

Critical Metals

For a Sustainable World

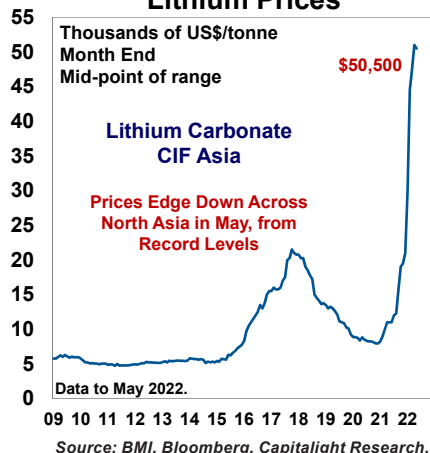
Capitalight
Research Inc.

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Patricia Mohr

Patricia.mohr@capitalightresearch.com

Lithium Prices

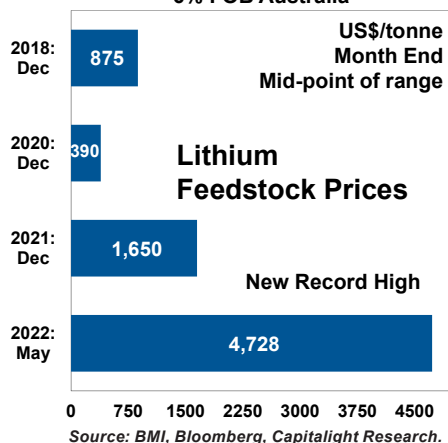


Special Edition – PDAC 2022

Remarks from Patricia Mohr's PDAC presentation – 'Critical Metals To Electrify The Global Economy – Outlook for Lithium & Rare Earths'

- Strong medium-term outlook for Lithium & Rare Earths, despite April stall in global EV sales.
- Shanghai re-opens on June 1, with measures to rejuvenate car sales, though some backsliding occurs in recent days.
- President Biden seeks to revive U.S. solar panel industry.

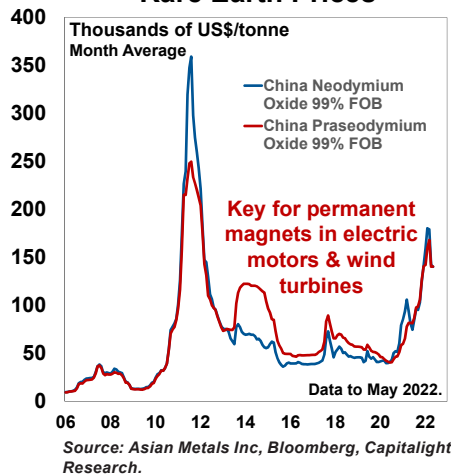
Spodumene Concentrates 6% FOB Australia



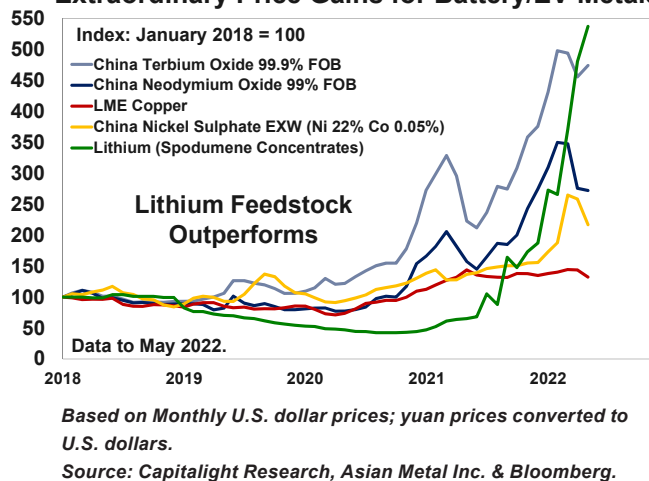
China announces Measures to Lift Its Economy

The transition to electric mobility and low-carbon power will dominate the outlook for lithium and key rare earths – neodymium, praseodymium, terbium and dysprosium – through 2030. EV batteries accounted for over 47% of world lithium demand in 2021 and will likely represent more than 70% by 2030. Permanent magnets – used in electric vehicle drive trains and wind turbine generators – are the largest end-use for REEs, accounting for about 35%, followed by catalysts at 26%, polishing at 13% and phosphors/pigments/ceramics at 8%. The fastest-growing applications for permanent magnets will be in EVs and wind turbines.

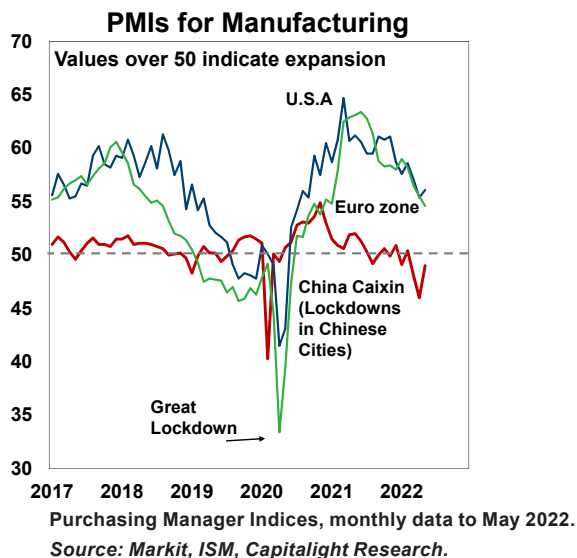
Rare Earth Prices



Extraordinary Price Gains for Battery/EV Metals



Global Economy Loses Momentum (Especially in China)



Global sales of electric cars doubled in 2021 to 6.6 million units and started 2022 on a fairly firm note. However, sales retreated to about 540,000 units in April (-34% y/y). As discussed in our previous Critical Metals report, NEV (new energy vehicle) sales in China dropped to 299,000 units in April from a strong 484,000 units in March (passenger + commercial vehicles). The decline reflects a 2-month lockdown in Shanghai as well as lockdowns in other cities – linked to China's zero-COVID strategy – hurting consumer spending and the operation of parts facilities and auto assembly plants (such as Tesla's Gigafactory 3).

EV sales also fell in Europe to about 158,600 units in April – due to an extended delivery schedule for Tesla vehicles from China and possibly economic uncertainty caused by Russia's invasion of Ukraine. Overall European auto sales have been very weak this year. While EV sales were strong in the United States in April (+37.1% y/y), the U.S. market is comparatively small.

On a more positive note, China's EV sales recovered to 447,000 units in May and should stay at this higher level over the balance of

2022. EV Sales should still achieve the 5 million unit forecast set out in early 2022 by the China Association of Automobile Manufacturers (CAAM). (It should be noted that CAAM data reflects sales to dealers, rather than consumers.) In an effort to bolster the industry, the Province of Guangdong recently led a move by local governments (including Shanghai and Jilin) to provide modest cash subsidies of 10,000 yuan (US\$1,513) for consumers to replace old cars with an EV. The City of Shanghai ended its lockdown on June 1, though there is some backsliding as of June 9, with 7 districts closed again for Covid testing. Shanghai has announced an increase of 40,000 in the annual quota on new licenses for passenger vehicles as well as the incentive to buy EVs.

China's central government is also introducing measures to rejuvenate its economy, with the recent lockdowns threatening to cut 1 percentage point from GDP growth to 4.5% (below this year's 5.5% target). Beijing has ordered state-owned policy banks to provide 800 bn yuan (US\$120 bn) in funding for infrastructure projects across China (likely benefitting base metal & steel demand). The People's Bank of

China has modestly lowered mortgage rates and is pressing commercial banks to step up lending to the hard-pressed property sector.

Strong Outlook for EV Sales Medium Term

Despite the risk of near-term weakness, the International Energy Agency projects a strong outlook for EV sales medium term. In its annual assessment – released on May 23, 2022 – the IEA set out two scenarios showing a significant transition from the Internal Combustion Engine to electric vehicles by 2025 and 2030. The scenarios model the impact of government policy and industry plans and include the following:

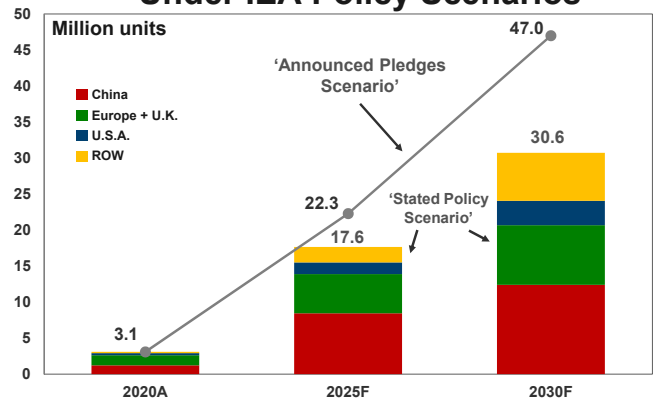
- 1) **‘Stated Policy Scenario’** – EV sales projections and the market share of EVs in overall vehicle sales are based on existing government policy – anchored in legislation to mitigate climate change plus industry announcements on EV deployment; industry plans are substantial and often exceed government targets; government and OEM targets for EVs have increased since 2021;
- 2) **‘Announced Pledges Scenario’** – projections are based on all recent government policy announcements, regardless of whether they are anchored in legislation. Countries signing the COP26 declaration on accelerating transition to 100% zero-emission cars & vans are assumed to achieve this goal.

The ‘Stated Policy Scenario’ assumes that EV sales of cars & light duty commercial vehicles (e.g. delivery vans) climb to 17.6 million units in 2025 and 30.6 million by 2030 – up significantly from only 3.1 million in 2020 and 6.7 million in 2021. EV sales are projected to be even higher in the ‘Announced Pledges Scenario’ – rising to 22.3 million in 2025 and a huge 47.0 million by 2030. Please see the diagram to the right.

Capitalight Research projections of EV sales in 2030 are above the ‘Stated Policy Scenario’, but below the ‘Announced Pledges Scenario’.

It should be noted that the IEA indicates a third scenario – with an even higher level of EV sales necessary for the global economy to achieve

Global EV Sales Outlook Under IEA Policy Scenarios



Light duty vehicles: cars + vans (light duty commercial vehicles)

EV Market Share In Cars (% Of Total Sales)

	2020A	2021A	2025	2030
Stated Policy	4.0	8.6	15.0	22.0
Announced Pledges	4.0	8.6	18.0	35.0

Source: IEA, May 2022, Capitalight Research.

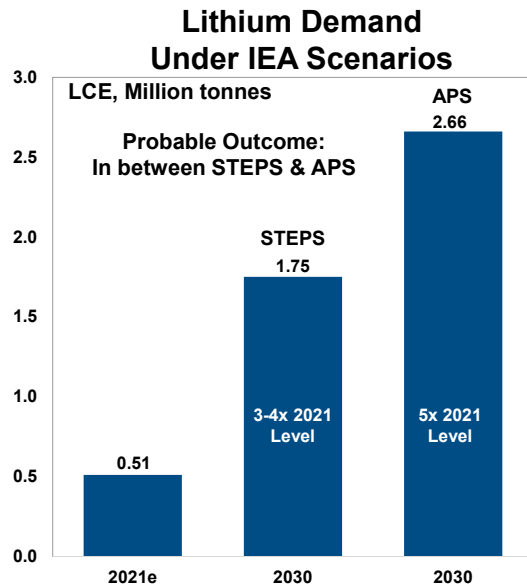
Capitalight Research EV Car Sales Forecast (Millions of Units)

2020	2021A	2022F	2025	2030
3.0	6.6	9.5	15.0	30.0

‘net-zero carbon emissions’ by 2050. The share of EVs in overall car sales would have to approach 60%.

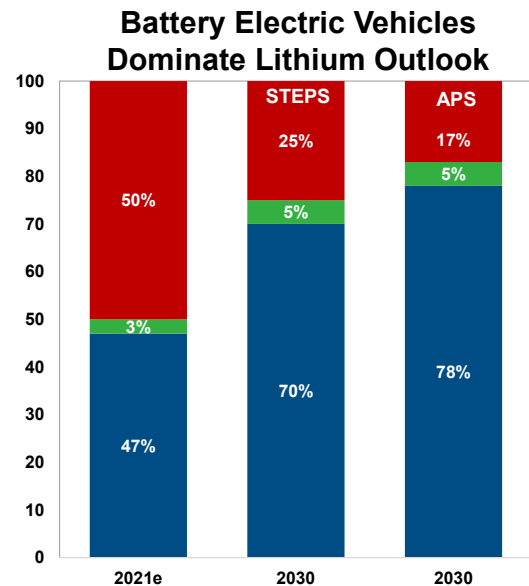
Global Lithium Demand Will Climb by Four-Five Times By 2030

The IEA Scenarios point to a huge expansion in world lithium demand. The ‘Stated Policy Scenario’ suggests that lithium consumption will increase from 505,000 tonnes of LCE (lithium carbonate equivalent) in 2021 to 1.75 million tonnes by 2030 (4X); whereas the ‘Announced Pledges Scenario’ suggests an increase to 2.66 million tonnes (5X). Again, a forecast above the ‘Stated Policy Scenario’, but below the APS scenario appears the most likely outcome.



LCE: Lithium carbonate equivalent.
STEPS: Stated Policy Scenario.
APS: Announced Pledges Scenario.

Source: IEA, May 2022; S&P Global, Capitalight Research



% of Total Demand (approximate)

- **EV Batteries;** Size expected to increase.
- **Clean Energy Technologies:** stationary energy storage batteries for renewables, grid technologies & nuclear.
- **Other:** Ceramics & glass, lubricants, continuous casting...

In making these projections, the IEA has factored in an increase in average vehicle battery size – needed to increase driving range. While lithium demand is also expected to grow for Stationary Energy Storage – serving renewable energy projects with intermittent power – and in the ceramics & glass sector (e.g. to provide strength to Corning Ware & Gorilla Glass), the importance of EV batteries in the overall demand outlook will continue to grow. Battery electric vehicles will account for about 70% of overall lithium demand by 2030.

Will Lithium Mine Supply Keep Pace?

Many industry observers, including the IEA, are concerned that global mine supply will not keep pace with demand. This partly reflects the 10-15 year lead time for new mine development and challenging government permitting requirements.

Despite the recent softening of lithium conversion prices in China, tight supplies lifted

spodumene feedstock prices in Australia to a new record high of US\$4,728 per tonne in May – up an extraordinary 8.2 X year-over-year and more than 5 X higher than the previous US\$915 peak in mid-2018. Spodumene concentrate prices (6% Li₂O) FOB Australia have posted the strongest price performance of the ‘critical metals’ within our universe – from January 2018 (pre-pandemic) through May 2022. Until recently, the mineral with the strongest price performance had been terbium oxide – a heavy rare earth.

(Please see the chart on page 1, which compares ‘critical metal’ prices indexed to January 2018 – including lithium spodumene 6% concentrates FOB Australia, China terbium oxide, China neodymium oxide, LME copper and China nickel sulphate EXW.)

Mine Capacity Expansion in Australia

The global demand & supply balance for lithium has been in ‘deficit’ since 2021. Australian

spodumene producers – who supply a great deal of the lithium feedstock imported into China – were largely sold out in 2022:H1. This partly reflects the shut-down of mine production during the price correction of 2019-2020 and very limited new mine capacity in 2022:H1. Pilbara Minerals' electronic auctions of small, spot-market volumes have contributed to the recent spike in prices, though prices – net of these auctions – would still have been at record levels in April and May.

On a more positive note for buyers, several large mine expansions and re-starts (involving spodumene concentrates) are scheduled in Australia over the balance of 2022 and into 2023, possibly easing market conditions – though only temporarily. The Mt. Marion mine – a JV of Mineral Resources & Gangfeng – will be expanded over the coming year in 2 tranches totalling 53.4 kt LCE; 2 trains will be restarted at Wodgina – a JV between Mineral Resources & Albemarle (59.4 kt LCE) and Core Lithium's Finnis mine will be commissioned, providing 20.5 kt LCE (with an offtake by Tesla). SQM will also be expanding its output in the Atacama (among others). However, it takes time to phase in new mine production and the impact on market conditions and prices of these expansions has yet to occur.

Buyers are currently quite concerned over the tight supply of lithium hydroxide, given the probable disruption of supplies from Russia. This accounts for a steady rise in hydroxide prices in recent weeks, with 'lithium hydroxide EXW China' at US\$70,875 back above 'lithium carbonate prices EXW China' at US\$69,750 in early June (BMI price assessments). Spot prices in Europe have climbed above US\$80,000.

Over the balance of the decade, we are optimistic that the industry will expand sufficiently to supply huge projected growth. Chinese companies (lithium miners, converters & battery manufacturers) are diversifying their overseas lithium investments from Australia to countries such as Argentina and are also acquiring domestic brine resources and vertically integrating (e.g. in Qinghai Province). New technology such as 'direct lithium extraction' (DLE) and 'direct lithium to product' (DLP) will play a role.

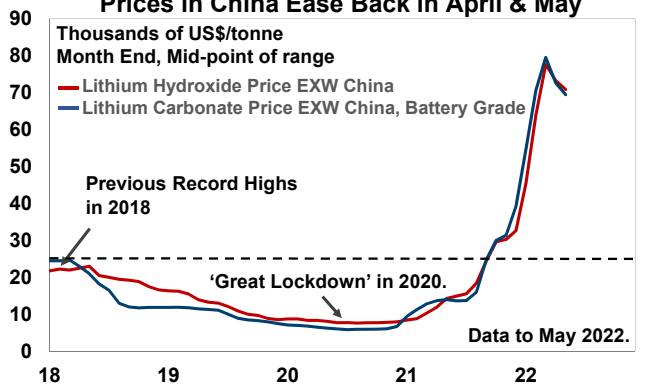
Canada currently has no operating lithium mines. However, three new projects and one re-start are probable in coming years. **Direct lithium extraction from brine in depleted Alberta oil reservoirs appears likely later in the decade and could be a major source of new supply (E3 Metals Corp.).** Canada is expected to account for 5% of global production by 2026; the United States – which has one brine operation – also 5%.

The challenge for mining companies in the next ten years will be to bring on stream significant new lithium capacity without causing substantial, temporary price declines. However, some volatility is to be expected.

Stellar Price Performance for Rare Earths

After peaking earlier this year at extraordinary levels, the price of the four major rare earth oxides also eased back in April and May – likely hurt by the stall in China's EV sales and a generally slowing Chinese economy. Beijing also pressured its State-Owned Enterprises (SOEs) – which mine & process REEs – to rein in prices. However, China neodymium oxide,

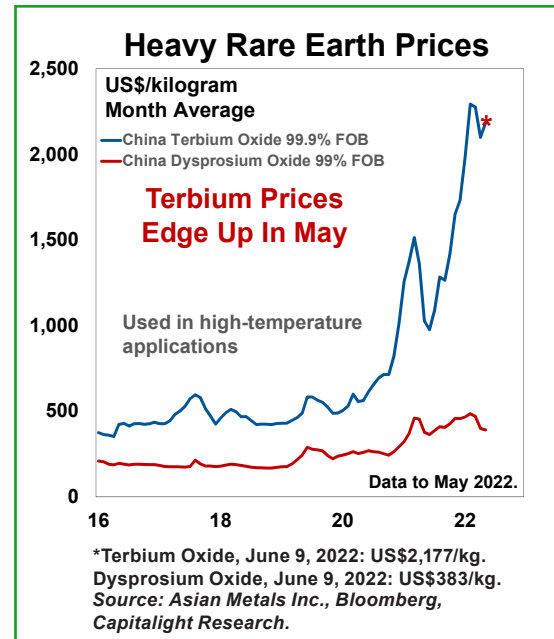
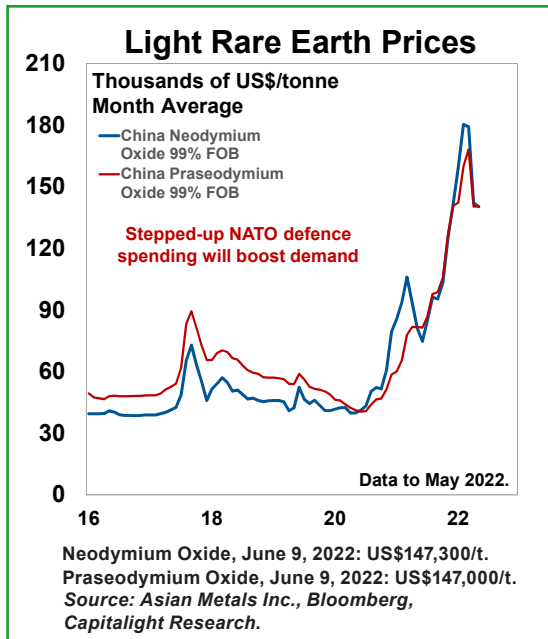
Lithium Carbonate & Hydroxide Prices in China Ease Back in April & May



Lithium Hydroxide EXW China, June 1, 2022: US\$70,875/t.
 Lithium Carbonate Battery Grade EXW China, June 1: US\$69,750/t.

Prices in China are the key determinant of global prices and are edging up again in early June

Source: BMI, Capitalight Research.



praseodymium oxide and terbium oxide prices have recently edged up again – likely buoyed by expectations of rebounding demand by magnet manufacturers.

‘China neodymium oxide’ retreated from a peak of US\$180,363 per tonne in February – up a stellar 92% y/y and the highest price since the heady days of 2012 – to a low of US\$140,300 in May, before inching up again to US\$147,300 on June 9. The gain in ‘China terbium oxide’ – a heavy rare earth – since 2018 has been even greater – climbing to a high of US\$2,293 per kg in February, before retreating back to US\$2,098 in April. Prices have now lifted off the bottom and are currently US\$2,177.

Terbium is a relatively ‘rare’ rare earth – in tight supply in China, which dominates global production of ‘separated’ rare earth oxides, refined metal & alloys (about 85%) as well as permanent magnets. China’s annual mine output quota for heavy rare earths has not been increased for three years and supplies of heavy REEs from Myanmar have been disrupted – probably accounting for the recent consolidation of the SOEs handling heavy REEs in China.

As background, rare earth magnets are a kind of permanent magnet made from rare earth alloys (Nd, Pr, Tb and Dy) which produce

stronger magnetic fields than ferrite or aluminium-nickel-cobalt magnets. Neodymium iron boron magnets (NdFeB) – made from an alloy of neodymium, praseodymium, iron & boron – are commonly used in electric vehicle drive trains and wind turbine generators, because they are the strongest class of permanent magnets. To offset loss of magnetic strength at high temperatures, some NdFeB magnets are infused with heavy rare earths terbium and dysprosium. In addition to EV drive trains, rare earth permanent magnets are used in small electric motors for non-powertrain applications such as power steering, windows and seats.

Turning to other applications, wind-generated electricity will also be a key growth driver for REEs, as many countries shift from coal-based power to renewable energy. The International Renewable Energy Agency (IRENA) estimates that wind represented 6% of world electricity generation in 2020, with onshore & offshore capacity of 732 GW. By 2030, IRENA projects capacity of 2,102 GW (a CAGR of 10%). The increasing use of ‘permanent magnet direct drive generators’ points to strong demand in this sector. The size of wind turbines is also increasing – the planned capacity of new offshore wind turbines is often 8-12MW versus 2-5GW.

Rare Earths: A Huge Business Opportunity for Canadian Mining Companies

Western countries increasingly recognize that China's dominance in mining & processing rare earth elements – for both industrial as well as defence applications – poses supply-chain vulnerabilities for manufacturers outside of China. Recent developments point to a gradual diversification in REE mining & processing to the West – including the 'separation' of individual rare earth oxides.

Canada's first REE mine came on stream in June 2021 – the Nechalacho mine (T-Zone & Tardiff-Zone) in the Northwest Territories. Initial processing into mixed REE carbonates will be undertaken in a company-owned facility in Saskatoon.

Canada can play a key role in developing secure supplies of 'critical minerals' for its trading partners, with significant resources available for development in British Columbia, Saskatchewan, Ontario, Quebec and Newfoundland & Labrador. Huge business development opportunities are also opening up in processing & manufacturing – for example in permanent magnets.

Copper: President Biden Takes Measures To Shore Up Solar Installations

LME copper prices lost ground in May to US\$4.25 per pound from US\$4.62 in April on concern over a slowdown in the global economy, given prospects for a significant tightening of U.S. monetary policy and prospects for higher interest rates in the EU. The release of U.S. CPI data for May showed an actual pick-up in inflation to 8.6% y/y compared with 8.3% a month earlier – driven by higher energy and food prices – caused indirectly by the Russian/Ukrainian war (EU sanctions on Russian oil exports and blocked shipments of Ukrainian & Russian wheat and other grains). In this environment, we view the performance of copper prices as fairly good, with prices remaining over

Global Gigafactory pipeline climbs above 300 over the next 10 years



China will continue to dominate battery cell manufacture with 226 gigafactories by 2031. However, announcements have also accelerated in the United States and Europe over the past year. Canada's first gigafactory – JV between Stellantis N.V. and LG Energy Solution Ltd. – was recently announced.

Source: BMI, Capitalight Research, Kolonko and Shutterstock.com

the US\$4 mark. The official cash settlement price for copper was US\$4.37 on June 9, though prices slipped on June 10 to US\$4.33, following release of the U.S. CPI data.

President Biden has recently ordered a two-year suspension of any tariffs which could be imposed retroactively by the U.S. Commerce Department on solar panel imports from Thailand, Vietnam, Malaysia and Cambodia, thought to be skirting anti-dumping rules limiting imports from China. The trade investigation was brought by a small U.S. solar panel producer, but has imperiled a large number of solar panel construction projects. However, the reaction by U.S. PV producers has been mixed. Solar panels use considerable copper for cabling, wiring and heat exchange.

Nickel: Prices Steady

LME official cash settlement prices have steadied around US\$12.73, after soaring to US\$14-15 in March & April following the LME 'squeeze'.

The 'Critical Metal' report will return to its normal format in July, with more in-depth coverage of nickel and copper markets.

Table 1

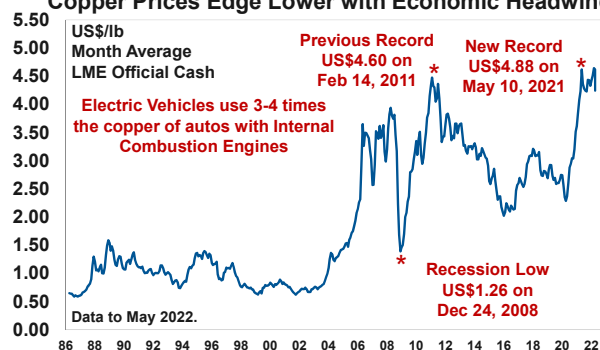
Critical Metals - Price Trends

	2018 Annual	2019 Annual	2020 Annual	2021				2022		
				Q1	Q2	Q3	Q4	Q1	May	Latest June 9
Copper										
LME Copper Official Cash Settlement ¹ (US\$/lb)	2.96	2.72	2.80	3.85	4.40	4.25	4.40	4.53	4.25	4.37
Nickel										
LME Nickel Official Cash Settlement ² (US\$/lb)	5.95	6.31	6.25	7.99	7.87	8.68	8.99	11.85	12.68	12.73
SHFE Nickel, Generic First Contract ² (CNY/tonne)	102,916	110,746	109,054	131,120	128,570	143,708	147,198	185,946	210,651	223,400
China Nickel Sulphate EXW > 22% Ni, 0.05% Co ² (CNY/tonne)	28,411	30,487	29,874	35,766	35,714	39,276	39,720	41,250	48,655	45,750
Lithium										
Lithium Carbonate, CIF Asia ≥ 99.2% Li ₂ CO ₃ ³ (US\$/tonne)	17,063	11,675	8,421	9,083	11,000	13,333	19,833	40,667	50,500	50,500 (Data to May 31)
Lithium Carbonate, CIF North America ≥ 99.0% Li ₂ CO ₃ ³ (US\$/tonne)	14,833	11,215	7,746	8,083	9,750	12,375	17,000	38,333	48,000	48,000 (to May 31)
Lithium Hydroxide, FOB North America ≥ 55.0% LiOH ³ (US\$/tonne)	16,771	13,521	10,629	10,458	11,750	14,333	19,333	37,750	47,500	47,500 (to May 31)
Spodumene Concentrate, FOB Australia 6% Li ₂ O, Lithium Feedstock ³ (US\$/tonne)	886	595	406	472	579	1,048	1,492	2,668	4,728	4,728 (to May 31)
Rare Earth Elements										
China Neodymium Oxide 99%, FOB ⁴ (US\$/tonne)	49,918	44,655	48,757	95,147	83,222	92,267	123,356	173,087	140,300	147,300
China Neodymium Metal 99% FOB ⁴ (US\$/kilogram)	64	57	62	116	102	115	153	210	173	179
China Praseodymium Oxide 99%, FOB ⁴ (US\$/tonne)	63,627	54,024	45,725	67,818	81,665	94,484	124,540	156,774	140,525	147,000
China Praseodymium Metal 99% FOB ⁴ (US\$/kilogram)	114	103	91	96	104	110	139	193	189	192
China Dysprosium Oxide 99%, FOB ⁴ (US\$/kilogram)	177	234	259	384	398	400	447	474	390	383
China Dysprosium Metal 99% FOB ⁴ (US\$/kilogram)	262	307	341	497	516	516	554	583	558	515
China Terbium Oxide 99.9% FOB ⁴ (US\$/kilogram)	455	503	664	1,382	1,121	1,213	1,600	2,185	2,183	2,177
China Terbium Metal 99% FOB ⁴ (US\$/kilogram)	604	655	849	1753	1,430	1,534	2,038	2,761	2,764	2,790

Sources:

1) LME, Bloomberg. 2) LME, SHFE, Asian Metal Inc., Bloomberg. 3) BMI, Bloomberg. 4) Asian Metal Inc., Bloomberg.

Copper Prices Edge Lower with Economic Headwinds



*May 10, 2021 record was intra-day;

June 9, 2022: US\$4.37/lb.

Source: LME, Bloomberg, Capitalight Research.

Slow Nickel Trading Volumes on LME, After 'Squeeze'



June 9, 2022: US\$12.73/lb.

Source: LME, Bloomberg, Capitalight Research.

Table 2

Copper Price Outlook - Annual Averages

pre-pandemic		2020	2021A	2022F	2023F	...	Long Term (2025+)
2018	2019						
2.96	2.72	2.80	4.23	4.30	4.20		5.50+

Copper Quarterly Averages

		Actual														
		20-1	20-2	20-3	20-4	21-1	21-2	21-3	21-4	22-1	22-2	22-3	22-4	23-1	23-2	23-3
		2.56	2.42	2.96	3.25	3.85	4.40	4.25	4.40	4.53						
Sensitivities	High										4.45	4.30	4.50	4.20	4.50	4.50
	Base										4.37	4.10	4.20	4.00	4.20	4.20
	Low										4.28	3.90	3.90	3.80	3.90	3.90
Probability	High										0.15	0.20	0.20	0.20	0.20	0.20
	Base										0.70	0.60	0.60	0.60	0.60	0.60
	Low										0.15	0.20	0.20	0.20	0.20	0.20
Probability-Weighted Forecast											4.37	4.10	4.20	4.00	4.20	4.20

LME official cash settlement, US\$/lb., quarterly averages.

Source: LME official cash settlement, US\$/lb., quarterly averages.

Nickel Price Outlook - Annual Averages

pre-pandemic		2020	2021A	2022F	2023F
2018	2019				
5.95	6.31	6.25	8.38	12.50	9.50-10.00

Nickel Quarterly Averages

		Actual														
		20-1	20-2	20-3	20-4	21-1	21-2	21-3	21-4	22-1	22-2	22-3	22-4	23-1	23-2	23-3
		5.77	5.53	6.46	7.23	7.99	7.87	8.68	8.99	11.85						
Sensitivities	High										15.30	14.00	15.00	12.00	11.50	11.50
	Base										13.65	12.50	12.00	10.00	9.50	9.50
	Low										12.00	11.00	9.00	8.00	7.50	7.50
Probability	High										0.20	0.20	0.20	0.20	0.20	0.20
	Base										0.60	0.60	0.60	0.60	0.60	0.60
	Low										0.20	0.20	0.20	0.20	0.20	0.20
Probability-Weighted Forecast											13.65	12.50	12.00	10.00	9.50	9.50

LME official cash settlement, US\$/lb., quarterly averages.

Source: LME official cash settlement, US\$/lb., quarterly averages.

Note: The LME nickel price forecast has been revised up significantly since March 2022 due to the logistical challenges facing Russian supplies and the recent short-covering 'squeeze' on the LME. Nickel prices are intrinsically volatile. The outlook over the balance of 2022 will depend upon the length of the conflict in Ukraine, the performance of the world economy (affecting stainless steel and EV demand) and the timing & extent of new supply from Indonesia. Prices have steadied on the LME, but trading volume is low.

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