Impact of uncertainty in automotive fuel and energy storage on selected elements

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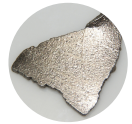
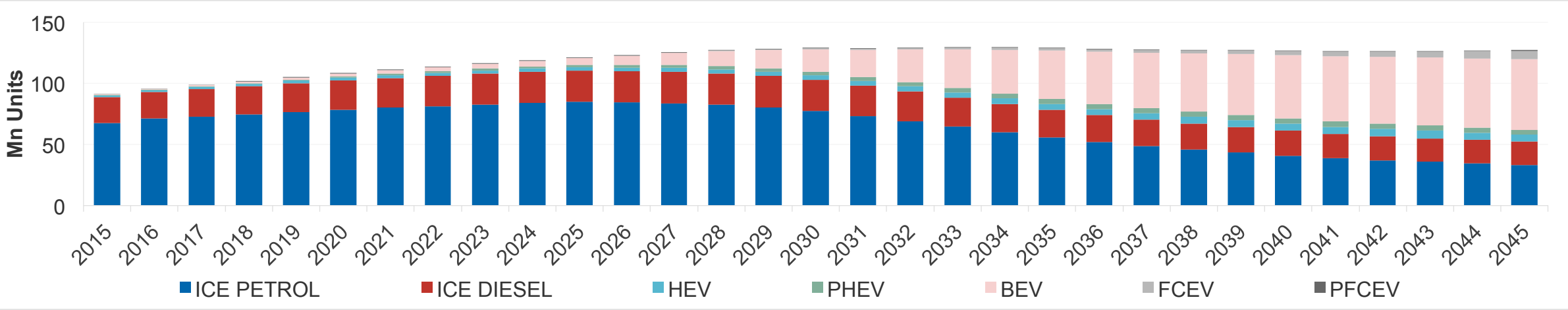
Selected elements

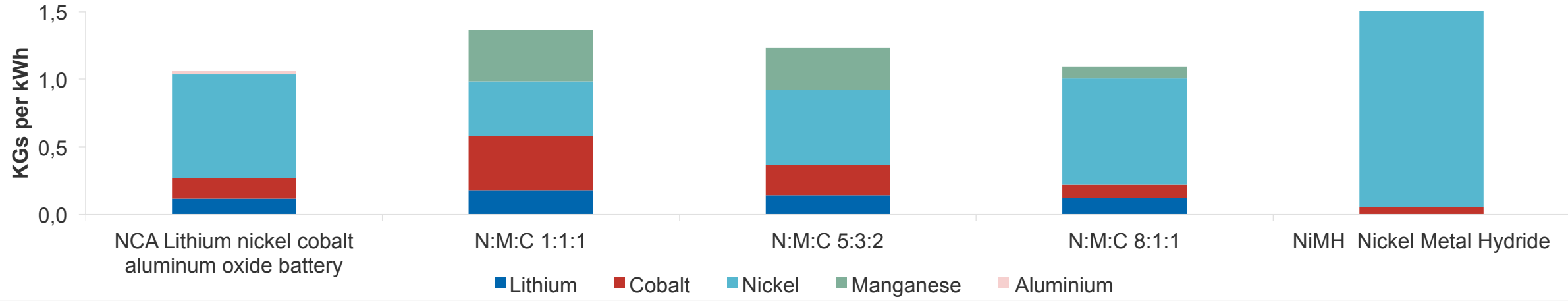
	23 V Vanadium	82 Pb Lead	28 Ni Nickel	25 Mn Manganese	27 Co Cobalt
					
Key uses can be summarised as follows:	Steel hardening	Batteries for automotive	Stainless steel	Metal alloys	High strength alloys Pigments

Stationary storage **ICE** **Batteries for NEVs**

Automotive “fuel”



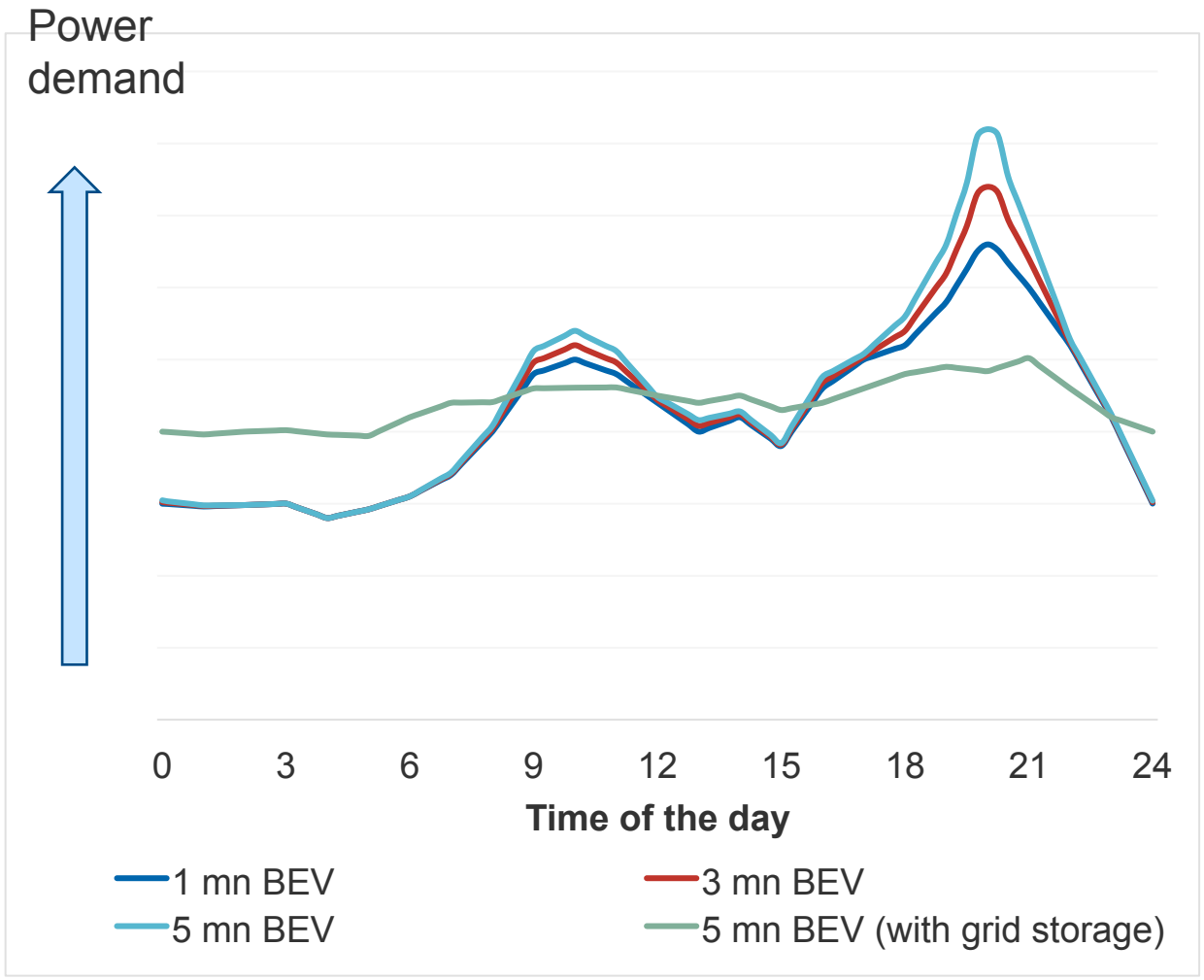
Cathode composition by battery storage technology



Increasing complexity of “fuel” types

Source: CRU Battery Metals Market Outlook

Energy storage set to grow



- NEV's will substantially increase electricity consumption
- New electricity demand will come from charge stations across the road network
- In parallel increased electricity generation from renewable sources and demand for recharging automobiles will put pressure on supply
- Stationary storage will be used to smooth peaks and troughs in demand

economically smoothing energy demand

Source: CRU Battery Metals Market Outlook

Many sources of uncertainty may delay decisions

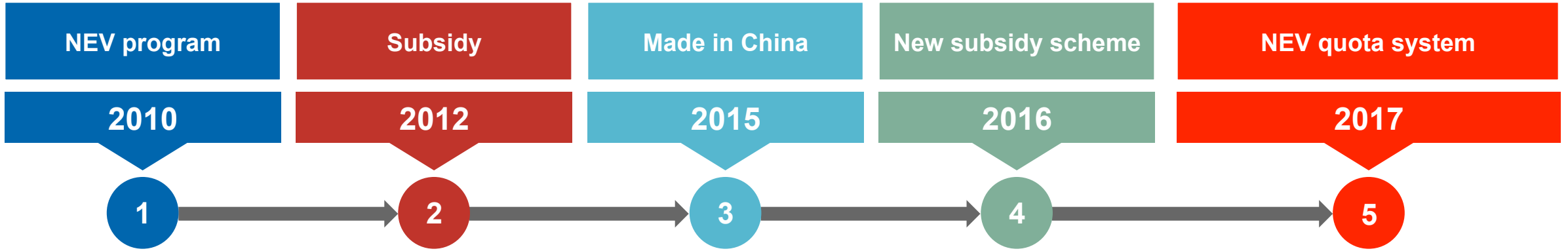
Policy	Technology	Capacity	Enabling Infrastructure
Many levels of government creating policy, from Inter-governmental to city majors creating layers of rules and policies	Rate of development is key to bringing down costs to make policy affordable. Many alternatives still available	Extreme commodity intensity; investments in production capacity face uncertainty about technology and infrastructure	Decision to invest will hasten demise of old technology (ICE). Higher renewables penetration compounds issues
Fast & important changes	**No clear winners yet**	**Some speculation will be needed**	**Additional set of market participants**

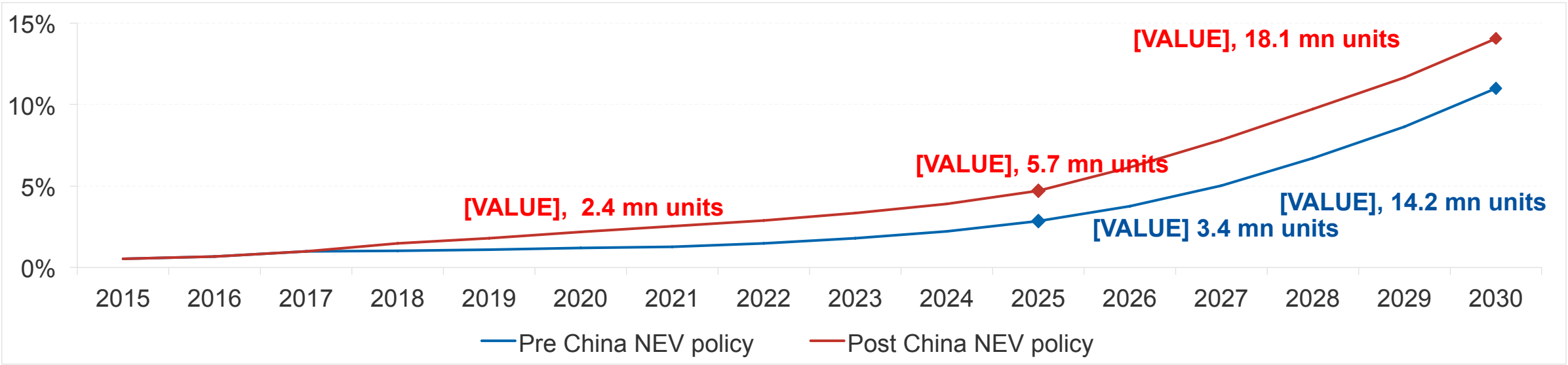
Wrong or mistimed decisions will cost participants dearly

Clarity about direction but not outcomes

Single policy statements can make a large difference

Government of China announcements





Credit /quota system if implemented +67% by 2025

Source: CRU Automotive Fleet Model

Automotive and storage

Storage demand as % of total demand		Automotive demand as % of total demand		
Vanadium	Lead	Nickel	Manganese*	Cobalt
1%	24%	2%	2%	8%
3%	24%	6%	4%	23%

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

Vanadium

19%

Lead

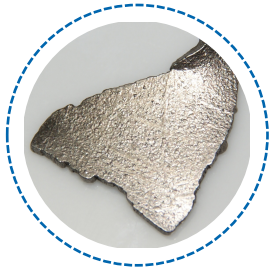
24%

Nickel

29%

Manganese (EMM*)

8%



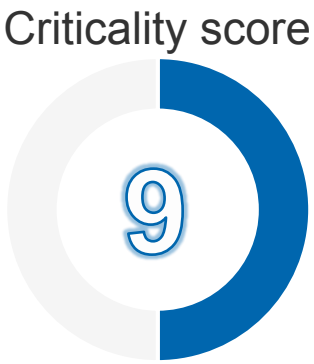
Cobalt

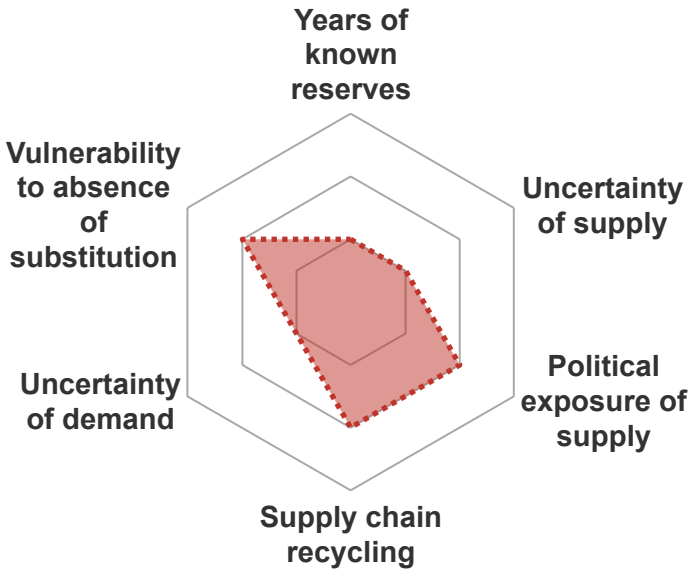
63%

a significant driver of demand growth.

2016 2021

Vanadium – recently surprised on the upside





Years of known reserves

Abundance of known reserves (250 years)

Uncertainty of supply

Ample mine capacity is available

Political exposure of supply

China, South Africa and Russia dominate supply, medium term alternative sources would be available

Supply chain recycling

Will be easy in stationary storage

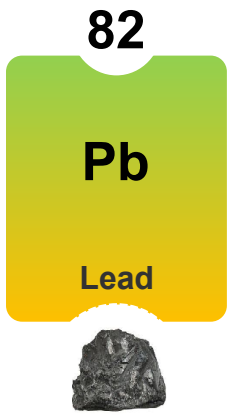
Uncertainty of demand

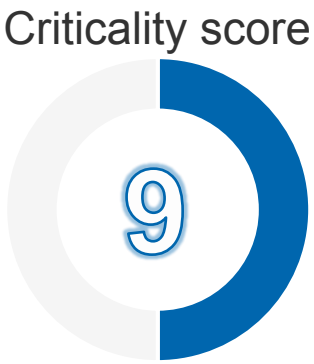
Civil engineering related legislation is a current driver of demand. Storage demand will not change balance

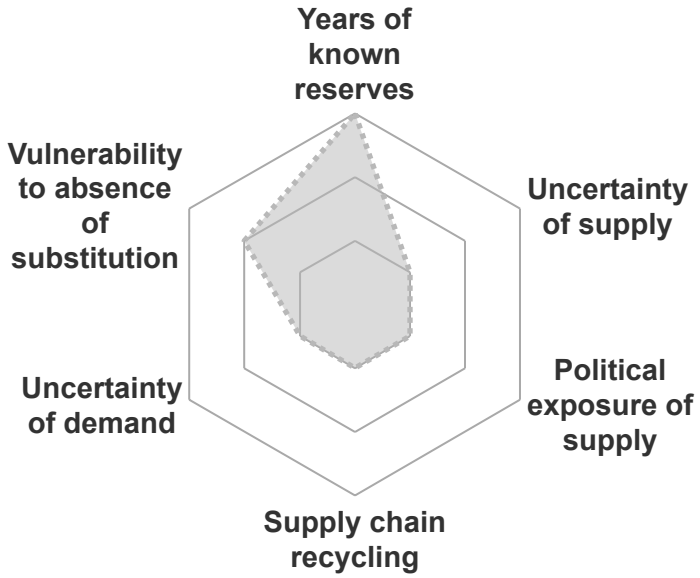
Vulnerability to the absence of substitution

Available in most applications, but at a higher cost

Lead – future is positive with automobile and storage







Years of known reserves
19 years of reserves

Uncertainty of supply
Sufficient mine capacity exists to meet future demand

Political exposure of supply
Diversified and low risk

Supply chain recycling
Well established and significant contribution to annual supply

Uncertainty of demand
Stable demand

Vulnerability to the absence of substitution
Pb-acid batteries dominance is threatened by new developments

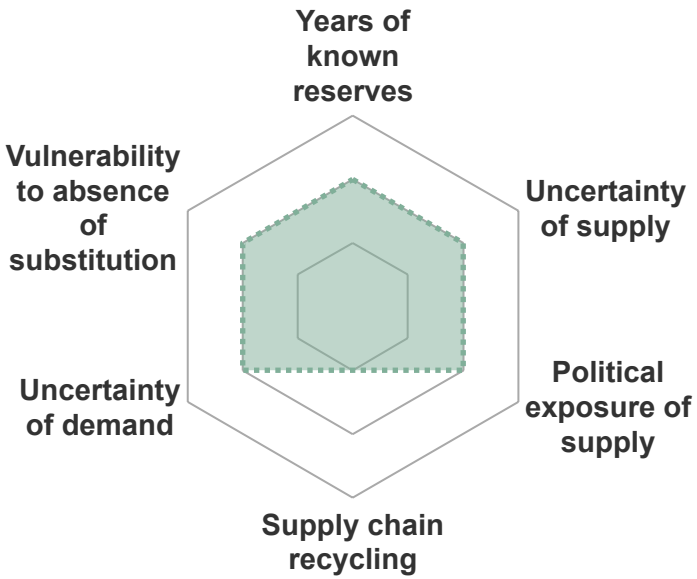
Nickel – vulnerable to fly-up in price

28

Ni

Nickel

Criticality score



Years of known reserves

35 years of reserves do not give huge comfort that there will not be a problem in the longer term

Uncertainty of supply

Additional capacity required to meet future demand

Political exposure of supply

is a medium risk, while there are diversified sources, many are in higher risk countries

Supply chain recycling

Recycling is well established

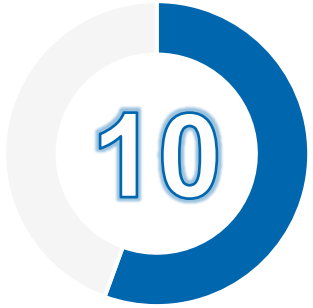
Uncertainty of demand

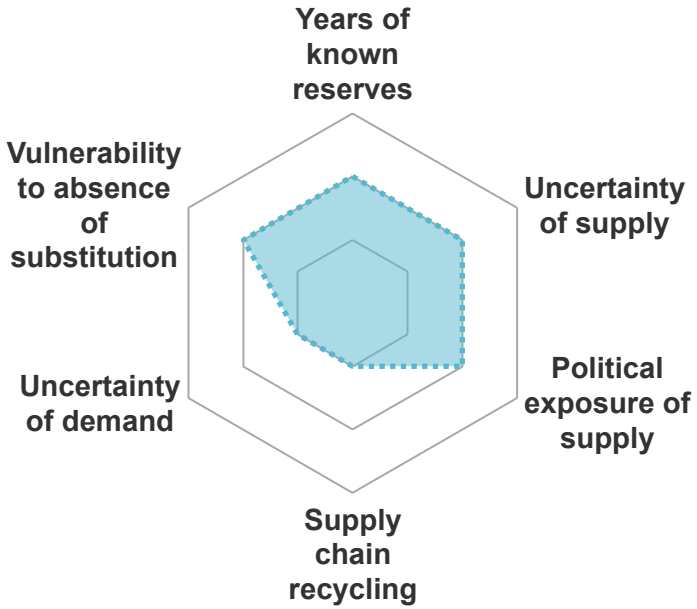
Nickel use is impacted by new technology and new applications

Vulnerability to the absence of substitution

Nickel can be substituted in key applications, but at higher costs

Manganese





Years of known reserves
37 years of reserves

Uncertainty of supply
Additional capacity required to meet future demand

Political exposure of supply
South Africa dominates supply then Australia and China

Supply chain recycling
Well established and increasing in line with steel

Uncertainty of demand
No disruptive demand expected

Vulnerability to the absence of substitution
Can't be substituted in certain applications - high strength alloy steels

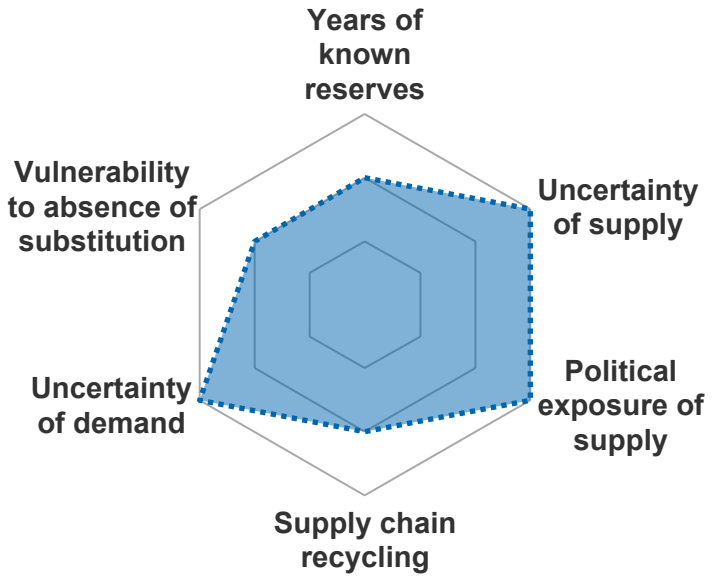
Cobalt – the risk of over-reliance is well known

27

Co

Cobalt

Criticality score



Years of known reserves

70 years of reserves at current production rates will decline to 25 years in ten years if no new reserves identified

Uncertainty of supply

Forecast supply deficit for 2027 is greater than 30%

Political exposure of supply

50% of mine supply comes from the Democratic Republic of Congo

Supply chain recycling

High recycling rate needed to maintain supply / demand balance

Uncertainty of demand

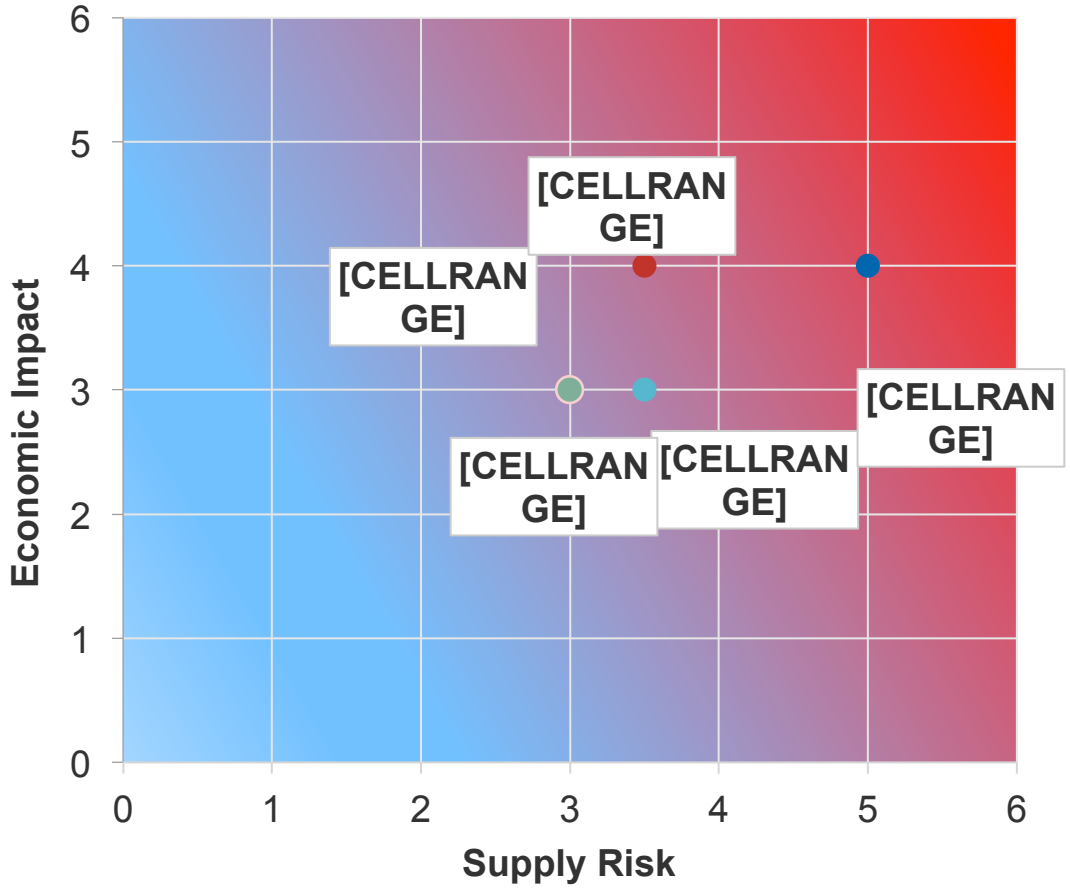
More than 60% of demand growth coming from automotive sector

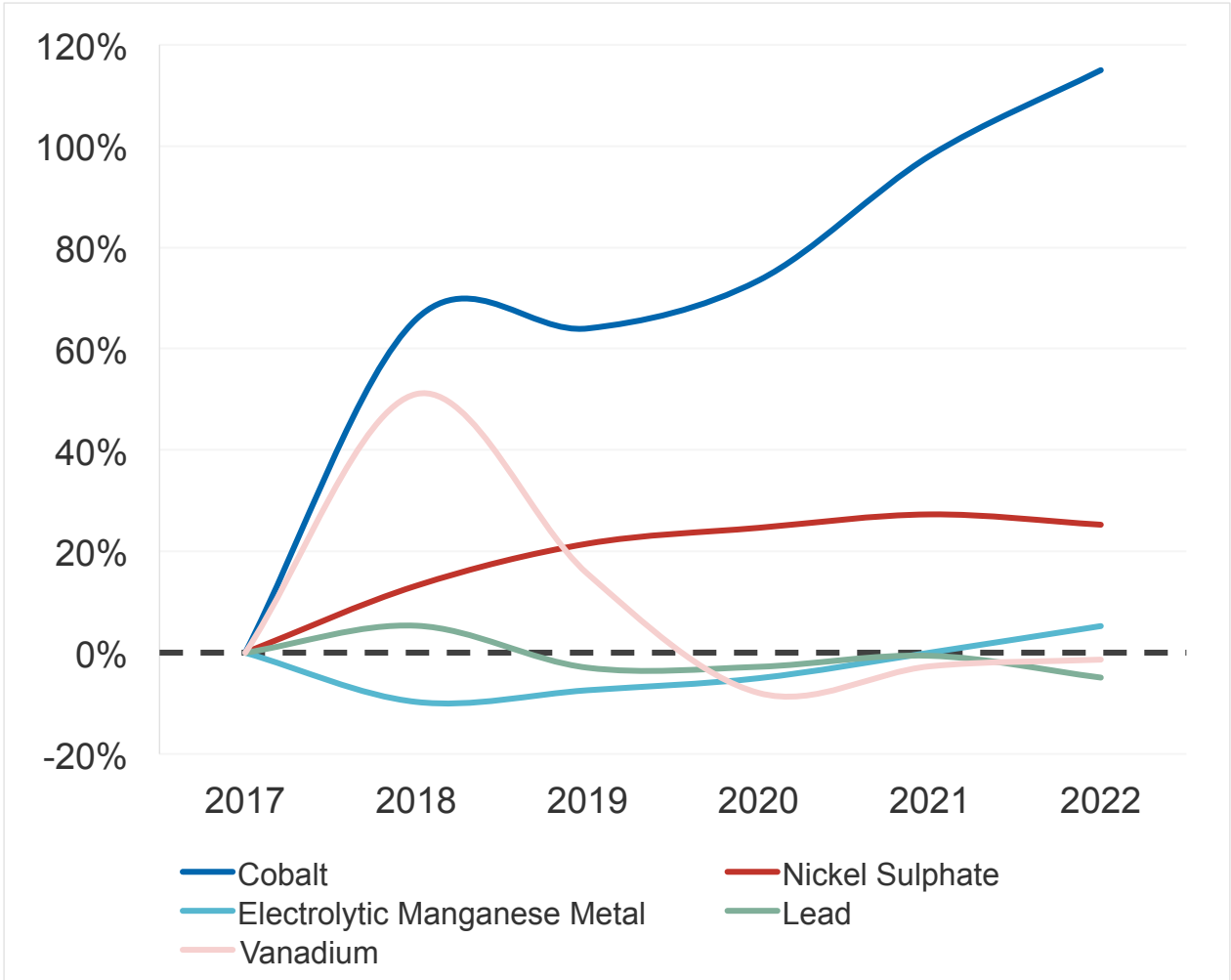
Vulnerability to the absence of substitution

Efforts being made to minimise use of cobalt in battery applications

Vulnerability matrix - used to identify risk of price fly-ups

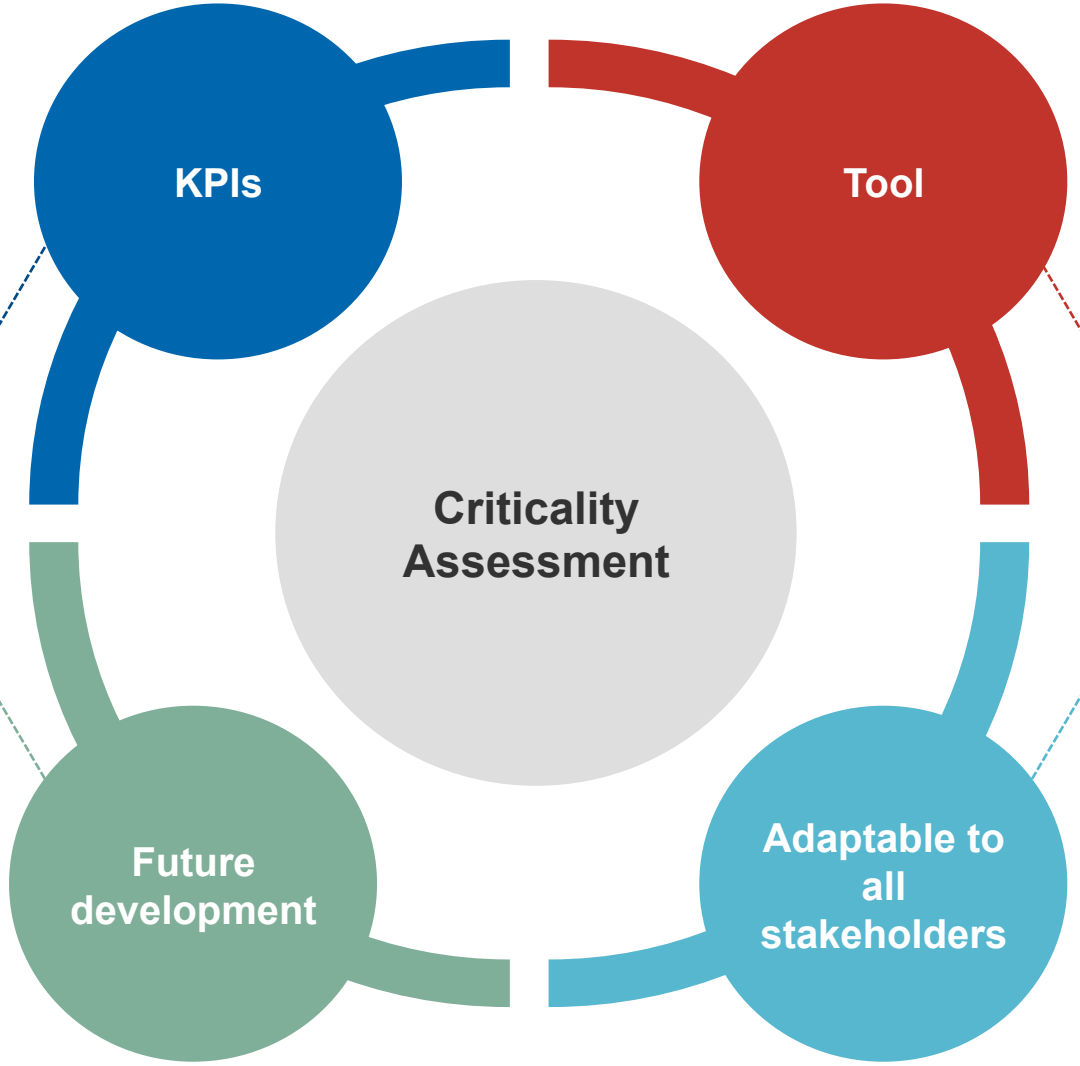
Vulnerability matrix
Based on criticality assessment





A criticality assessment tool usable by all stakeholders

1. Years of known reserves
2. Uncertainty of supply
3. Uncertainty of demand
4. Political exposure of supply
5. Supply chain recycling
6. Vulnerability to the absence of substitution



- A guide to make sound decisions aware of incumbent risks about choices of raw material and reasonable opinions

- Could be expanded further to include “end of life” recycling of electric and electronic waste

- Business leaders and policy makers
  - from different regions
  - at various stages of the supply chain
  - with different time perspective

THANK YOU

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