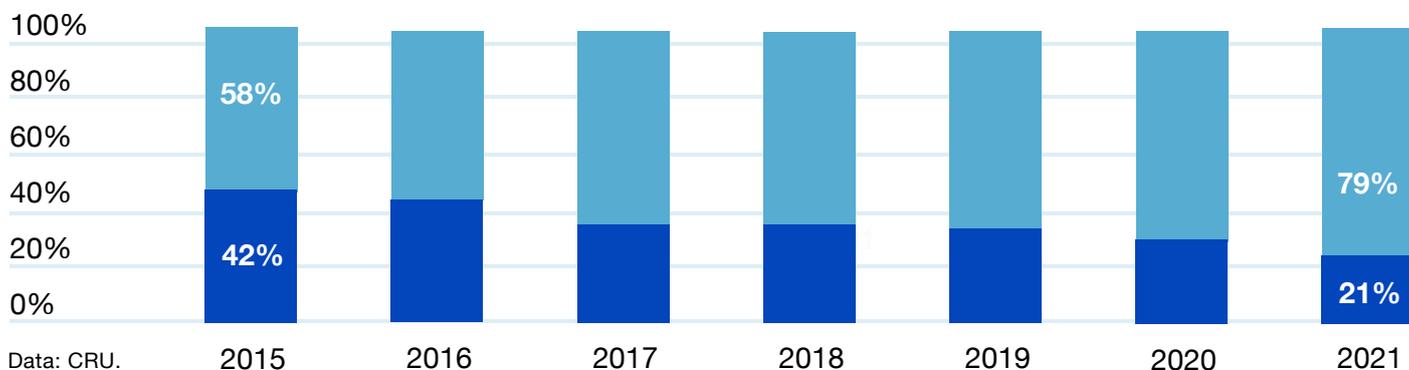


Figure 24: Cobalt chemicals accounted for 79% of total refined production in 2021

Share of global primary refined production, %

■ Metal ■ Chemical



REFINED CHEMICALS IN CHINA

China's cobalt chemical production increased by 17 kt in 2021 to 97 kt, up 21% y/y compared to 6% growth in 2020. China's dominance of the cobalt chemical market is even greater than total refined production as a whole with 85% of global primary chemical production in 2021.

The major producers that increased capacity in 2021 include Huayou, GEM/KLK and Hanrui, Smaller additions came from Shanghai Greatpower, Tengyuan, Yi Hao Umicore and Yingde Jiana. Due to weakness in the metal market, some producers chose to produce chemicals instead of metals thanks to flexibility in their production processes.

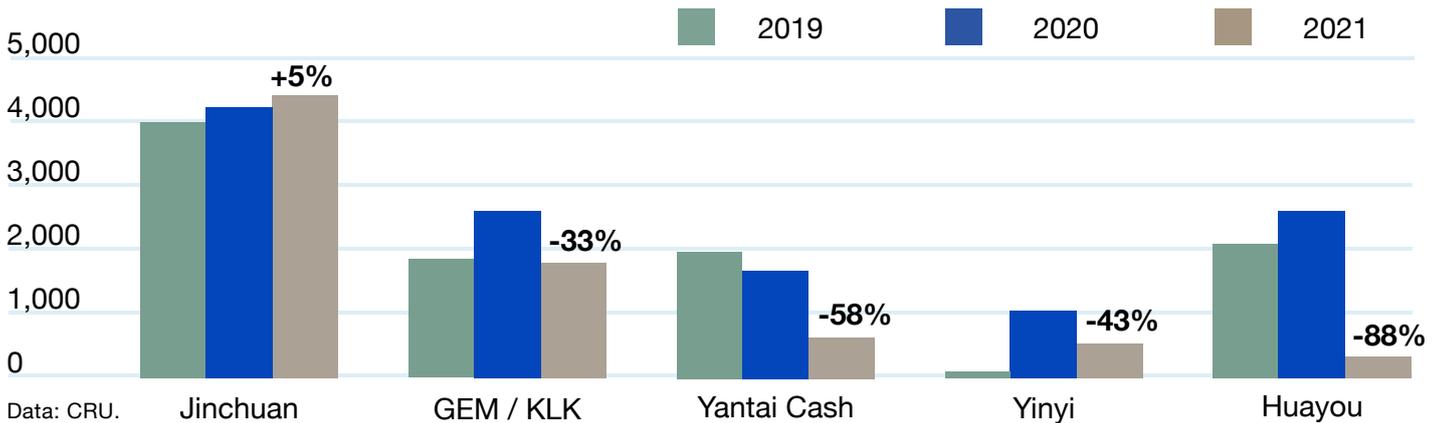


REFINED METAL IN CHINA

The Chinese metal market had very different fortunes in 2021, falling 35% y/y after 20% y/y growth in 2020. Three (of five) companies halted production for multiple quarters as they battled negative margins, with output low for the remainder of the year to satisfy only existing contracts. Jinchuan, a state-owned enterprise (SOE), was the only producer not to significantly reduce output in 2021 due to higher realised prices (from high grade applications) and contract obligations.

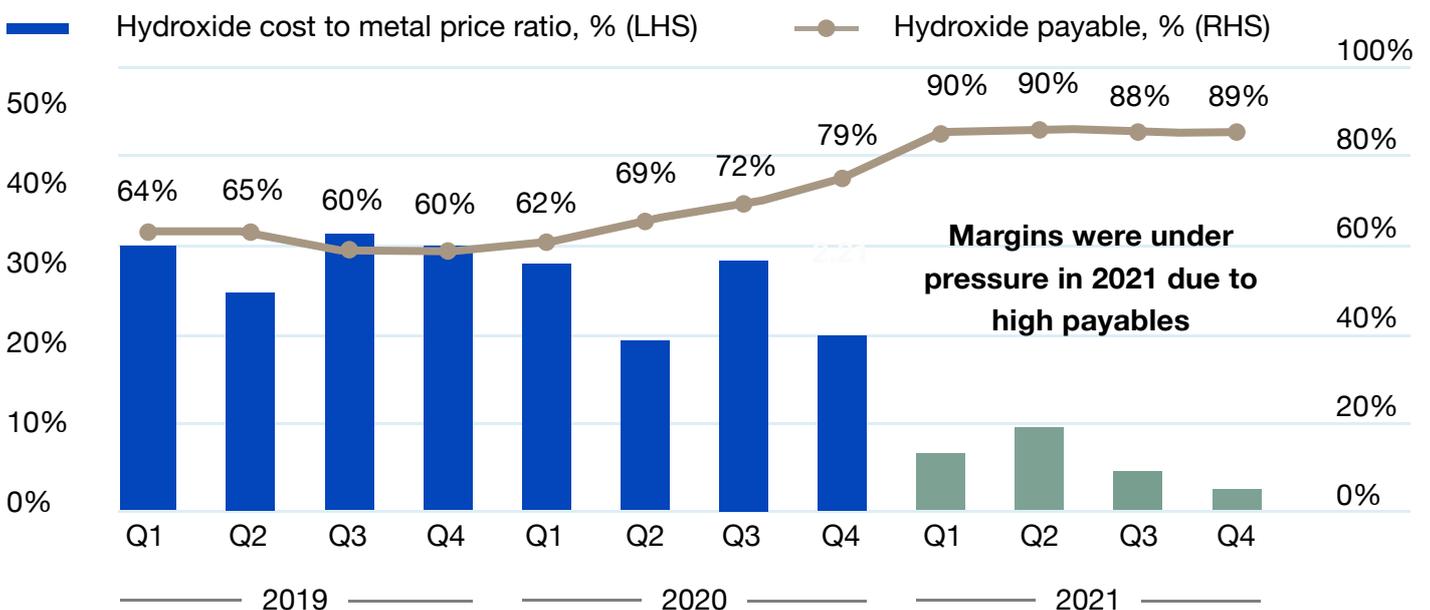
Figure 25: Chinese metal production fell 35% y/y in 2021

Chinese cobalt metal production, tonnes Co



Before the pandemic, hydroxide payables were significantly lower, averaging in the low 60s in 2019, leading to higher margins for metal producers. In 2020, payables varied but steadily rose through the year. However, in 2021, payables were persistently high (averaging around 90%) impacting the margins of metal producers in China and forcing many producers to slow or stop production. Payable drivers will be discussed in more detail in the next chapter.

Figure 26: High payable levels in 2021 have negatively impacted Chinese metal margins



Data: CRU, market participants.



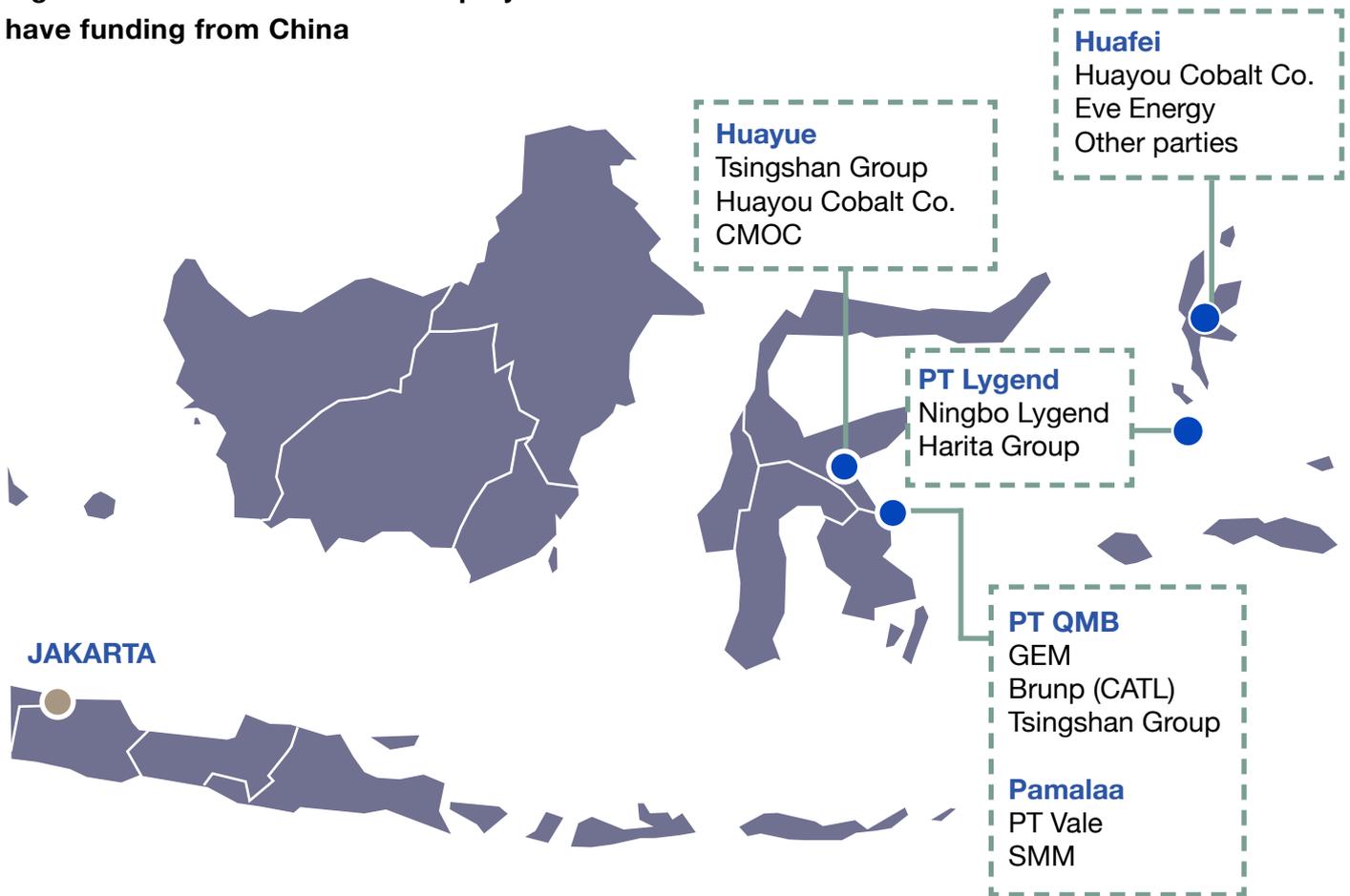
INDONESIAN HPALS

Indonesia is the largest growth market for refined cobalt production after China. Despite not producing refined cobalt prior to 2021, in the medium term the country is expected to provide a quarter of total refined and 32% of refined chemical growth. Cobalt mining is also rising in the country as the HPAL facilities are processing domestic Ni-Co laterite deposits.

A number of new High Pressure Acid Leach (HPAL) facilities are planned in Indonesia, two of which started in 2021 and will continue their ramp up in 2022 – PT Halmahera Persada Lygend (PT Lygend) and Huayue Nickel & Cobalt. At least two further HPALs are also expected in the short term (PT QMB in 2022 and Huafei in 2023).

PT Lygend started production in May and successfully installed two autoclaves in 2021. In Q4 they announced that an additional four autoclaves would be added by 2023 increasing capacity to 15 kt/yr Co and 120 kt/yr Ni, doubling of the original capacity plan.

Figure 27: Four of the five HPAL projects in Indonesia have funding from China



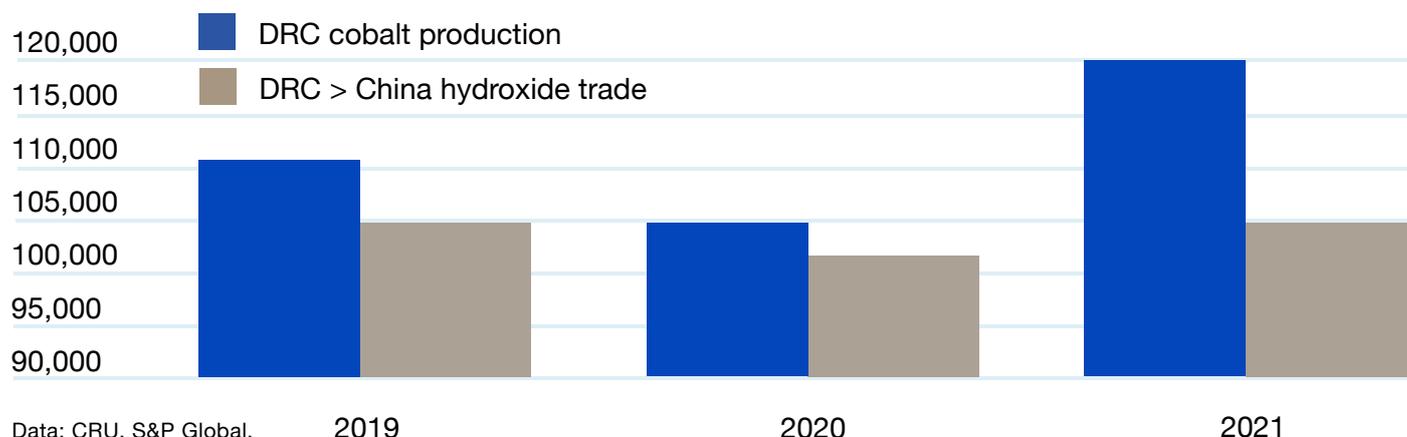
6 | SUPPLY CHAINS REMAIN A CONSTRAINT ON THE MARKET

HYDROXIDE EXPORTS FROM THE DRC PLAGUED BY SUPPLY CHAIN BOTTLENECKS

Supply chain bottlenecks have been a persistent feature of the Covid-19 pandemic for many markets and cobalt has been no exception. The major trade route, from the DRC to China via South Africa (China typically purchase 90-95% of material from the DRC) has been particularly impacted which has caused volatility in cobalt hydroxide volumes reaching China. This has been seen throughout the pandemic but most acutely in 2021. Despite mined production increasing by 15 kt in 2021, and Chinese demand rising rapidly, imports into China did not match this, with the balance not sold to other markets. This disconnect emphasises the magnitude of the supply chain constraints and the backlog of material in South Africa through 2021 and into 2022.

Figure 28: Disconnect between the DRC's production and exports to China in 2021

DRC cobalt production and exports to China, tonnes Co



Through 2021 there were a number of drivers of supply chain bottlenecks, both local and international. Freight routes were already under pressure in 2020 from Covid-19 restrictions, quarantine procedures and inconsistent levels of demand with container rates rising in late 2020 as global demand started to pick up again after the first wave.

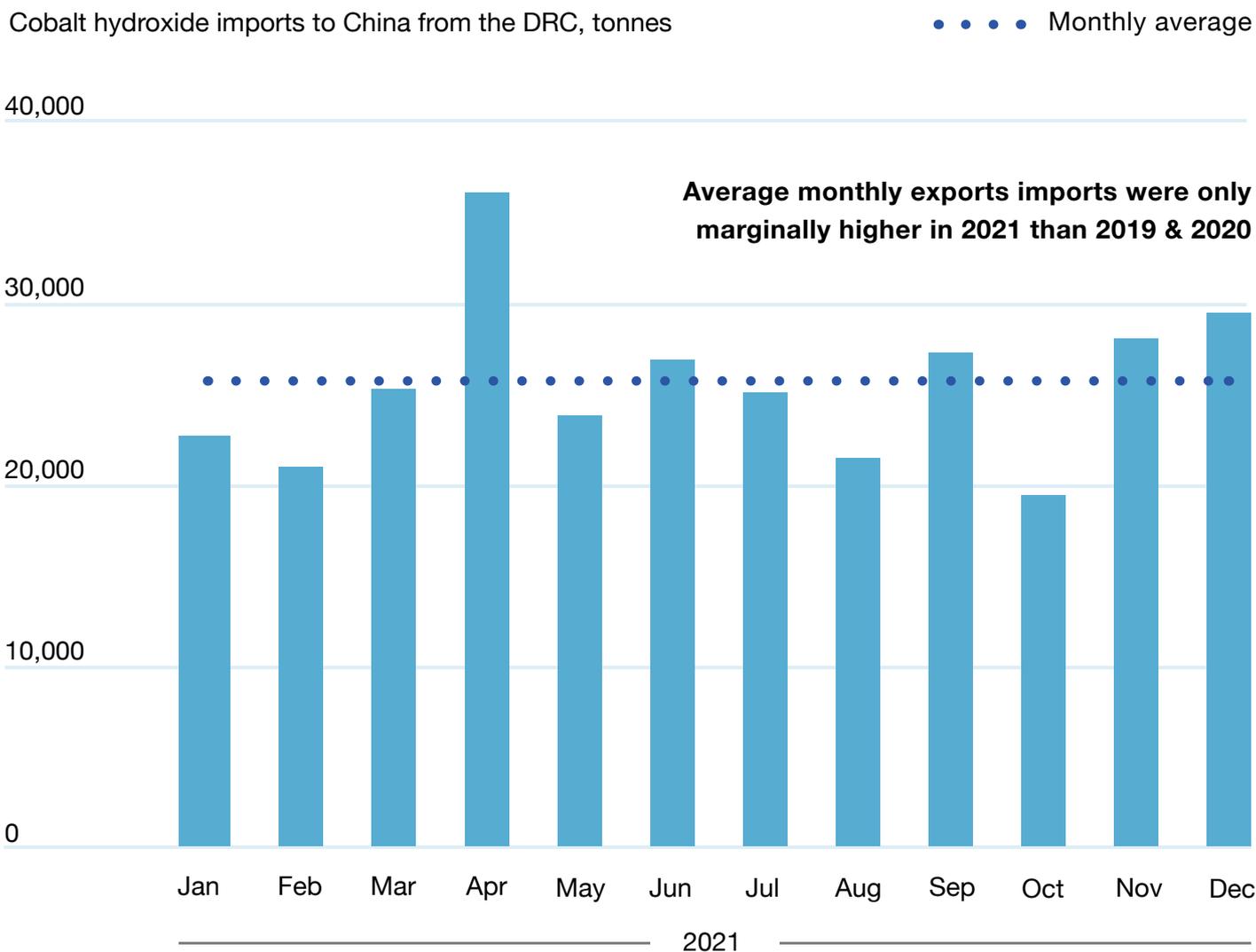
In South Africa, issues began in August 2020 as tightened Covid-19 restrictions slowed processing at the Port of Durban, with renewed restrictions in early 2021. In April, various issues along the DRC to Durban route slowed trucking freight. In July, there were violent riots and civil unrest after former President Zuma was imprisoned, again slowing the port.



Container rates have also pressured international freight markets. Rates rose during 2020 but soared in 2021 as shipping demand bounced back and container supply was limited (Covid-19 restrictions and delays) causing shortages in most regions. Drewry's World Container Index rose from around \$5,000 per 40 ft container in Q1 to a peak of more than \$10,000 in October, after being below \$2,000 in early 2020.

Supply chain constraints slowed volumes reaching China from the DRC and kept hydroxide payables persistently high throughout 2021. This put a significant amount of pressure on the Chinese metal industry in particular and continues into early 2022 as various supply chain bottlenecks continue.

Figure 29: Volumes of cobalt hydroxide from the DRC to China were volatile throughout 2021



Data: CRU, S&P Global. Note: South Africa to China shipping typically 30-40 days without delays.



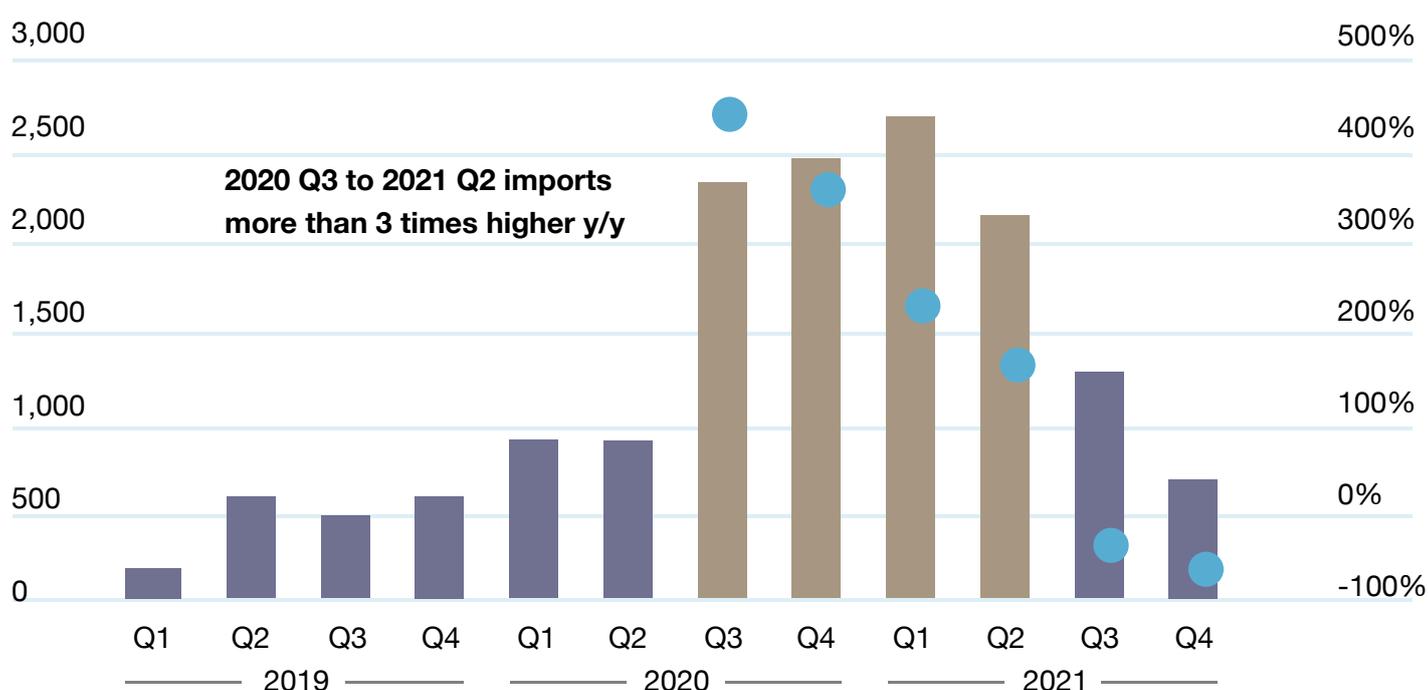
CHINESE METAL IMPORTS BOOM TO FEED CHEMICAL REFINERS

With tight intermediate availability in late 2020 and into 2021 leading to high payables, Chinese chemical producers turned to other feedstocks, namely cobalt metal. Alongside reduced metal output from domestic producers (also due to high hydroxide costs), volumes were sourced from the international market with imports rising dramatically from 2020 Q3. This was also driven by European metal prices remaining at a discount to Chinese metal due to the relative weakness of the market.

From 2020 Q3 until 2021 Q2, imports averaged 279% higher y/y. In volume terms, China imported more than 9 kt of metal compared to 2.6 kt in the equivalent period from 2019-20. Imports adjusted down from 2021 Q3, although remained above pre-pandemic levels.

Figure 30: Chinese metal imports boomed with hydroxide prices high and European metal prices low

LHS: Chinese metal imports, tonnes Co; RHS: y/y change, %



Data: CRU, S&P Global.



7 | PRICES DOUBLE THROUGH 2021

OVERVIEW OF COBALT METAL BENCHMARK PRICES IN 2021

Q1: PRICES UP 37% Q/Q

- China's State Reserve Bureau (SRB) announced its intention to buy 2 kt of cobalt in 2020 Q3 and a second round of stockpiling (3 kt) followed in January 2021. This lifted prices from \$16/lb in early January to \$20 by February.
- Prices continued to rise throughout Q1 on the back of strong demand and logistics constraints increasing intermediate costs. Metal prices finished the quarter at \$25/lb.

Q2: PRICES DOWN 1% Q/Q

- Spot market activity was weak through April and May. As prices rose in Q1, many end users purchased ahead of requirements and destocked into Q2. This caused prices to adjust down, from \$25/lb in late March to \$21 by the end of Q2.
- Weak spot market purchasing was exacerbated by the increasing popularity of longer term contracts to mitigate rising prices. This is particularly the case for hydroxide with most new volumes already assigned to existing contracts.

Q3: PRICES UP 14% Q/Q

- Prices began to rise again from the start of Q3, increasing from \$21/lb to \$24 in July alone with limits on intermediate supply (particularly hydroxide exports from South Africa), strong downstream demand and tight market conditions.
- The spot market was quiet for the remainder of Q3 during the Northern Hemisphere summer with prices maintaining at around \$24/lb.

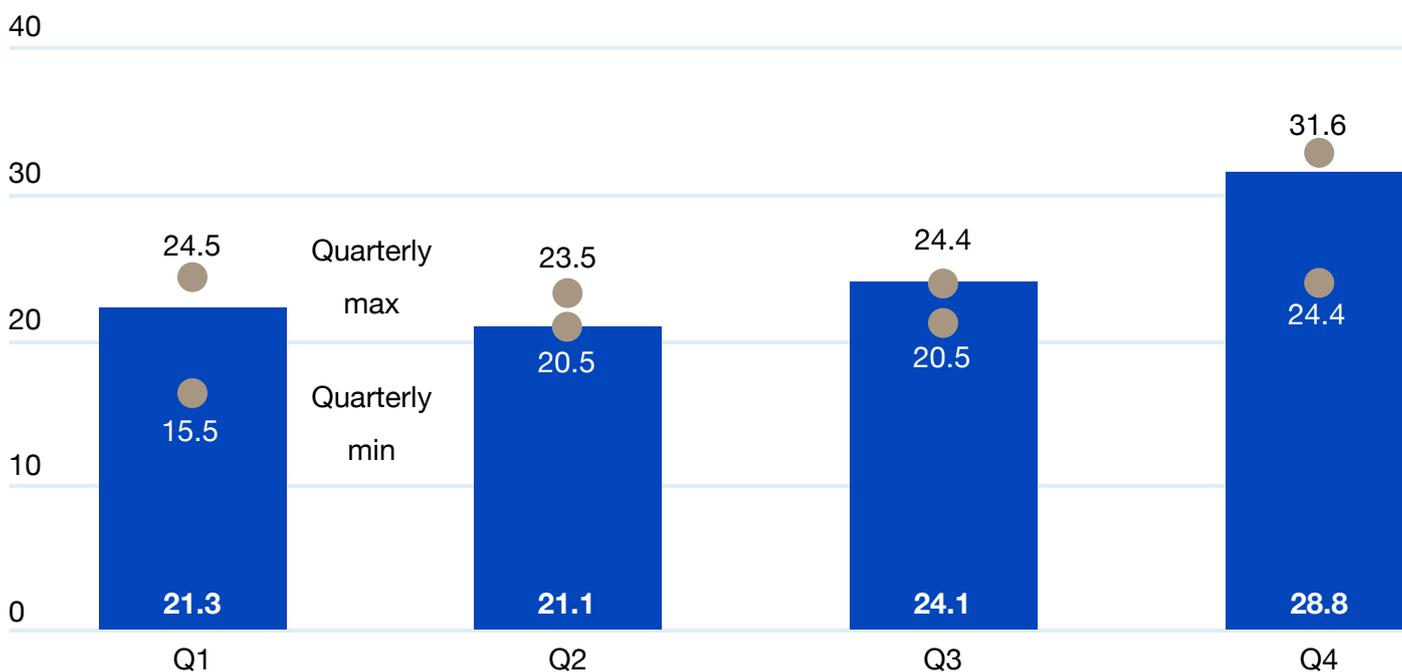
Q4: PRICES UP 20% Q/Q

- Activity in the European market picked up ahead of contract negotiations during Q4. Prices rose by 29% from early October to December due to strong demand during the annual contract negotiation period (discussed below).
- Price rises gained pace as the market deficit continued to widen, lifting to \$27/lb in October, \$29 in November and finishing the year at \$32.



Figure 31: Cobalt metal prices doubled in 2021, from \$16/lb in January to \$32/lb in December

Quarterly average, minimum & maximum European cobalt metal prices*, \$/lb (nominal)



Data: CRU Price Assessments. Note: * EU Co 99.8% min (ex. works).

EUROPEAN MARKET HAS REMAINED WEAK RELATIVE TO CHINA

European metal prices have consistently been below Chinese prices since late 2020 due to weaker demand recovery in Europe following the first wave of the Covid-19 pandemic. Due to this and weak domestic metal supply, China switched to become a net importer of metal in 2020 and 2021 after traditionally being a net exporter.

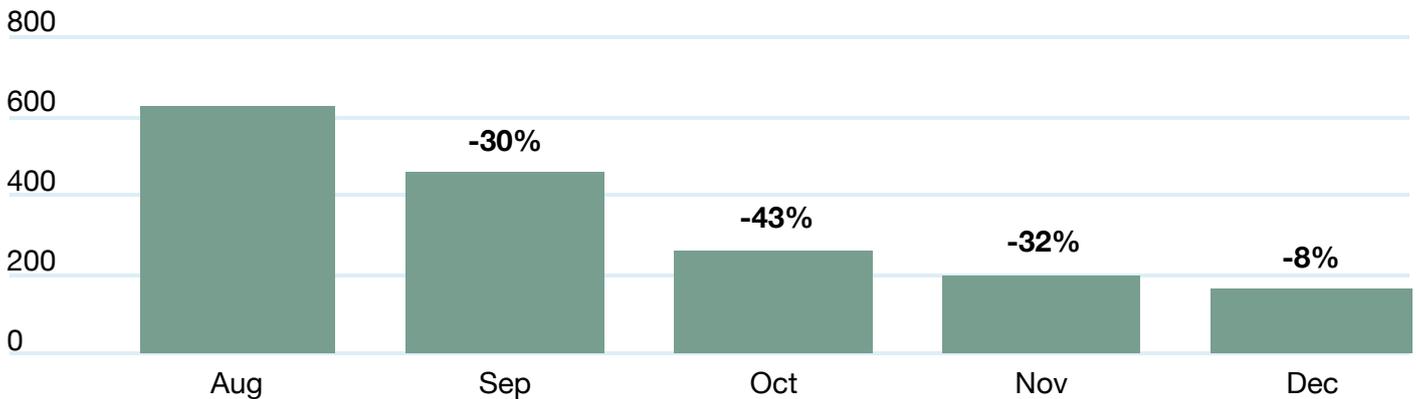
European metal prices averaged a discount of -\$2.5 relative to Chinese prices in 2021, with the discount persisting since mid-2020. Discounts have varied but reached as high as -\$3.85 in May 2021. According to CRU's in-house price assessments, Chinese metal prices averaged \$26.3/lb in 2021, compared to \$23.8/lb for European metal.

The reduction of metal refining in China and tight market conditions has weighed on Wuxi Exchange stocks with volumes declining by more than 500 tonnes from August to December.



Figure 32: Wuxi Exchange stocks declined through the second half of 2021

Estimate of cobalt metal stocks on Wuxi Exchange, tonnes Co (m/m change, %)



Data: CRU, market participants.

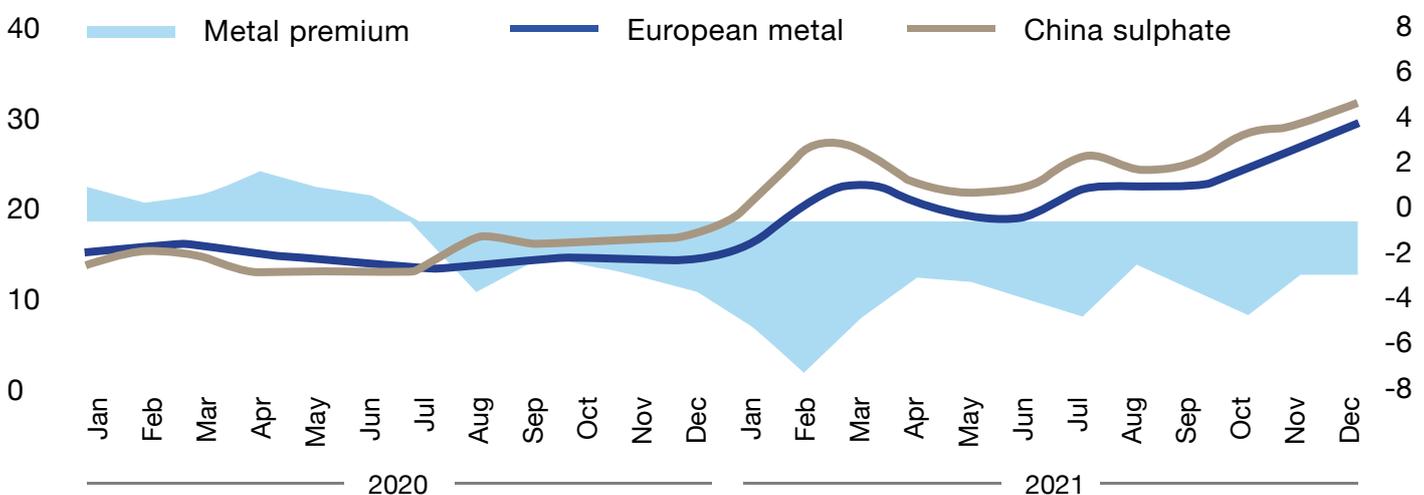
RAPID CHEMICAL DEMAND GROWTH MAINTAINING SULPHATE PRICES ABOVE METAL

Up to mid-2020, European metal prices were typically at a premium to Chinese sulphate. However, with demand for sulphate rising as the Li-ion battery market surges, sulphate has maintained a price advantage over European metal.

In the second half of 2020, sulphate prices averaged \$2.2/lb above metal. In 2021, the premium increased to \$3.6/lb on average, with a high of \$6.8/lb in February. The story is the same in China, with Chinese sulphate averaging a premium of \$1.1/lb over Chinese metal prices in 2021, with only a few occasions where metal was at a brief premium.

Figure 33: Chinese sulphate has maintained a premium over European metal since mid-2020

Monthly average Chinese sulphate and European metal prices*, \$/lb (nominal)



Data: CRU. Note: * EU Co 99.8% min (ex. works); Co sulphate 20.5% (China 100%-Co basis).



LONG TERM CONTRACT NEGOTIATIONS PROVIDE CLUES TO 2022 AND BEYOND

Contract negotiations for the subsequent year typically take place during Q4 and are a useful indicator of market sentiment. In 2021, demand was very strong in what was certainly a sellers' market.

Compared to the norm of discounts to benchmark prices, many producers reported flat prices and some small premiums in their agreed contracts for 2022, for both cobalt hydroxide and metal. Discounts were very small if at all.

Premia in contracts are typically uncommon indicating that demand for contract volumes was particularly high and end users were looking to lock in volumes. This is consistent with the tight market conditions seen during much of 2021, limited spot market availability and high price and payable levels.

Many producers were well sold indicating that spot volumes will remain limited again in 2022. Some producers also commented that they had interest from new customers who are looking to secure initial, small volumes to ensure that they have access to contract volumes in future years – this is another indication that market conditions were tight and participants expect limited availability going forwards.

There continues to be interest in longer-term agreements, either in fixed volume contracts or as a memorandum of understanding (MOU), supporting the expectation of tighter market conditions in future.



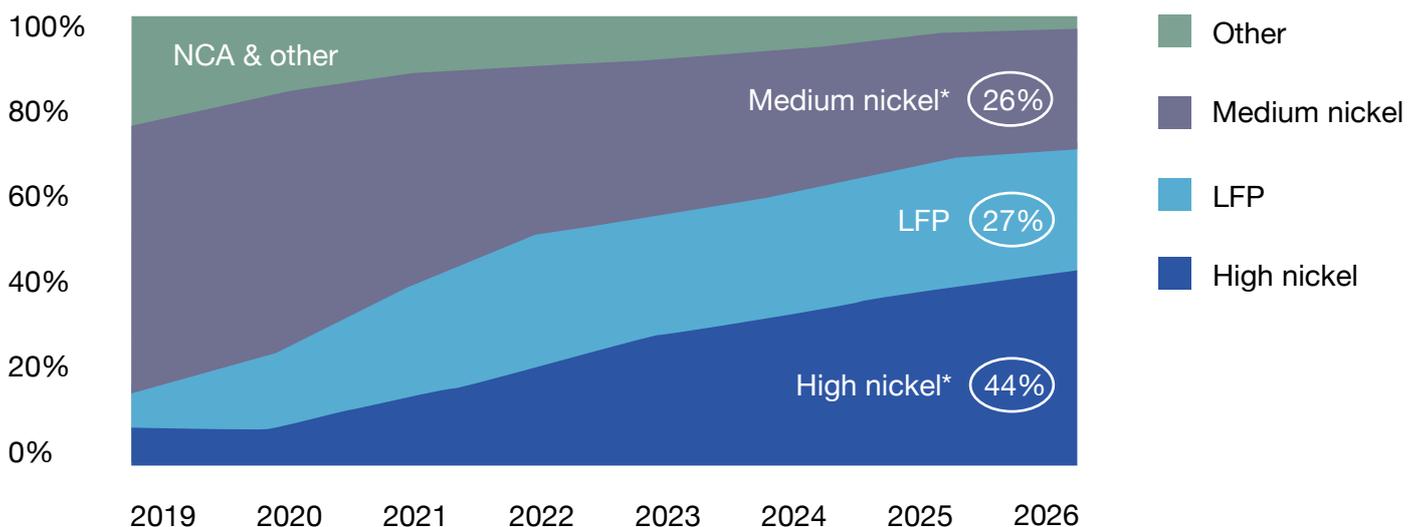
8 | COBALT MARKET OUTLOOK

DEMAND TO EXCEED 300 KT IN THE MEDIUM TERM

Cobalt demand is expected to continue to rise rapidly as part of the global energy transition and shift to EVs. In the next 5 years, demand is forecast to approach 320 kt from 175 kt in 2021, rising at a CAGR of 12.7%. EVs alone will drive around 70% of this growth with other battery applications contributing 20%. By 2026, EVs will account for half of cobalt demand.

By 2026 we expect NEVs to account for more than a fifth of annual light vehicle sales, from 8% currently in 2021, with BEVs progressively taking share relative to PHEVs. This equates to an additional 17 million of annual NEV sales compared to 2021. The EV market will continue to progressively shift towards higher nickel intensity nickel-cobalt chemistries as well as LFP to suit varying consumer requirements – high nickel cathodes are forecast to account for around 44% of EV cathode demand in 2026 compared to 27% for LFP.

Figure 34: High nickel chemistries will sit alongside LFP as the cathodes of choice for EVs



Data: CRU. Note: * High nickel chemistries include NMC721, NMC811 and NCMA; medium nickel chemistries include NMC532 and NMC622 – all contain cobalt.

In April and May 2022, the Covid-19 lockdowns in Shanghai and other regions are posing a risk to the battery supply chain. Around 15% of precursor/cathode capacity and 40% of gigafactory capacity is being impacted by restrictions as of late April and a number of automotive factories are closed due to the measures or issues with sourcing parts. NEV sales are likely to be lower than expected in April and May after sales rose 143% y/y in Q1. However, The Ministry of Industry and Information Technology (MIIT) has recently announced new policy to support industries to restart and reduce the economic impact of the Covid-19 outbreak – we expect the majority of the battery supply chain to be operating again from mid-May onwards. The duration of the outbreak and timeframe for easing restrictions will determine the overall impact on the supply chain and therefore raw materials demand.



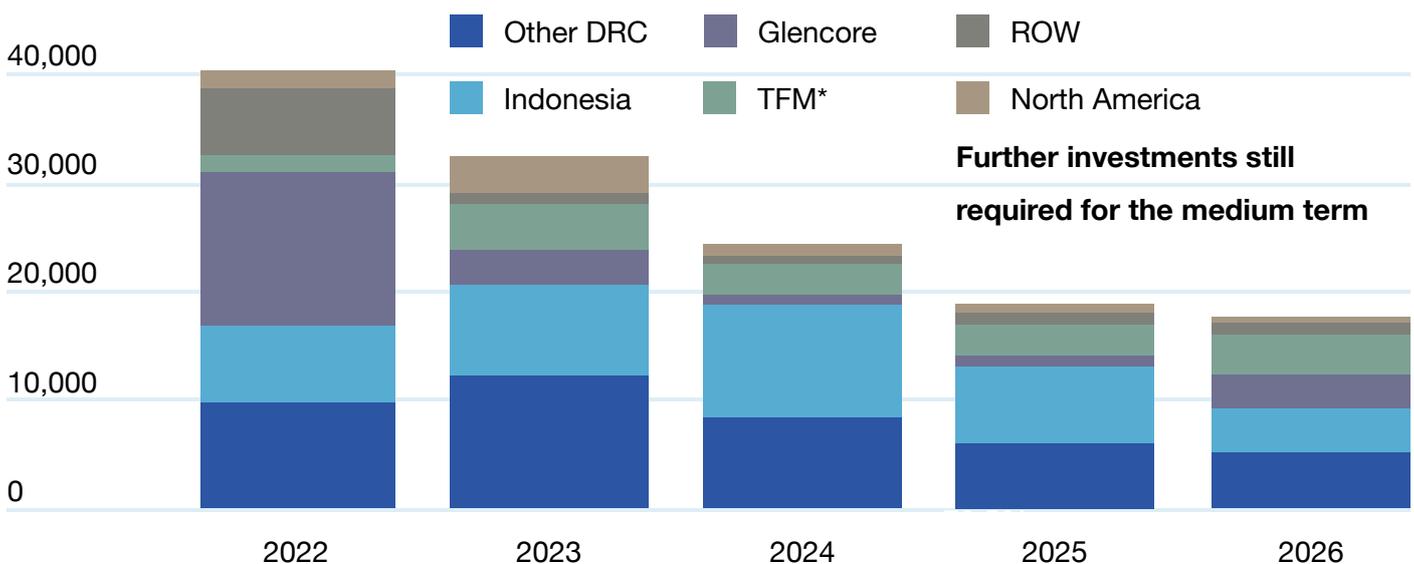
SUPPLY NOT KEEPING PACE WITH DEMAND DESPITE INVESTMENTS

Supply growth will lag demand in the medium term, particularly for mined supply. We expect refined supply to keep pace with mined volumes. Rising prices over the last 12 months have incentivised further supply side investments but these are currently insufficient to meet the rate of demand growth. Mined supply will continue to see healthy increases y/y in 2022 and 2023 before starting to fall away from 2024 onwards.

The DRC and Indonesia will contribute close to 90% of mined cobalt growth in the medium term, with smaller but rising volumes also from the USA and Canada. The key assets in the DRC include the Tenke Fungurume expansion (CMOC), the start of Mutoshi (Chemaf), Mutanda’s ramp up (Glencore), increased output from Katanga (also Glencore) and new cobalt production at Kinsevere (MMG). In Indonesia, increased domestic mined supply will support the new HPAL refining capacity.

Figure 35: Healthy mined supply growth in short term but declines in medium term

y/y mined supply additions, tonnes Co



Data: CRU. Note: * TFM = Tenke Fungurume.

Supply chain bottlenecks, particularly with the backlog of material from the DRC in South Africa, continue to be a key constraint for the cobalt market and are limiting production growth from the DRC reaching the market. The war in Ukraine and recent Covid-19 lockdowns in China have slowed the recovery of global ocean freight and severe flooding at the Port of Durban in April will further delay hydroxide exports to China. Freight routes were expected to begin to normalise in the second half of 2022, but this is now at risk of being pushed back to later in the year or even into 2023. Until this happens, hydroxide payables will remain elevated and put pressure on refiners, and particularly metal production in China.



The war in Ukraine has been a source of uncertainty for many commodities and led to market volatility. However, the impact on the cobalt market has been relatively muted so far. Prices have continued to rise since the start of the invasion with pre-existing market tightness and general global economic uncertainty the key drivers. The reason for the limited impact is that Russia only accounts for around 2.5% of global mined supply from Nornickel's cobalt and nickel mine in Norilsk; a similar proportion of refined supply comes from Nornickel's metal refinery and their Harjavalta chemical refinery in Finland. These assets are reportedly only experiencing minor impacts to production volumes and have needed to adjust logistics routes around sanctions and other measures. Some customers have avoided purchasing spot volumes from Nornickel, but others continue to source their material as part of contracts or on the spot market.

MARKET MORE BALANCED IN SHORT TERM BUT FACES MEDIUM TERM DEFICITS

Following a deficit of around 14 kt developing in 2021, the market is expected to be more balanced in 2022 and 2023 as supply additions keep pace with demand growth. Although this is on the assumption that supply chains begin to normalise from the second half of 2022 which continues to be at risk of further delays.

In 2024, the market is forecast to shift back into a deficit which will widen into the medium term as supply growth fails to keep pace with demand. From 2024-26, supply growth will average 8% per year, compared to more than 12% for demand.

Prices are forecast to adjust down marginally and steady in a more balanced market in the short term. Beyond that, prices will remain elevated to incentivise further investment and prevent wide deficits developing. Supply side investment remains critical to ensure sufficient supply into the longer term as cobalt demand continues to rise even higher.



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10 | ABBREVIATIONS & DEFINITIONS

GENERAL:

ASM: artisanal and small scale mining.

CAGR: compound annual growth rate in percentage terms, %.

DRC: Democratic Republic of the Congo.

EGC: Entreprise Générale du Cobalt (a subsidiary of Gécamines).

HPAL: high pressure acid leaching technology used for cobalt and nickel refining.

IP: industrial production, an economic measure of the output of the industrial sector of an economy.

kt: kilotonnes, equivalent to 1,000 metric tonnes.

Li-ion: lithium-ion battery, the current dominant battery technology. LIBs have a higher energy density (amount of energy stored for the weight of the cell) than all competing battery types, meaning they have dominated usage in portable electronics and electric vehicles.

OEM: original equipment manufacturer, e.g. automotive company.

SOE: state-owned enterprise in China.

SRB: State Reserve Bureau in China.

y/y: year on year change.

BATTERY CATHODE CHEMISTRIES:

LCO: a lithium-ion battery formulation containing lithium cobalt oxide as the cathode active materials.

LFP: a lithium-ion battery formulation containing lithium iron phosphate as the cathode active materials.

NCA: a lithium-ion battery formulation containing lithium nickel-cobalt-aluminium oxide as the cathode active materials. This has been developed and patented by Panasonic, and was used in the early generation, and some current models, of Tesla.

NCMA: a lithium-ion battery formulation similar to NMC containing nickel-manganese-cobalt as the cathode active materials as well as an aluminium dopant.

NiMH: nickel metal hydride is a battery chemistry that is separate to the lithium-ion group of batteries.

NMC: a lithium-ion battery formulation containing nickel-manganese-cobalt as the cathode active materials. Often referred to alongside three figures representing the ratio of the contents of these three metals in the cathode, e.g. 5:3:2, meaning the cathode contains nickel, manganese and cobalt in this ratio respectively.



ELECTRIC VEHICLES:

BEV: battery electric vehicle. A vehicle that lacks any non-electric powertrain and so is powered solely by its battery.

EV: electric vehicle.

HEV: hybrid electric vehicle. HEVs have fairly minimal electrification and a small battery, which is used primarily to rationalise the consumption of petroleum/diesel. HEVs typically use regenerative braking where the friction caused by applying the brakes is converted into electrical energy and stored for future use in e.g. accelerating. HEVs cannot be plugged in to recharge and are therefore not included as plug-ins with BEVs and PHEVs.

ICE: internal combustion engine, powered by either petrol or diesel.

LDV: light duty vehicles under 3.5 tonnes. Not including heavy duty vehicles or buses.

NEV: new energy vehicle is a term typically used in China to describe battery electric (BEV), plug-in hybrid (PHEV) and fuel cell (FCEV) electric vehicles. For the purposes of this report, we use this term generally to describe BEVs and PHEVs and do not include FCEV in our definition.

PHEV: plug-in hybrid electric vehicle. These vehicles have a moderately sized battery to power an electric powertrain that precedes/complements the traditional ICE motors. Once the energy for the electric powertrain is exhausted, the vehicle will automatically switch across to run on fossil fuels. The battery must be plugged in to recharge.

xEV: to describe all types of electric vehicle.





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