

Green Metals

Battery Metals Watch: The end of the beginning



The battery metals bull market has peaked. Battery metals – cobalt, lithium and nickel – will power the green industrial revolution, facing a wave of demand comparable to that of copper and iron ore during China’s rapid growth in the 2000’s. With climate change top of mind, investors are fully aware that battery metals will play a crucial role in the 21st century global economy, just as bulk and base metals did before them. Yet despite this exponential demand profile, we see the battery metals bull market as over for now. Crucially, with no prior large-scale demand or supply cycle behind them, these ‘new economy’ commodities have avoided copper and aluminium’s ‘Revenge of the Old Economy’ investment trap. Indeed, the reverse has occurred, with a surge in investor capital into supply investment tied to the long term EV demand story, essentially trading a spot driven commodity as a forward-looking equity. That fundamental mispricing has in turn generated an outsized supply response well ahead of the demand trend in focus. In this context, we see prices on a downward trajectory over the course of the next two years, with a sharp correction in lithium (spot \$60,350/t versus GSe average 2022 \$53,982/t and 2023 \$16,372/t), and to a lesser extent cobalt (spot \$87,100/t, GSe 2022 average \$78,500/t and 2023 \$59,500/t). Nickel’s price profile is flatter versus spot (GSe 2022 average \$31,000/t and 2023 \$30,250/t), though we assume a rally in price over the rest of this year to \$36,500/t after which fundamental pressures will then drive a correction lower.

A head start on the super cycle. Battery’s demand prospects, combined with their clear ESG benefits, helped trigger the start of a supply capex surge from the late 2010s that was merely accelerated by the policy response to COVID. As a result, over 2022-25, we expect lithium supply to grow on average by 33% y/y, cobalt by 14% y/y and nickel by 8% y/y against annual demand growth rates of 27%, 11% and 7%, respectively. We expect Chinese lithium project expansions to multiply rapidly, in particular integrated hard rock projects, just as ex-China spodumene supply continues to strengthen. Moreover, whilst nickel still faces a battery-grade supply crunch for the next few quarters, fundamentals will subsequently soften as chemicals supply response from Indonesian HPAL and matte projects ramp up, before potential tightness returns mid-decade. Lastly, cobalt supply is riding the coat-tails of nickel and copper projects as a key by-product, creating additional supply from the phase of peaking copper mine supply over the next 12 months and Indonesian HPAL projects to 2024. Finally, it is important to note that this phase of

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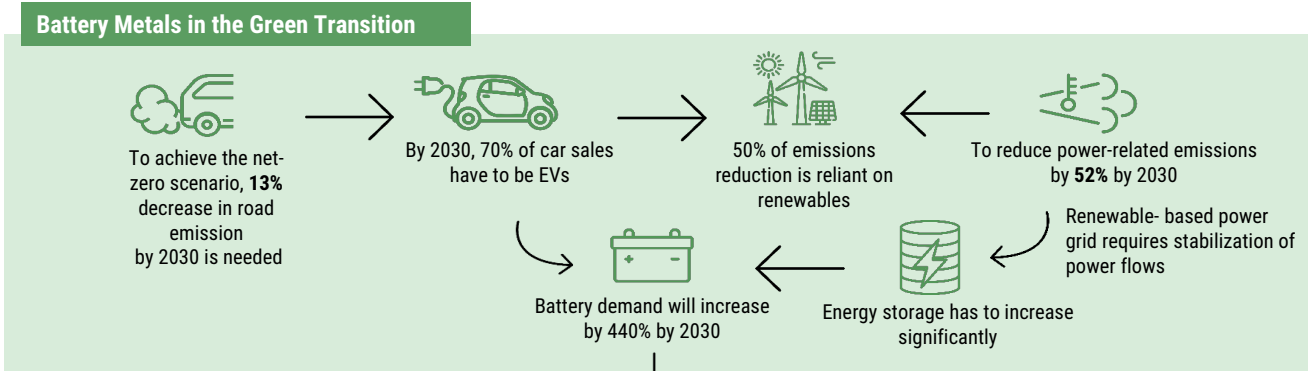
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oversupply will ultimately sow the seeds of the battery materials super cycle over the second half of this decade, in our view, where the demand surge will more sustainably overcome current supply growth.

Supply dynamics offer relative value. Yet there is still value to be found in the battery metals complex. We believe the best indication of relative value in the battery metals complex comes from the differentiating supply risks. Demand ratios remain broadly fixed - existing contracts by OEMs to secure raw material supply and fixed investments in production capacity for today's chemistry mix limits material adjustments in relative battery metals demand over the near term. Moreover, battery demand is not cyclical, rather it is structurally underpinned by strong policy incentives and rapid EV market momentum. In such a fixed demand environment, favouring cobalt – with its more constrained supply path – over lithium and nickel offers protection from the prospect of accelerated demand via policy, or downside surprise to supply projections.



+376% increase in green demand intensity of use in 2030... even as ... halves

27 Co Cobalt
58.933

95% is produced as a by-product of copper and nickel

67% of cobalt mine supply comes from DRC

15% of DRC mined supply is artisanal

DRC- Durban-China prone to disruption

28 Ni Nickel
58.693

2022 2025

Changes in chemistry mix are slow moving

95% of EV batteries are nickel based in the US & EU (45% of global battery sales)

+364% 2020 2025
146kt 317kt 675kt

Chemical supply from Indonesia to increase rapidly starting 2023

2020 2025
Green demand **+418%**

50% of nickel supply is coal fuelled

3 Li Lithium
6.94

2020 2025
13kt LCE **71kt LCE** **233kt LCE**

An increment in China's lepidolite projects is raising supply

7 fold increase in green demand

~50% Of lithium brine production located in water scarce countries

21% China 26% Chile 45% Australia

More countries are entering the supply chain

10% Argentina 24% China 34% Australia 18% Chile

2022
2% Cobalt in deficit
2% Nickel in deficit
1% Lithium in surplus

2023
0% Cobalt in deficit
0% Nickel in deficit
8% Lithium in surplus

2030
32% Cobalt in deficit
22% Nickel in deficit
13% Lithium in deficit

Even as recycling supply accounts for **18%** of cobalt **15%** of lithium & **7%** of nickel demand by **2030**.

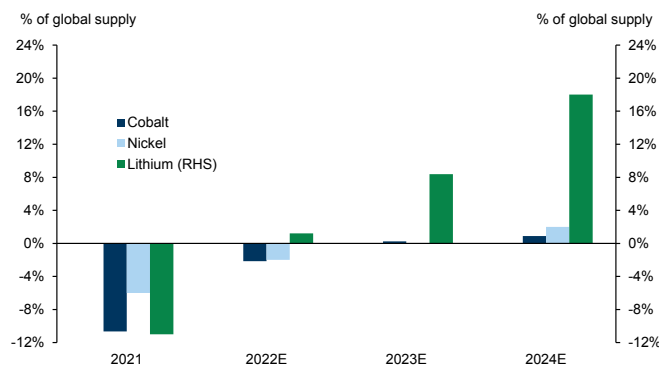
Source: Cobalt Institute, ANL, IEA, BNEF, Woodmac, Goldman Sachs Global Investment Research

The end of the beginning

1. Softer fundamental phase ahead for battery metals. The past two years has seen a surge in battery raw material demand tied to accelerating EV sales and stationary storage installations. This has in turn been a key tightening factor on respective balances and bullish price trends for cobalt, lithium and nickel. We expect these strong demand trends to continue, with the recent shifting focus from energy transition to energy security likely to spur increasing policy support for battery demand. However, we see a set of emerging more significant supply responses across the battery metals triggering a multi-year softening path for fundamentals. We forecast all three metals to shift into sustained surplus over the next 1-2 years (see [Exhibit 1](#)), which means materially lower price levels, in our view (see [Exhibit 2](#)). Unlike other more established commodity sub sectors where the revenge of the old economy continues to restrain supply investment, the rapid demand growth prospects from the EV sector have triggered a supply capex surge across the battery metals. Lithium is the most prominent in this trend, where we expect supply growth to average just over 30% per year over 2022-25, reflecting the ramp-up of new projects in Australia, China and Chile in particular. While nickel still faces a battery-grade supply crunch over the rest of this year, we expect an increasing chemicals supply response in the medium-term from Indonesian HPAL and matte projects to softer fundamentals before potential tightness returns mid-decade. Cobalt's position as a by-product leaves it less directly tied to this battery focused capex surge, though we think a phase of stronger copper mine supply over the next 12-18 months still leaves the metal on a softer path during that window.

Exhibit 1: A phase of softening fundamentals begins across battery metals complex

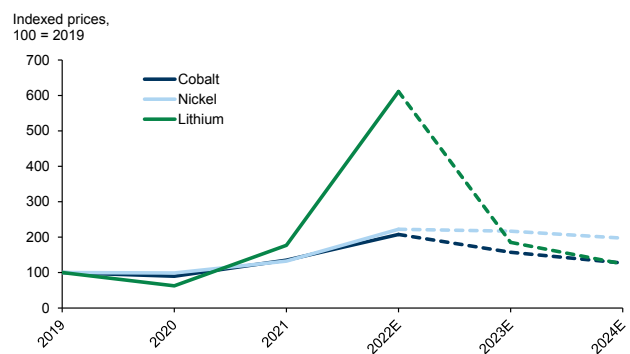
Battery metals balances (% of supply), GSe



Source: Goldman Sachs Global Investment Research

Exhibit 2: Lithium prices set to fall at the fastest pace over 2023

Battery metals prices, indexed at 2019



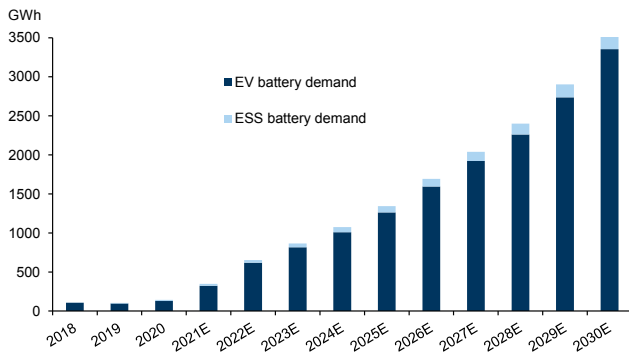
Cobalt price: Fastmarket standard grade Cobalt (\$/t); Nickel price: LME Nickel (\$/t); Lithium: Fastmarket lithium carbonate CN spot excl. VAT (\$/t)

Source: Fastmarkets, Goldman Sachs Global Investment Research

2. Policy support overpowers cyclical headwinds to battery demand. Our bearish view on the fundamental path for battery as a raw material is not rooted in a negative take on demand prospects. We continue to expect a strong trend of growth in EV demand underpinned by increasingly supportive policy globally led by Europe and China. Indeed, our estimates show that the battery demand from energy storage and EVs will grow ten-fold to 3453GWh by 2030, from just 348GWh in 2021 (see [Exhibit 3](#)).

Moreover, our auto analysts show that the cost of ownership for both ICE and BEV are currently similar (see Exhibit 4), hence rising fuel prices along with supportive regulation suggests potential upside risk to EV sales projections. Trends so far this year have remained very strong, with EV sales in China, US and EU having risen +127%, 69% and 3% YTD by April'22 (see Exhibit 5). While the stringent lockdown on China's main automotive hubs onshore have brought down EV sales and production, we see this a temporary hiatus to increasing battery demand. Our analysis shows that the auto sector was affected only during the early 2020 lockdown and the most recent Shanghai-Jilin lockdown (see Exhibit 6). The early 2020 COVID lockdown episode showed a sharp initial decline in production followed by a sharp rebound immediately after, in line with what our auto analysts expect for May when auto production is expected to grow at +15% y/y. In our view, this shields battery metals from any sustained negative demand impact from the lockdown, with volumes deferred rather than lost. Moreover, we see sustained policy support for the EV sector in China limiting any potential deterioration, utilizing the EV transition as a key tool for decarbonisation decreasing reliance on imported hydrocarbons and use the EV industry to build a greener economy.

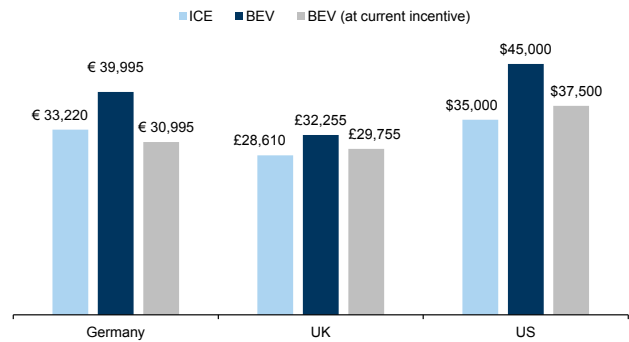
Exhibit 3: Global battery demand is set to rise ten-fold over this decade



EV battery demand does not account for e-buses and two wheelers

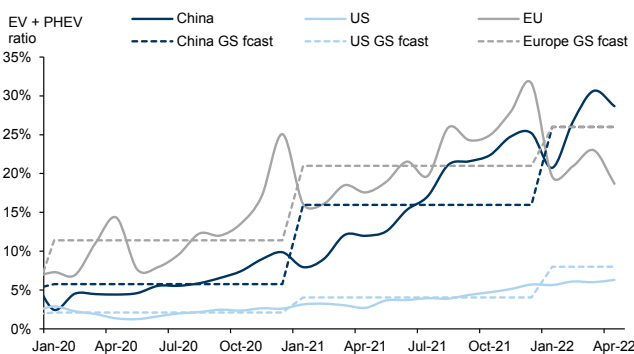
Source: BNEF, Goldman Sachs Global Investment Research

Exhibit 4: ICE and BEV have the similar cost of ownership
TCO for ICE and BEV, by country



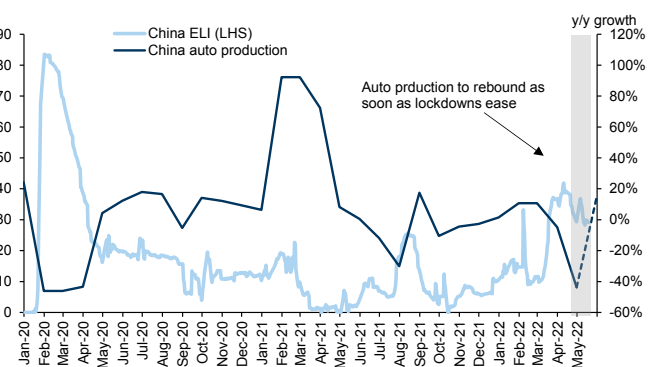
Source: Goldman Sachs Global Investment Research

Exhibit 5: EV sales in China and US have risen 127% y/y and 69% y/y YTD



Source: Goldman Sachs Global Investment Research

Exhibit 6: COVID lockdowns in China have deferred demand rather than destroyed it

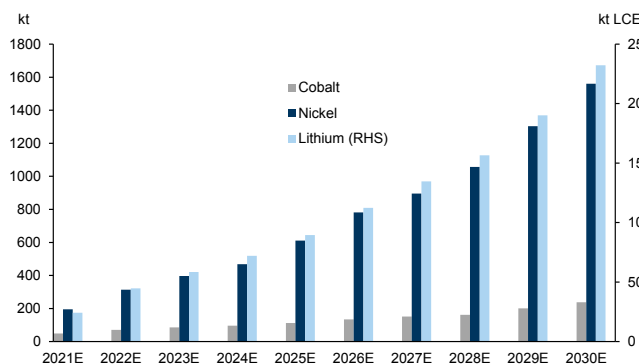


Dashed line represents GS est. for China auto production y/y growth

Source: Wind, Goldman Sachs Global Investment Research

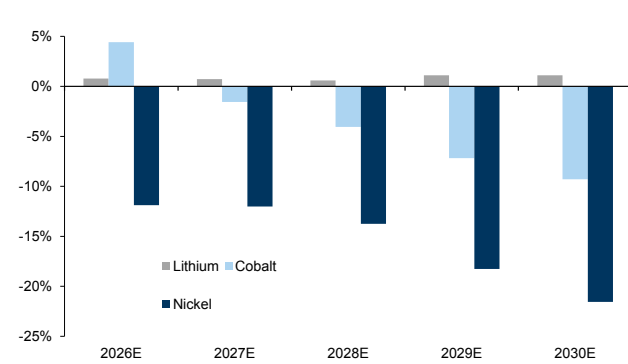
3. Battery chemistry is key to demand but is a slow moving change. Whilst the rapid growth in EV sector supports a broadly positive path in battery metals demand, the relative path between them reflects trends in battery chemistry. The adoption rate of a given chemistry in current lithium ion batteries – the dominant EV and storage battery type - will depend upon the safety, energy density, cost and recycling value of the battery pack among other factors (see [Exhibit 11](#)). Raw material competition is focused on the battery cathode, which currently reflects a scale of composition between nickel and cobalt based chemistries, as well as nickel-free chemistry (LFP – lithium iron phosphate). Current cost competitiveness, higher safety and a preference for small-sized EVs has resulted in a rapid rise of LFP market share in China growing to 50% by end 2021 from just 30% in 2020. However, the ex-China developed market is dominated by nickel based NCM and NCA chemistries given the emphasis of most consumers in the West on longer range. Whilst there is growing tilt towards LFP chemistry due to its cost advantage, most western OEMs have only started to consider it for their segment of small EVs. The increase in LFP share ex-China can also be attributed to expiry of key LFP patents, which restricts the production of LFP exclusively to China. We use the GS auto analysts base case for EV battery chemistry mix as the basis for our demand modelling. However, given a growing interest in the West in LFP, we have also modelled a scenario of ‘LFP hyperadoption’ (see [Exhibit 9](#)). This scenario starts from 2026 given the existing contracts limit adjustment before that point and investment in nickel-based chemistry, which cannot be easily discarded. Whilst the LFP hyperadoption leads to a material softening in our nickel balance in the second half of the decade (see [Exhibit 8](#)), the lithium balance remains similar to our base case given net demand gains. This relative insensitivity of lithium demand to changing chemistry mix lower risks to future supply investment, which nickel and cobalt lack as a hedge. Lastly we would note that the growing emphasis on battery recycling will be an increasingly important deciding factor which favours NCM chemistries due to higher recycling credit relative to LFPs (see [Exhibit 10](#)).

Exhibit 7: Demand from EVs is set to increase by 100% for lithium, 95% for nickel and 58% for cobalt by 2025 from this year's levels
EV battery metals demand



Source: BNEF, ANL, Goldman Sachs Global Investment Research

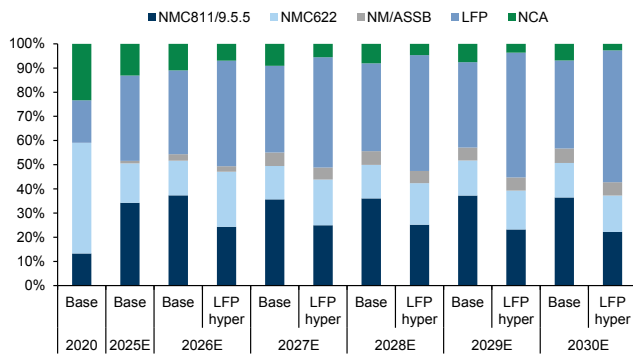
Exhibit 8: Nickel is exposed to material demand loss if LFP share grows in the West
Demand loss under LFP hyper adoption scenario as % of EV base case demand



Source: Goldman Sachs Global Investment Research

Exhibit 9: The West needs to move away from nickel-based batteries for a LFP hyperadoption scenario

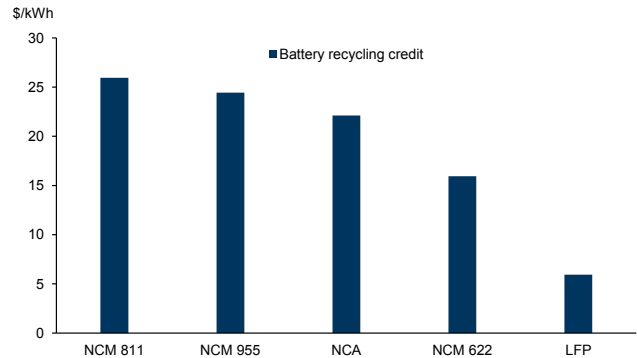
Cathode chemistry mix under base case and LFP hyperadoption scenario



Source: Goldman Sachs Global Investment Research

Exhibit 10: Nickel based batteries have a 3-5 times higher recycling value than LFP batteries

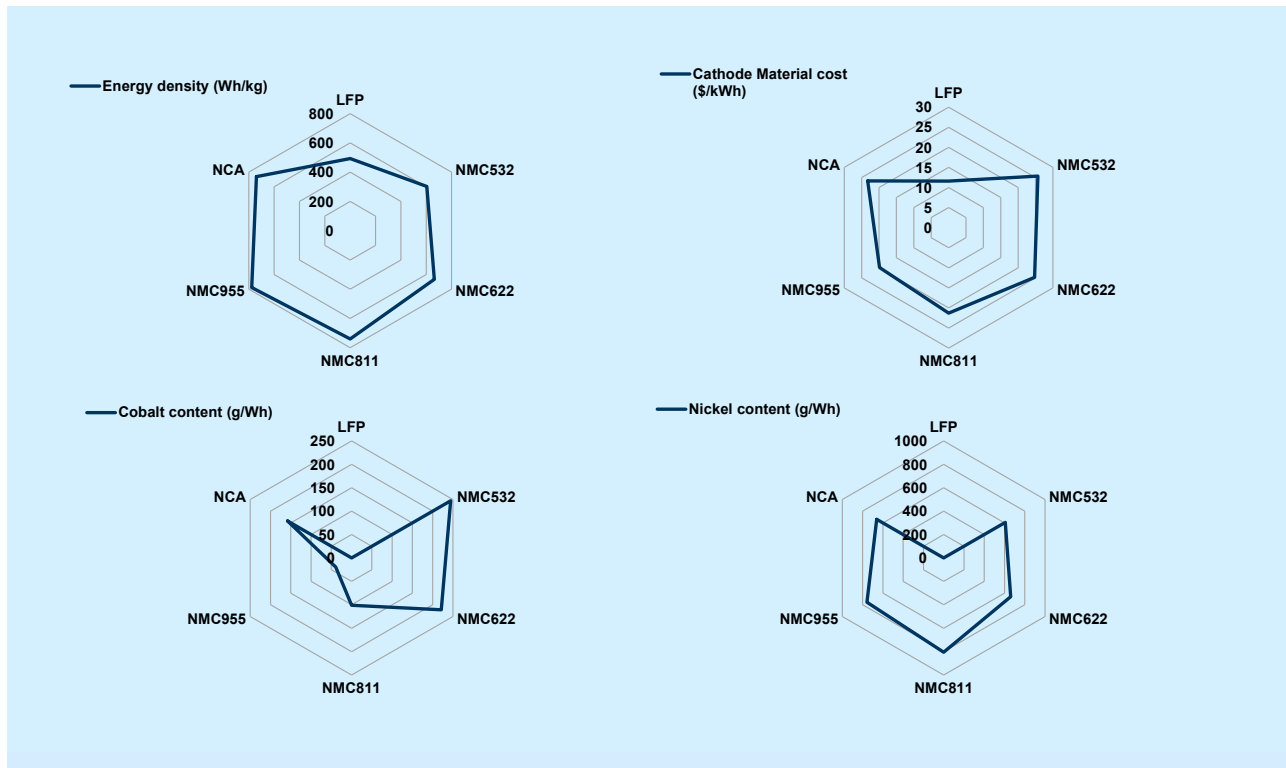
GS estimates



Source: Goldman Sachs Global Investment Research

Exhibit 11: Nickel-based NCM batteries provide longer range whereas LFP batteries are cheaper

A higher energy density implies lighter batteries whereas low cathode material costs imply cheaper batteries.



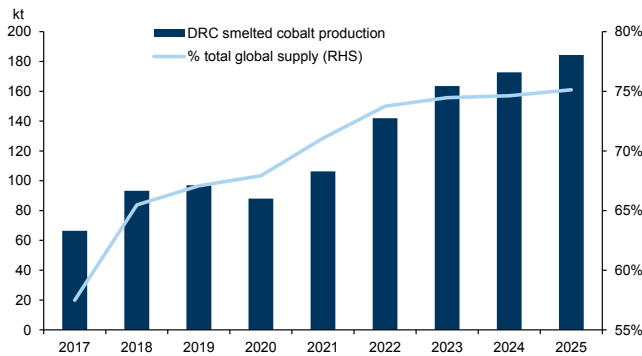
Source: Goldman Sachs Global Investment Research, IEA

4. Supply surge across the battery metals complex. In contrast to the supply constraints seen across the majority of industrial metals, in particular copper and aluminium, the battery metals complex is facing a phase of sharp supply growth acceleration. Over 2022-25E, on supply we expect lithium to grow on average by 33% y/y, cobalt by 14% y/y and nickel by 8% y/y against annual demand growth rates of 27%, 11% and 7% respectively. Compounded this leads to some substantial misalignment in fundamentals - notably lithium supply should more than double against

a 73% increase in demand between now and the middle of the decade. This significant supply growth phase has been catalysed by strong capex flows into projects in Australia, China, Chile and Indonesia in particular where countries’ and OEMs’ have aggressively pursued securing raw material supply for the EV transition, even as broader mining capex has remained restrained. On lithium, we see China expansions likely to be more and faster than consensus expectations, especially regarding integrated hard rock projects. Specifically, in our base case, we estimate total upstream-integrated chemical supply to grow by 351 kt LCE from 2021 to 2025E, through expansions from lepidolite (mica), spodumene, and brine projects in China. The supply addition is equivalent to 64% of 2021 global demand, and would contribute to 32% of total global supply growth over 2022-2025E in average. Potential probable projects could add another 12% of supply by 2025E (or 194 kt LCE over the period), yet should require higher prices than our annual forecast. Despite projected healthy supply growth rates, some risks remain, linked to the high geographical concentration, with cobalt supply the most exposed (see [Exhibit 12](#)). Indeed, 70% of metal is being mined and smelted in the DRC, meaning that any disruptions in the region have major impacts in the market. For lithium and nickel, risks are more on the long term and linked to the environmental impact of their processes (see [Exhibit 14](#)), as 30% of lithium supply is located in water scarce countries and more than 50% of nickel production is fueled by coal.

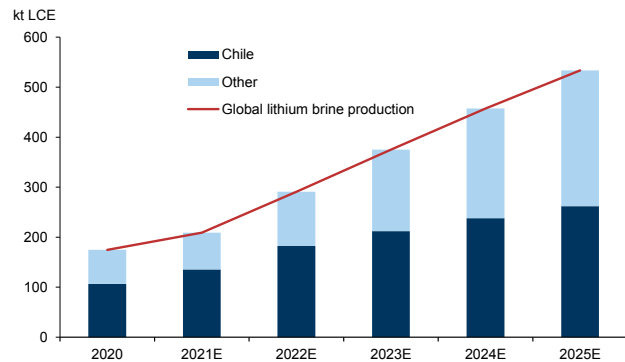
Note: The above discussion of China’s lithium supply sector herein represents the views of Trina Chen and Joy Zhang who are equity analysts covering China Basic Materials. All other views are those of the analysts Commodities Research team.

Exhibit 12: The highly concentrated cobalt supply increase risk toward supply underperformance



Source: Woodmac, BNEF, Goldman Sachs Global Investment Research

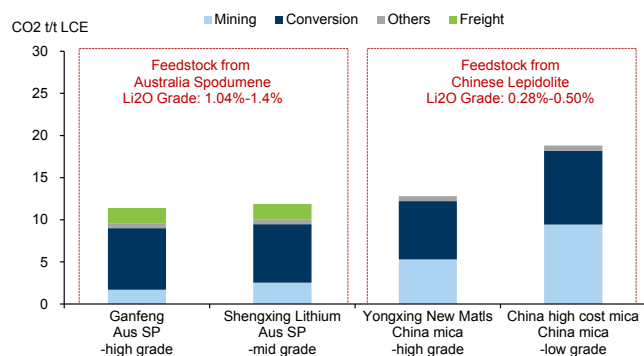
Exhibit 13: More than 50% of brine production is located in Chile, a water scarce environment



Source: Woodmac, BNEF, Goldman Sachs Global Investment Research

Exhibit 14: Chinese lepidolite projects are more carbon intensive than Australian spodumene projects

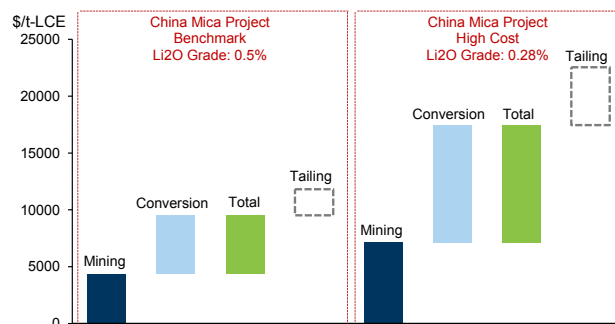
Carbon emission (from ore to chemicals) - estimated (CO2 t/t LCE)



Source: Company data, Goldman Sachs Global Investment Research

Exhibit 15: Tailing management for low-grade mica are more enviromentally costly

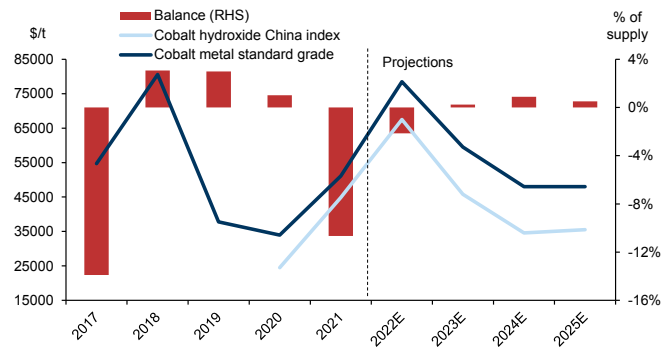
Unit cost incl. tail treatment (\$/t-LCE)



Source: Goldman Sachs Global Investment Research

5. Cobalt: Shifting from deficit to balanced. A shortage of supply exacerbated by disrupted supply chains amid an unprecedented rise in global demand tightened the cobalt market into a substantive deficit last year (15kt, 11% of global supply). This year we estimate the cobalt market will face a smaller sized deficit (see Exhibit 16), reflecting the impact from auto manufacturers reducing cobalt content in their batteries as well as stronger supply trends (see Exhibit 17). The heightened price volatility and ESG concerns around the cobalt supply chain has started to convince battery manufacturers to move away from cobalt-intensive batteries. However, the magnitude of this demand adjustment should not be overstated. The decoupling from the current supply chain takes time and strong demand from NMC batteries along with the recovery in the electronics sector has still kept cobalt demand growth strong in 2022E (GSe: +19% y/y). Moreover, whilst COVID lockdowns have induced demand sluggishness in China, this has been offset by significant disruptions to the flow of cobalt from DRC (70% global mined supply), which has faced severe delays due to recent flooding in Durban which led to port closures. We would also note that unlike lithium and nickel, 95% of current smelted cobalt supply is achieved as a by-product of copper/nickel production rather than from direct cobalt supply capex. With global copper mine output peaking in H1-2024, this limits the duration of the supply driven softening path in cobalt relative to the other battery metals. In this fundamental context, we forecast a relatively modest downward path for standard grade cobalt prices, to average at \$78,500/t in 2022 and \$59,500/t in 2023 (see Exhibit 21).

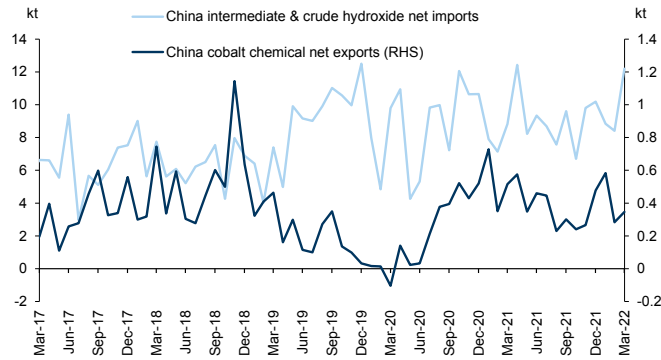
Exhibit 16: Cobalt market to move to a balanced profile after a year of small deficit in 2022E



Cobalt metal standard grade: Fastmarkets standard grade Co (\$/t); Cobalt hydroxide China index: Fastmarket Co hydroxide index 30% CIF CN (\$/t)

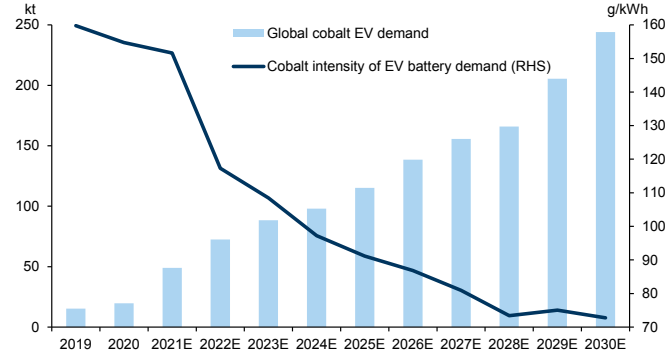
Source: Woodmac, BNEF, Fastmarkets, Goldman Sachs Global Investment Research

Exhibit 18: Co hydroxide imports in China are yet to improve suggesting tight DRC supply
China cobalt trade flows



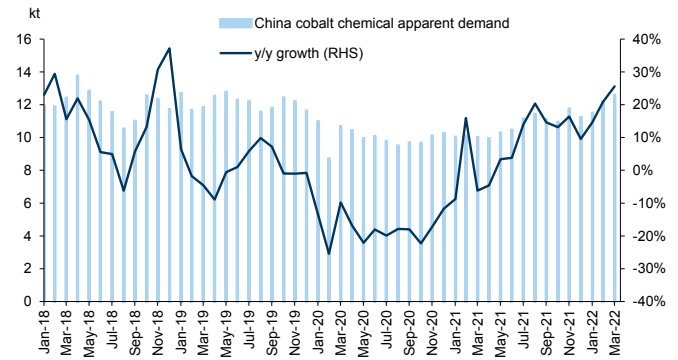
Source: BNEF, Goldman Sachs Global Investment Research

Exhibit 17: Cobalt demand will continue to grow amid decreasing intensity of use



Source: BNEF, Woodmac, Goldman Sachs Global Investment Research

Exhibit 19: Strong demand for ternary batteries has supported cobalt demand growth
China cobalt chemical apparent demand



Apparent demand = production + net imports

Source: Wind, Goldman Sachs Global Investment Research

Exhibit 20: GS Cobalt supply-demand balance

('000 tonnes)	2020	2021E	2022E	2023E	2024E	2025E
Global demand						
Consumption - batteries	73	107	132	150	163	180
% change y/y	-4%	46%	24%	14%	8%	11%
EV	20	49	71	86	96	112
ESS	2	2	3	4	5	5
E-buses, two-wheeler EVs	2	3	2	3	5	5
Portable electronics	47	50	52	53	54	54
Other	4	4	4	4	4	4
Consumption - ex batteries	53	57	59	62	63	65
% change y/y	-14%	8%	3%	5%	3%	3%
Superalloys	13	14	14	14	15	15
Tool materials	11	12	12	13	13	14
Other	29	31	33	34	35	36
Global consumption	126	164	191	212	226	245
% change y/y	-8%	30%	17%	11%	7%	9%
Global Production						
World smelter output	130	150	192	220	233	249
% change y/y	-10%	15%	29%	14%	6%	7%
DRC	88	106	142	164	174	186
Ex- DRC	42	43	51	56	60	63
World refined output	126	146	188	214	228	243
World output (adj. for disruption)	126	146	183	203	216	230
% change y/y		15%	26%	11%	6%	7%
Battery Scrap Supply	1	3	4	8	12	16
% change y/y		2%	2%	4%	5%	7%
Global Balance	1	-16	-4	0	2	1
as % of global supply	1%	-11%	-2%	0%	1%	1%
Cash Prices (annual average)						
Current dollar (\$/t)	33947	51119	78500	59500	48000	48000
Current dollar (c/lb)	1540	2319	3561	2699	2177	2177

Prices refer to Fast Market Rotterdam cobalt standard grade

Source: Woodmac, BNEF, Goldman Sachs Global Investment Research

Exhibit 21: Average Co metal prices are set to fall 24% y/y in 2023

GSe

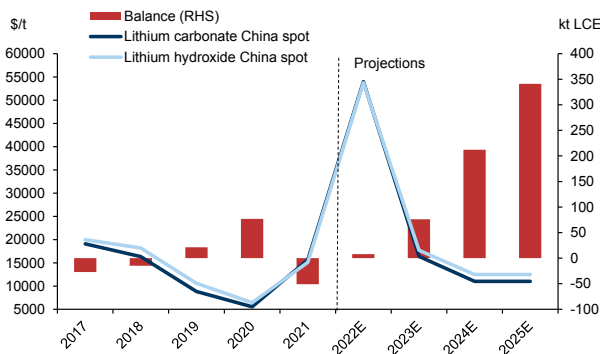
Unit: \$/t	Cobalt hydroxide China index	Cobalt metal standard grade	Cobalt hydroxide payable (%)	Cobalt hydroxide spread
2017	-	54723	-	-
2018	-	80582	-	-
2019	-	37803	-	-
2020	24488	33947	70	9460
2021	44855	51119	88	6264
2022E	67510	78500	86	10990
2023E	45815	59500	77	13685
2024E	34560	48000	72	13440
2025E	35520	48000	74	12480

Source: Fastmarkets, Goldman Sachs Global Investment Research

6. Lithium: Where strong demand and an even stronger supply collide. After a significant tightening trend last year which generated a 51kt-LCE deficit (11% of global supply) resulting in a 200% rise in prices, we expect the lithium market to pivot towards a prolonged phase of surplus starting this year (see [Exhibit 22](#)). This softening trend is a result of a strong supply response even as demand continues to surge. Indeed we expect the lithium demand from batteries to rise five-fold to 562kt-LCE this year from just 105kt-LCE in 2016. As a result, we forecast global lithium consumption to grow

nearly 50% y/y in 2022 and nearly triple by 2025E from 2021 levels. This increase in demand is a result of the resurgence of lithium based LFP battery chemistry in China from the beginning of the current decade, which matters given its share of market size (56% of 2022E global battery sales). This adoption trend has reflected LFP’s relative lower cost and the region’s strong preference for small-size EVs. Despite this strong demand profile, we see it outpaced by strong supply trends, most notably from ex-China spodumene and China lepidolite production growth (see Exhibit 23). The most significant supply additions are from China, specifically from lepidolite (mica), a hardrock lithium resource different to traditional spodumene. We now expect nearly 350kt-LCE of supply additions from China to start producing by 2025E, contributing to nearly one-third of global increments over the period. As per the table (see Exhibit 27), we expect lithium prices to continue to correct for the rest of the year and remain under pressure from increasing supply over the next few years. We forecast lithium carbonate and hydroxide price to fall 70% y/y and 67% y/y respectively in 2023. It is important to note that the oversupply and price pressure forecast will ultimately sow the seeds of the next bull market, in our view, as it will reinforce lithium’s position as the preferred raw material by battery makers.

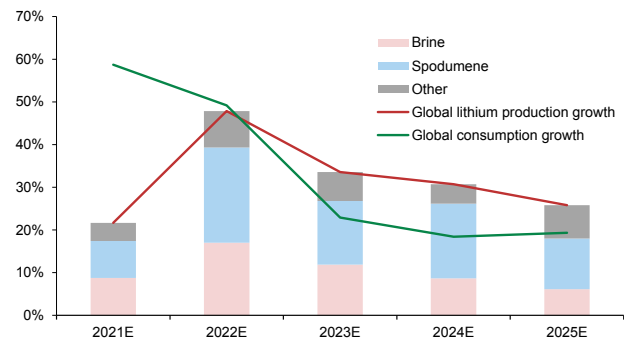
Exhibit 22: We expect a sharp correction in Lithium fundamentals with carbonate and hydroxide price to fall 70% y/y and 67% y/y respectively in 2023



Lithium carbonate China spot: Fastmarkets Li carbonate 99.5% Li₂CO₃ min, China excl. VAT (\$/t);
 Lithium hydroxide China spot: Li hydroxide 56.5% excl. VAT (\$/t)

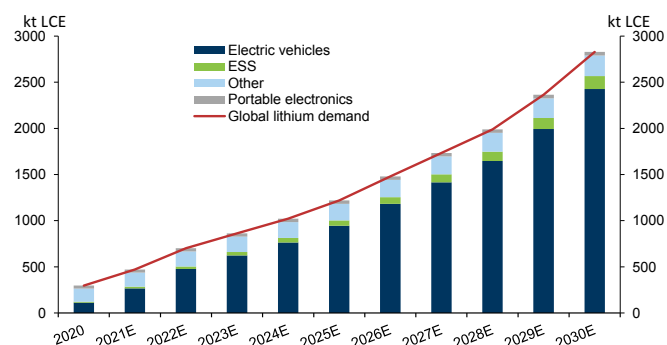
Source: Woodmac, BNEF, Fastmarkets, Bloomberg, Goldman Sachs Global Investment Research

Exhibit 23: Supply response in the lithium market has outpaced the massive demand growth



Source: Woodmac, Company data, Goldman Sachs Global Investment Research

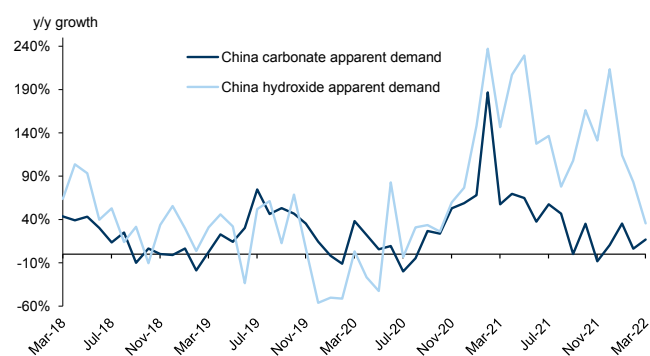
Exhibit 24: Lithium demand from EVs set to increase by 98% by 2025



Source: BNEF, Goldman Sachs Global Investment Research

Exhibit 25: Apparent demand has risen 31% y/y YTD

China lithium apparent demand



Apparent demand = production + net imports

Source: BNEF, Wind, Goldman Sachs Global Investment Research

Exhibit 26: GS Lithium supply-demand balance

Li ('000 tonnes LCE)	2020	2021E	2022E	2023E	2024E	2025E
Global demand						
Consumption - batteries	169	336	562	720	876	1070
% change y/y	7%	99%	67%	28%	22%	22%
EV	95	243	446	585	721	895
ESS	10	18	26	37	49	58
E-buses, two-wheeler EVs	17	24	31	38	43	50
Portable electronics	32	34	35	36	36	37
Other	14	17	23	23	27	30
Consumption - ex batteries	128	135	140	143	146	149
% change y/y	-4%	5%	4%	2%	2%	2%
Ceramics	32	33	34	35	36	37
Glass-ceramics	26	27	29	29	30	31
Other	70	74	77	78	79	81
Global Consumption	296	471	702	863	1022	1219
% change y/y	2%	59%	49%	23%	18%	19%
Global Refined Supply						
Brine	175	209	291	375	457	533
China	38	41	69	79	95	112
Ex-China	137	168	222	296	362	421
Spodumene	207	241	349	455	621	768
China	10	7	16	16	38	84
Ex-China	197	234	332	438	582	684
Other	13	30	71	119	162	259
China	13	30	71	119	158	233
Ex-China	0	0	0	0	4	26
World output	395	481	711	949	1240	1561
% change y/y		22%	48%	34%	31%	26%
Total output (adj. for disruption)	395	481	693	902	1178	1483
% change y/y		22%	44%	30%	31%	26%
Battery Scrap Supply	3	9	18	37	55	77
% change y/y		2%	3%	4%	5%	5%
Global Balance	77	-51	8	76	212	341
as % of global supply	19%	-11%	1%	8%	18%	23%
Cash Prices (annual average)						
Current dollar (\$/t)	5538	15656	53982	16372	11000	11000
Current dollar (c/lb)	251	710	2449	743	499	499

Prices refer to Fast Market Li carbonate-CN spot (excl. VAT)

Source: Woodmac, BNEF, Goldman Sachs Global Investment Research

Exhibit 27: Lithium carbonate and hydroxide price to fall 70% y/y and 67% y/y respectively in 2023E

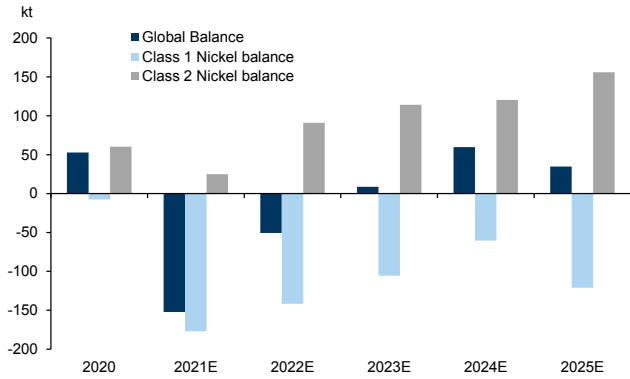
Unit:\$/t	Lithium carbonate China spot (ex VAT)	Lithium hydroxide China spot (ex VAT)	Spodumene 6% China CIF	Carbonate spread spot	Hydroxide spread spot	Hydroxide premium
2017	19073	19995	613	14166	15701	921
2018	16329	18196	868	9388	12122	1867
2019	8833	10594	624	3840	6224	1761
2020	5538	6427	435	2062	3385	888
2021	15656	15101	869	8707	9020	-555
2022E	53982	53761	2800	31582	34161	-221
2023E	16372	17699	1100	7572	9999	1327
2024E	11000	12500	800	4600	6900	1500
2025E	11000	12500	800	4600	6900	1500

Source: Fast Market, Goldman Sachs Global Investment Research

7. Nickel: Near-term tightness unresolved but fundamentals softening into 2023.

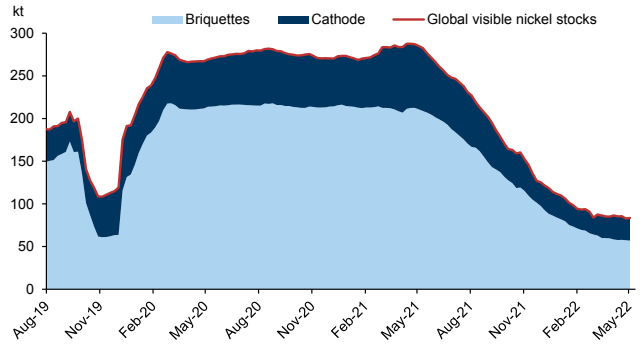
The significant deficit and rapidly rising prices in the nickel market over the past 12 months have reflected a surge in battery demand, falling/low inventories and supply unpreparedness (see [Exhibit 29](#)). Even with the most expedient short cycle supply solution and the Chinese demand hit from lockdowns, the battery grade nickel market will continue to face tightness over the remainder of this year (142kt deficit). With inventories already at low levels, this suggests further draws in exchange class 1 nickel inventory should in turn provide support for a higher price. We would note a temporary reprieve in this tightening trend since late Q1 due to the impact on China demand from COVID lockdowns (restraining both autos and stainless), whilst Indonesian supply growth has remained unimpeded. However, we expect nickel's near dated tightness to ultimately transition into a softer path from 2023. This reflects a strong growth trend in chemical supply as well as conversion capacity, which enables a pass through of low-purity class 2 nickel – used in stainless steel – to the high-purity class 1 nickel required for batteries (see [Exhibit 31](#)). As a result of this we now expect a materially smaller class 1 deficit in 2023 (GSe 105kt versus 165kt previously) and a surplus in the global refined market next year (see [Exhibit 33](#)). Over the course of H2-22, we expect prices to rise amid low inventories and lack of battery grade supply as Chinese lockdowns lift and battery demand strengthens, but then expect a downward trajectory in prices starting from mid-2023 on stronger supply trend from Indonesia in particular. We subsequently adjust our 3/6/12M price targets to \$32,500/36,500/34,000/t (from \$36,000/38,500/\$42,000).

Exhibit 28: Class 1 nickel faces open-ended deficits but global refined market moves into a surplus in 2023



Source: Woodmac, Goldman Sachs Global Investment Research

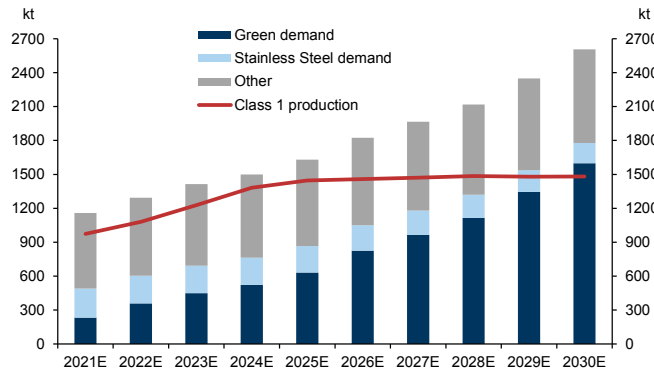
Exhibit 29: There isn't enough visible stock left to solve class 1 shortfall even this year



Source: SMM, Goldman Sachs Global Investment Research

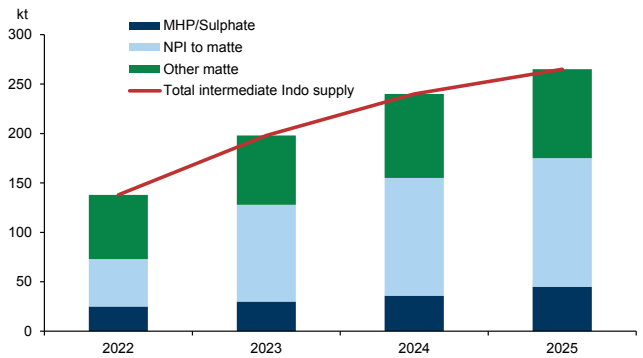
Exhibit 30: Nickel market is unprepared for the rise in battery demand

Class 1 nickel demand and supply



Source: Woodmac, Goldman Sachs Global Investment Research

Exhibit 31: NPI-to-matte conversion is becoming the crucial Indonesian intermediate for battery grade nickel supply



Source: Woodmac, Goldman Sachs Global Investment Research

Exhibit 32: GS Nickel supply-demand balance

('000 tonnes)	2020	2021	2022E	2023E	2024E	2025E
Consumption - DM						
US	134	130	140	168	193	245
% change y/y	-13%	-3%	8%	20%	15%	27%
Europe	279	338	355	363	389	425
% change y/y	-9%	21%	5%	2%	7%	9%
Japan	146	171	184	205	210	225
% change y/y	-5%	17%	7%	12%	3%	7%
Other DM	7	8	9	9	9	9
% change y/y	-11%	7%	8%	2%	2%	2%
Sub- DM	567	646	688	745	801	904
% change y/y	-9%	14%	6%	8%	8%	13%
Consumption - EM						
China	1454	1540	1677	1835	1949	2023
Indonesia	206	383	394	441	493	496
China & Indonesia	1660	1923	2071	2277	2442	2519
% change y/y	10%	16%	8%	10%	7%	3%
Other EM	265	299	266	280	291	298
% change y/y	-18%	12%	-11%	5%	4%	2%
Sub- EM	1925	2222	2337	2557	2733	2817
% change y/y	5%	15%	5%	9%	7%	3%
Global Consumption	2492	2868	3025	3302	3534	3721
% change y/y	1%	15%	5%	9%	7%	5%
World ex-China & Indonesia	832	945	953	1025	1092	1202
% change y/y	-12%	14%	1%	8%	7%	10%
Global Production						
Global Primary Production	2542	2709	2961	3281	3550	3693
% change y/y	7%	7%	9%	11%	8%	4%
China	783	746	695	795	888	931
% change y/y	-3%	-5%	-7%	14%	12%	5%
Indonesia	638	905	1122	1308	1429	1511
% change y/y	65%	42%	24%	17%	9%	6%
ex-China & Indonesia	1121	1057	1144	1178	1233	1251
% change y/y	-5%	-6%	8%	3%	5%	1%
Global Battery Scrap Supply	3	7	13	29	44	62
Global Balance	53	-152	-51	9	60	35
Cash Prices (annual average)						
Current dollars (\$/t)	13803	18474	31000	30250	27500	27500
Current dollars (c/lb)	626	838	1406	1372	1247	1247

Source: Goldman Sachs Global Investment Research

Exhibit 33: GS nickel class 1 and 2 fundamental projections to 2025

('000 tonnes)	2020	2021E	2022E	2023E	2024E	2025E
Global demand						
Class 1 Nickel demand	986	1158	1289	1430	1538	1693
% change y/y		17%	11%	11%	8%	10%
Green	142	254	390	504	600	734
Stainless Steel	223	228	208	204	201	194
Other	621	676	690	721	738	765
Class 2 Nickel demand	1506	1710	1736	1872	1997	2028
% change y/y		14%	2%	8%	7%	2%
Stainless Steel	1506	1710	1736	1872	1997	2028
Global consumption	2492	2868	3025	3302	3534	3721
% change y/y	1%	15%	5%	9%	7%	5%
Global production						
Class 1 Nickel	830	791	817	822	831	834
Class 2 Nickel	1566	1735	1827	1986	2117	2184
Chemicals	146	183	317	473	602	675
Global output	2542	2709	2961	3281	3550	3693
% change y/y	4%	7%	9%	11%	8%	4%
Battery Scrap Supply	3	7	13	29	44	62
Global Balance	53	-152	-51	9	60	35
Class 1 Nickel balance	-8	-177	-142	-105	-61	-121
Class 2 Nickel balance	60	25	91	114	120	156

Source: Woodmac, Goldman Sachs Global Investment Research

8. Battery metals scorecard. There is little doubt that fighting climate change needs investments channeled to green metals. Nevertheless, this is yet to happen and metals are often disregarded as not ESG compliant. To help increasingly ESG-conscious investors navigate the battery metals market, we have built a simple framework to rank them all. We rank cobalt, lithium and nickel from 1 to 3 (where 1 is the best performing metal) according to various metrics, summarizing key aspects of their fundamentals, environmental footprint and sustainability.

Exhibit 34: GS battery metals scorecard

		FUNDAMENTALS				ENVIRONMENT				SOCIAL & GOVERNANCE				
Metric		Supply-demand balance	Raw materials supply	Green demand share	Summary	Environmental impact	Energy intensity of production	Water stress	Summary	Social impact	Ease of doing business	Infrastructure	Summary	Total
Description		A smaller deficit implies a tighter market	Higher geographical mine concentration increases supply and logistical risks	Higher green demand share increases policy-driven upside risks	Fundamentally most attractive	A carbon intensive raw material supply chain discourages its usage	High energy requirement can hinder production in an energy scarce environment	Production in water scarce environment puts at higher risk future supply	Most environmentally friendly	Consumers are increasingly paying attention to socially responsible resources	Higher ease of doing business attracts investments	Smooth supply chain infrastructure reduces supply disruptions	Most socially sustainable	
Battery Metals Scorecard	Cobalt	1	1	2	1	2	1	1	1	3	3	3	3	1
	Lithium	3	2	1	2	3	3	3	3	1	1	1	1	2
	Nickel	2	3	3	3	1	2	2	2	2	2	2	2	3

Source: World Bank, Woodmac, BNEF, ANL, ILO, Goldman Sachs Global Investment Research

GREEN METALS



Green Metals: Nickel's class divide

28 April 2022

At the beginning of the year, nickel's place within green metals was as a key competitor in the race for mineral dominance of energy storage. Now, it sits at the intersection of Europe's push for decarbonisation and energy independence. At the heart of Europe's strategy lies its desire to rapidly electrify its transportation sector - a source of 20% of its emissions and c.2mb/d of Russian oil imports.



Green Metals: Solving Aluminium's Climate Paradox

20 June 2021

At the heart of the coming surge in green aluminium demand lies a paradox: aluminium is a key input required to produce decarbonising technologies like EV's and solar power, yet its own production is very carbon intensive, generating 2% of all global emissions. This paradox begs the question: how can we secure enough aluminium to effectively decarbonise, while keeping the climate impact of the path to net zero to a minimum? In our view, the resolution of this paradox will drive a structural bull market in aluminium over the next half decade, driven by the necessity to grow supply to meet green demand while cutting emissions to prevent a climate catastrophe.



Green Metals: Copper is the new oil

13 Apr 2021

The critical role copper will play in achieving the Paris climate goals cannot be overstated. As the most cost-effective conductive material, copper sits at the heart of capturing, storing and transporting these new sources of energy. Leveraging equity analysis across EVs, wind, solar, and battery technology, we estimate that by 2030, copper demand will grow nearly 600%. Yet the copper market as it currently stands is not prepared for this demand, and producers are leery of committing to new supply. We significantly increase our price forecasts and explore the implications across the metals and mining complex.

Disclosure Appendix

Reg AC

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