Material demand for batteries and potential supply constraints

IEA seminar on e-mobility

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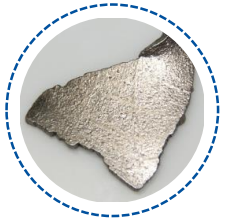
The EV revolution is demanding larger proportions of some key commodities…

Automotive demand as % of total demand

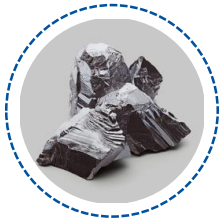
Lithium	
2016	35%
2021	47%



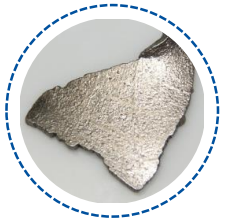
Cobalt	
2016	8%
2021	23%

Nickel	
2016	2%
2021	6%

Automotive demand growth as % of total demand growth, 2016-2021

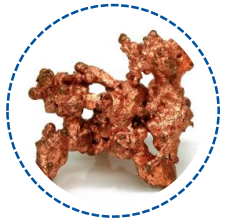


Lithium
77%



Cobalt
63%

Nickel
29%



Copper
14%

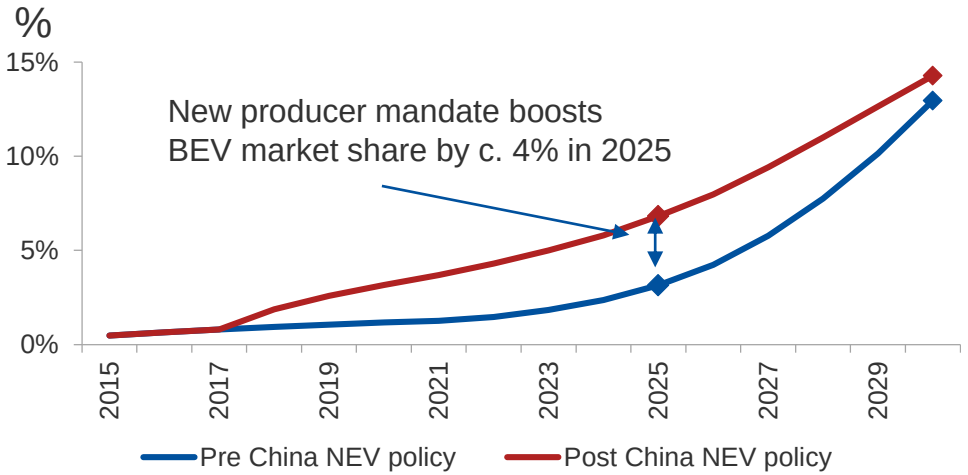
Data: CRU

…but what are the key drivers of market opportunities and risks?

China's EV policy is evolving rapidly from subsidies to quotas…

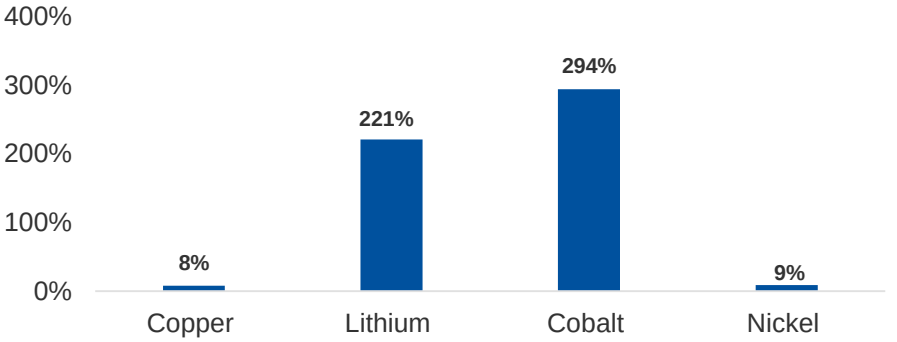
NEV program China	Subsidy	Made in China	A new subsidy scheme	Credit/quota system	Sales of new ICE
Introduced its NEV program to support EVs	Introduction of subsidies to support NEVs	To support innovative and technology upgrades to boost high technology industrial sector including EVs.	Eliminate subsidies for NEVs that have recharge mileage. NEV subsidies to decline by 20% from 2017. Subsidies for higher quality passenger EVs will remain attractive.	Implementing a minimum NEVs sale share for each carmakers from April 2018, from 10% in 2019 and 12% by 2021.	China is drawing up plans to phase out the sale of new ICE. **Under review**
2010	**2012**	**2015**	**2016**	**2017**	
1	2	3	4	5	

BEV market share in China, 2017-2030



Incremental demand under crediting system

2025, % 2017 demand in China



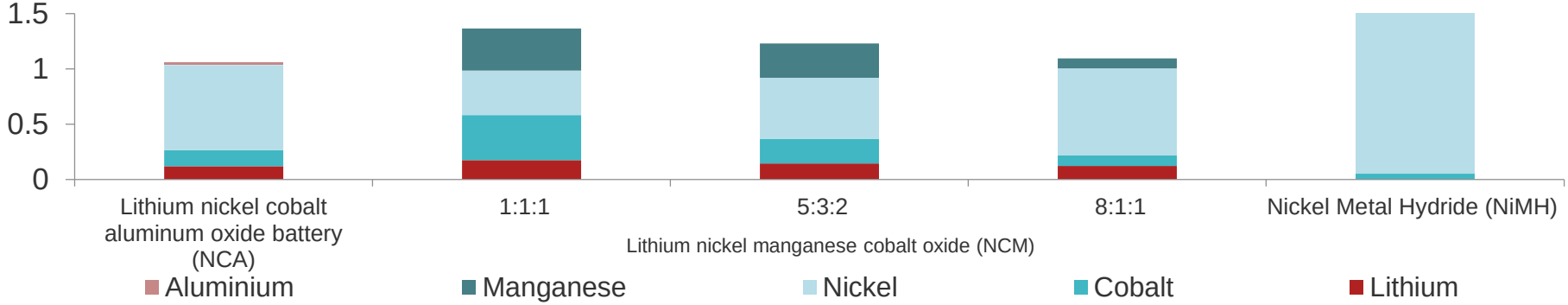
…recent policy reforms likely to spur metals demand, particularly for li & co

CRU, NDRC, MIIT, MOST

Metal intensities differ in new vehicle & energy storage technologies…

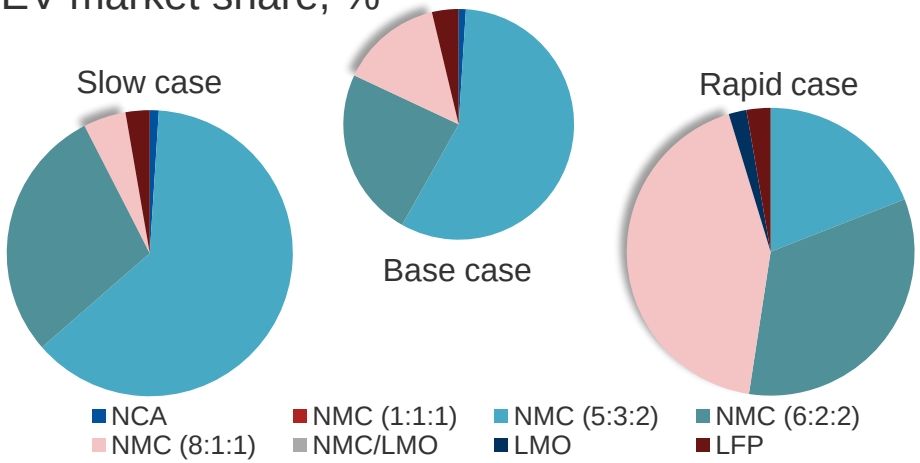
Cathode composition by battery storage technology

KGs per kWh



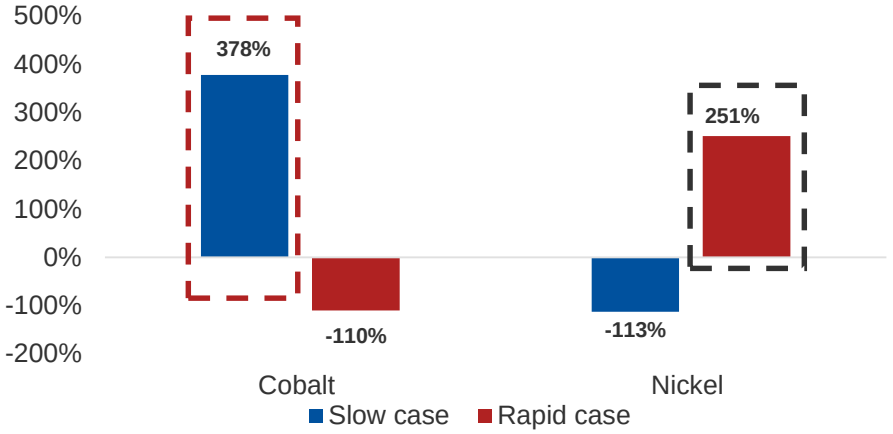
Battery technology in China, 2025

BEV market share, %



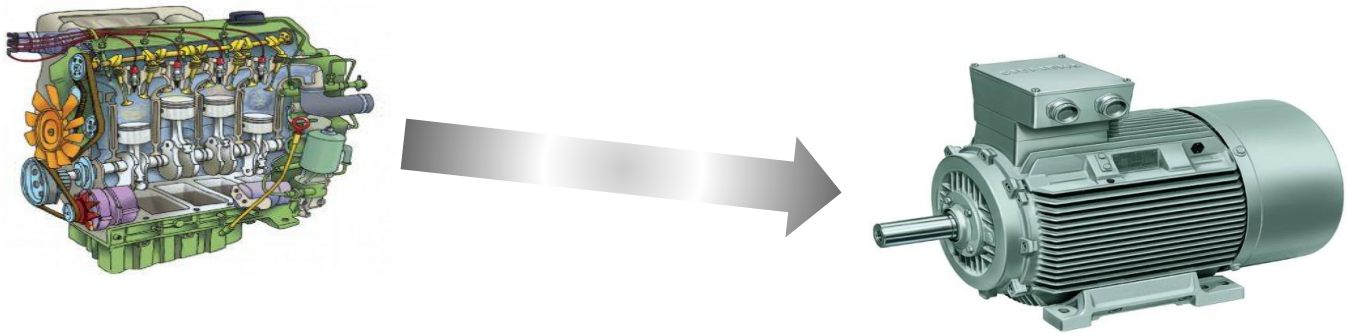
Change in metal demand 2025 compared to base

deviation from 2025 baseline, % 2017 demand

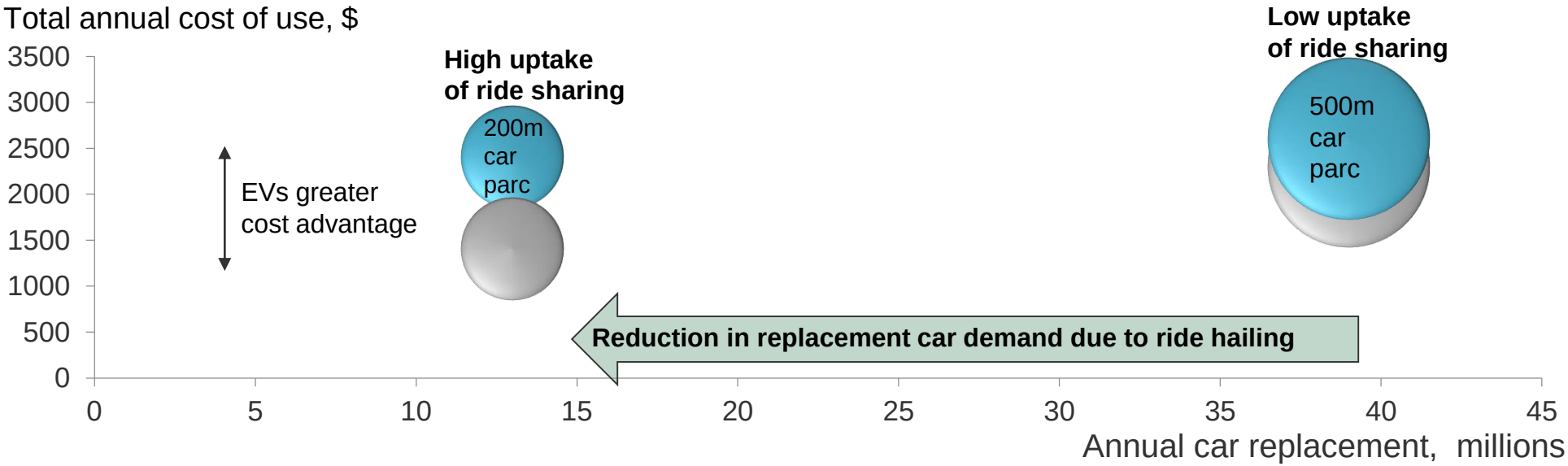


…innovation in NCM cathode a major driver of future ni & co demand

Ride sharing has huge potential impacts on vehicle demand…

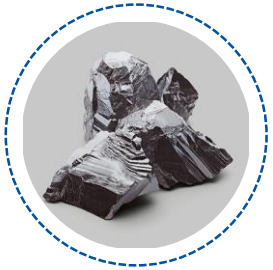


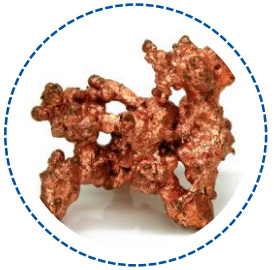
Ride hailing, car ownership costs & replacement demand in China, 2035



…this disruption is more likely in an EV world

Key takeaways for nickel, lithium, cobalt, and copper prices





	Nickel	Lithium	Cobalt	Copper
UPTREND	• Further Ni substitution away from Co as battery technology continues to develop (e.g. 8:1:1 for 5:3:2)	• Faster uptake, growth of EV market than expected • Inability of new producers to rapidly ramp up battery grade material production results in more persistent deficits	• Looming deficits • DRC supply disruptions lead to price spikes • Depressed Cu & Ni prices keep Cu-Co, Ni-Co production low	• Need to build out / reinforce distribution networks • Transformers and motors needed for EVS drive up wire demand
DOWNTREND	• Supply challenge is to increase availability of battery grade nickel sulphate to match rapid demand growth • Large stocks of LME grade material available	• Emergence of superior battery technology, fuel cell vehicles • Project enthusiasm creates oversupply	• Price and supply risks leads to continued & increased substitution away from Co battery chemistries	• Emergence of, say, a pouch based cell technology or with no need for Cu foil that limits Cu demand inside battery packs

Data: CRU

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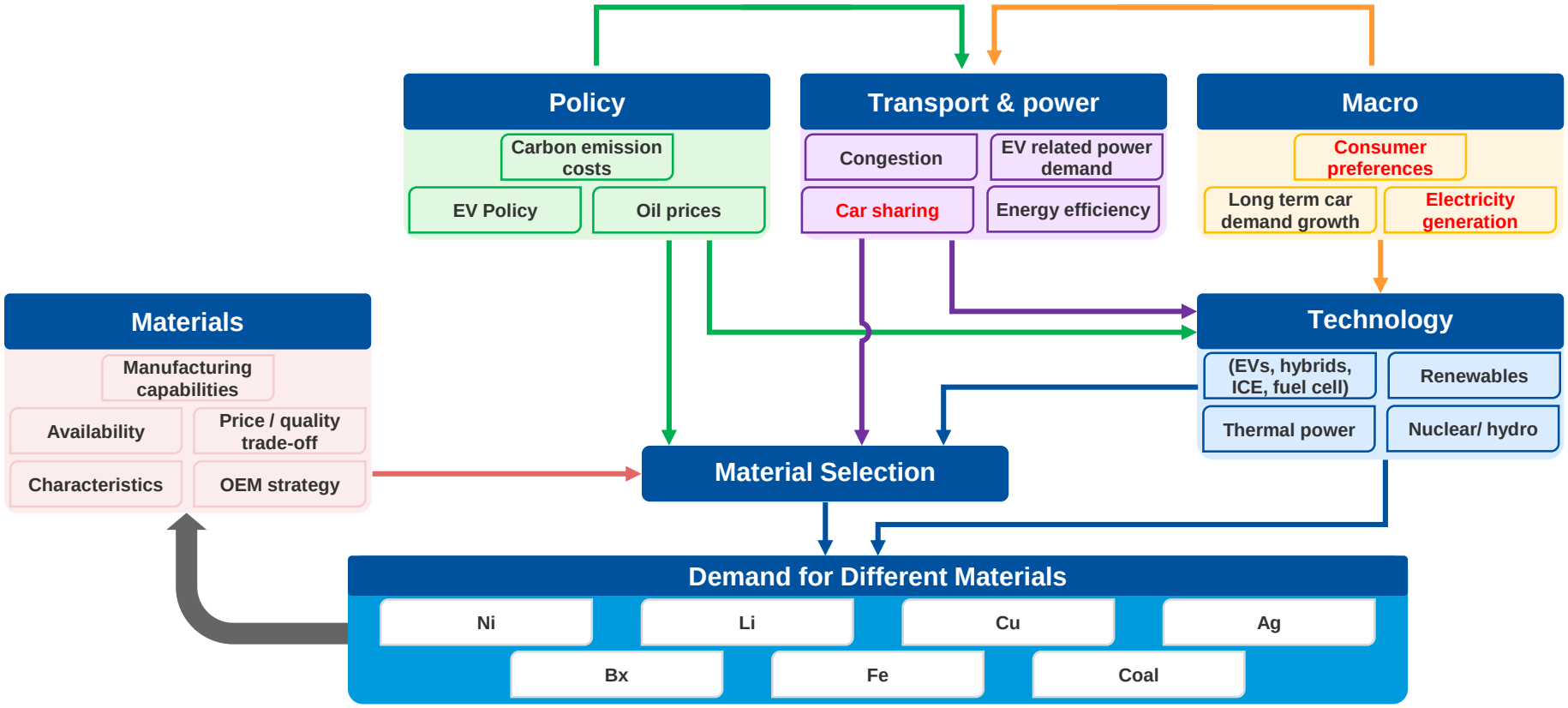
Overview of demand modelling framework

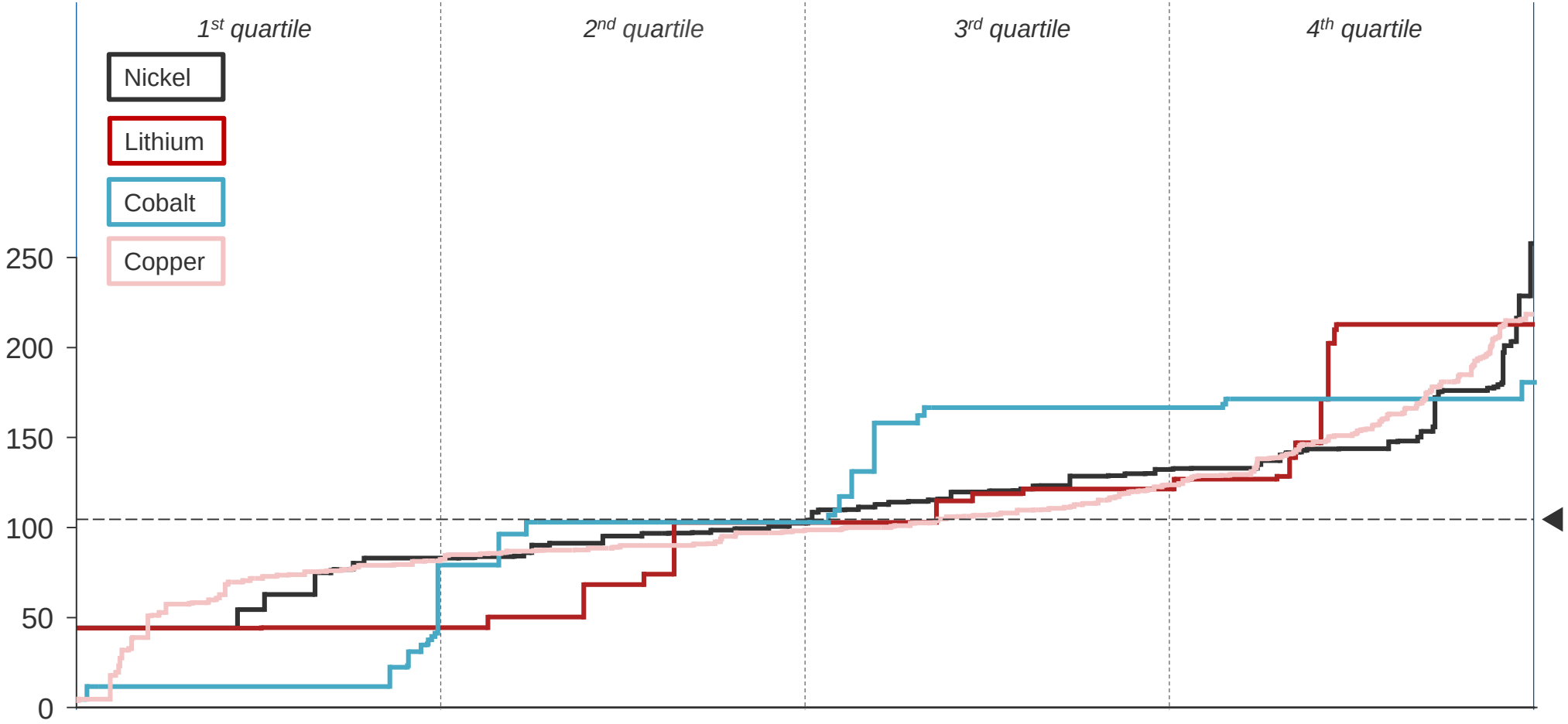


Economics, policy, technology and consumer preferences determine metals demands

Analysing cost curves key to understanding price risk

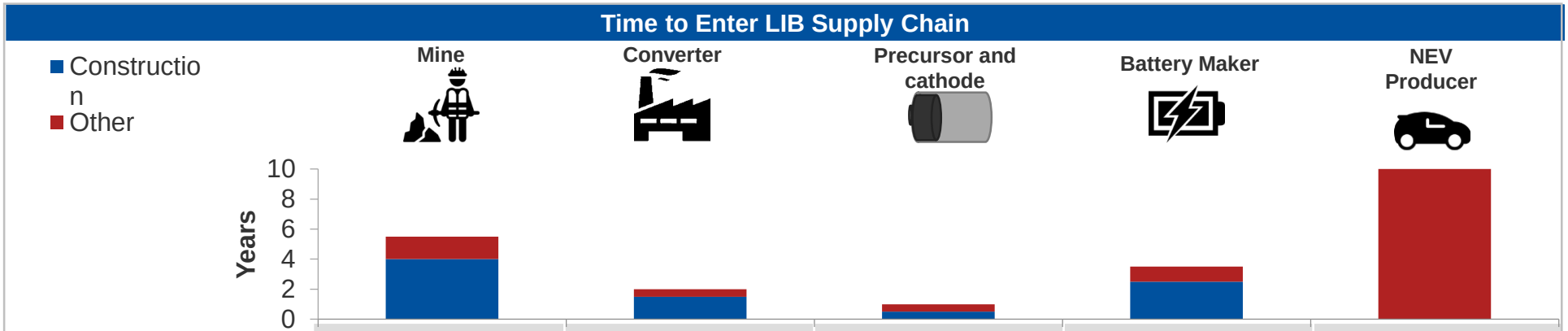
Metal business cost curve, 2018

100=50th percentile



Timing mismatch in the supply chain: room for bottlenecks

- Timing mismatch in the supply chain, a glut can occur anywhere due to volume, quality and obtaining accreditation

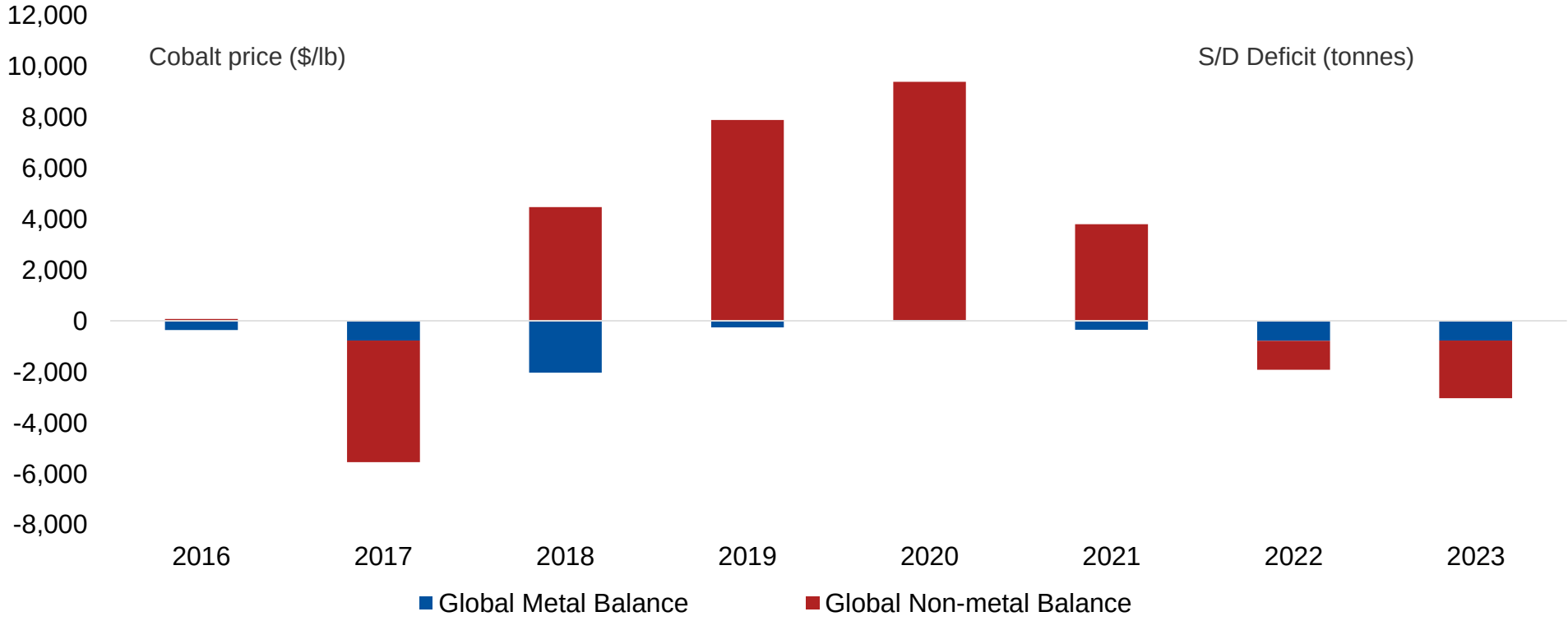


	Mine	Conversion Facility	Precursor/cathode	Battery maker	Car Maker
Average Construction Time	1.5 years	1.5 years	6 months	2-3 years	n/a
Other Time Requirements	Exploration to construction:	New plant to produce stablised lithium chemicals:	Lithium chemical accreditation process in battery use:	Government and EV maker accreditation process	EV/LIB design:
	Average 5 years +	6 months	6 months +	Up to 12 month	8+ years

Chemical market well-supplied due to additional volumes from Katanga & ERG…

Annual Cobalt supply-demand balance

Tonnes



…but the metal market remains tight due to low metal refining capacity