The *New* Great Game

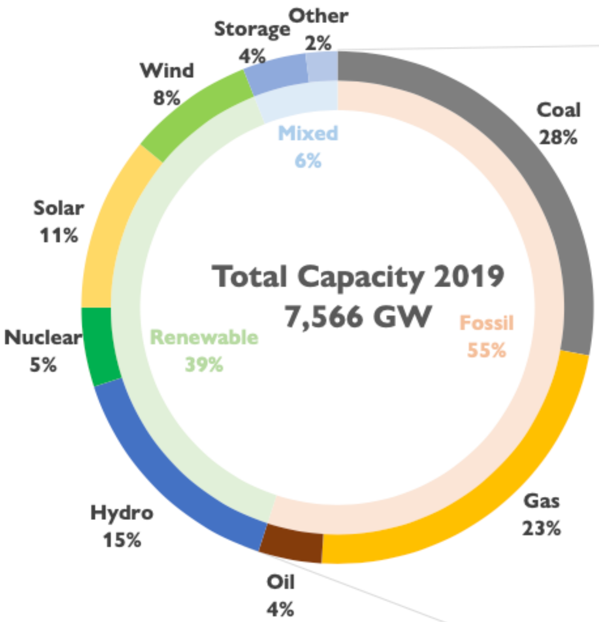
Securing Critical Materials today for a cleaner energy system tomorrow

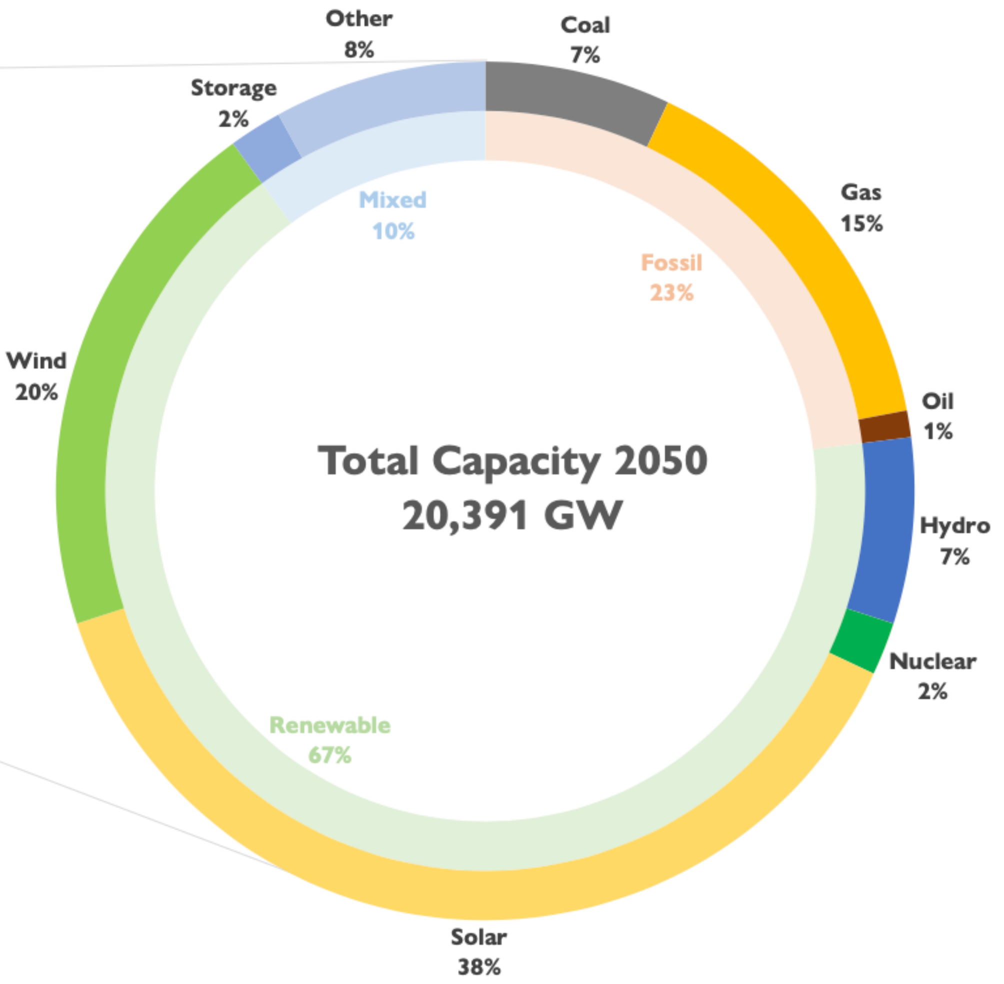
The perfect storm: two key drivers to demand

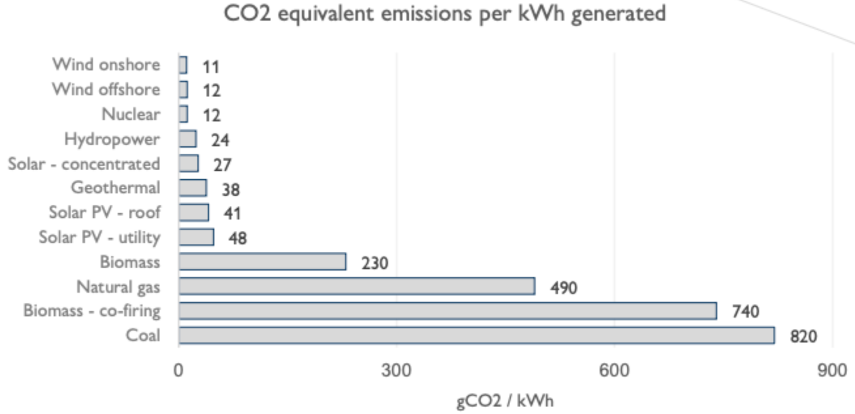
Climate change

Geopolitics

From fossil to renewable energy production

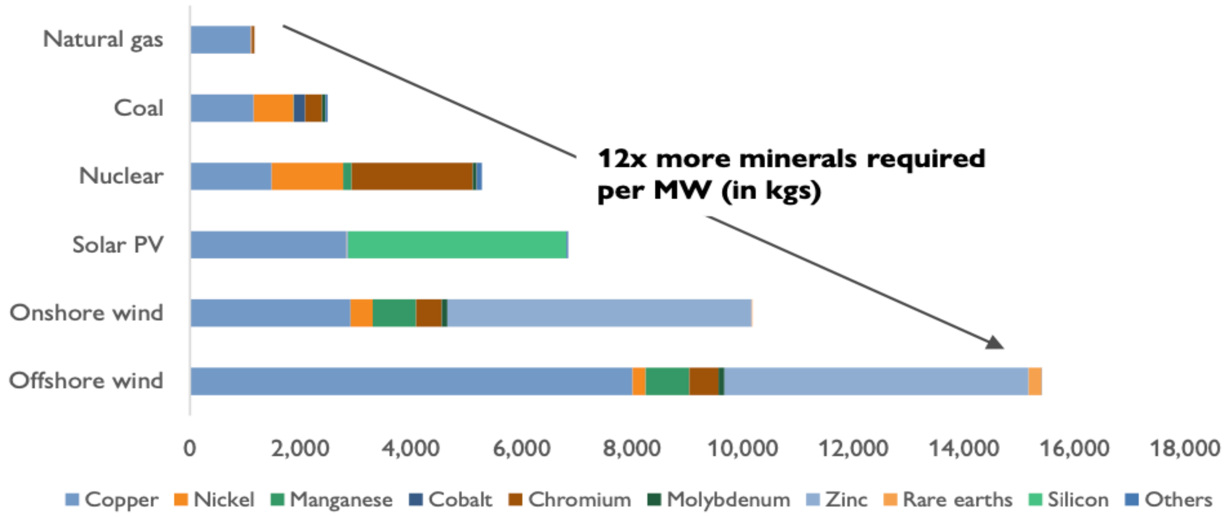


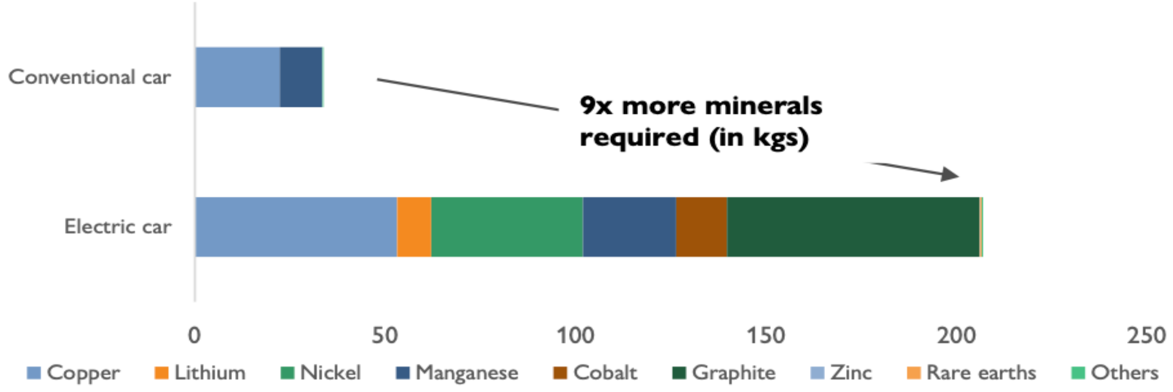




Less is More

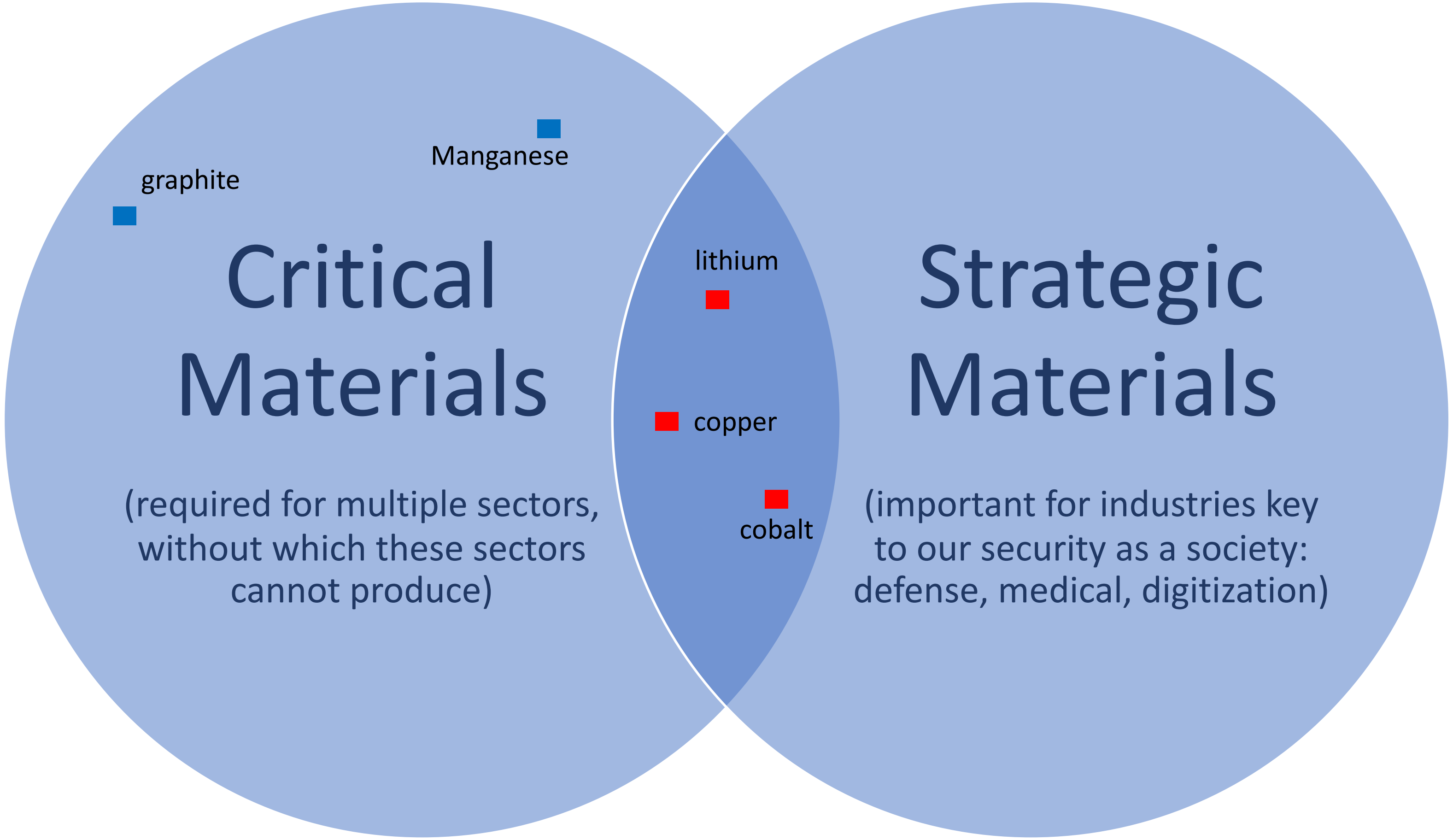
Technologies that emit less GHGs require more critical minerals



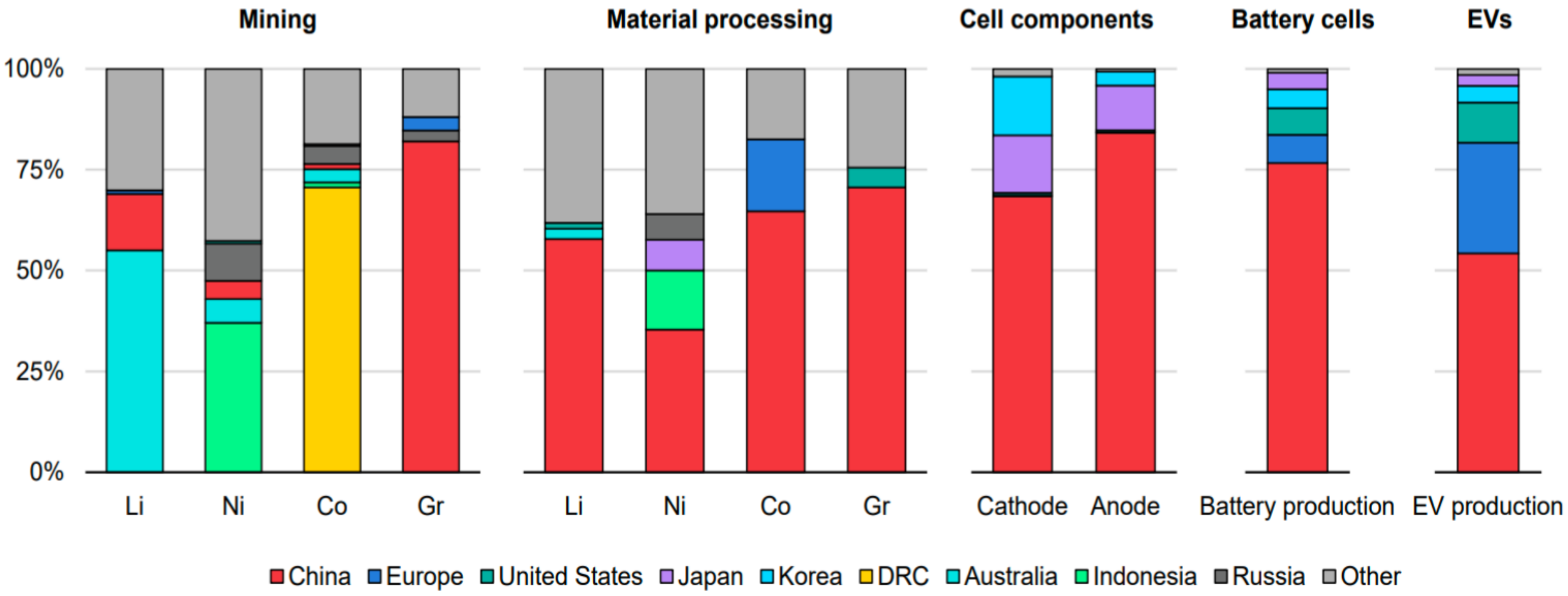


Source: IEA

Critical Materials and Strategic Materials



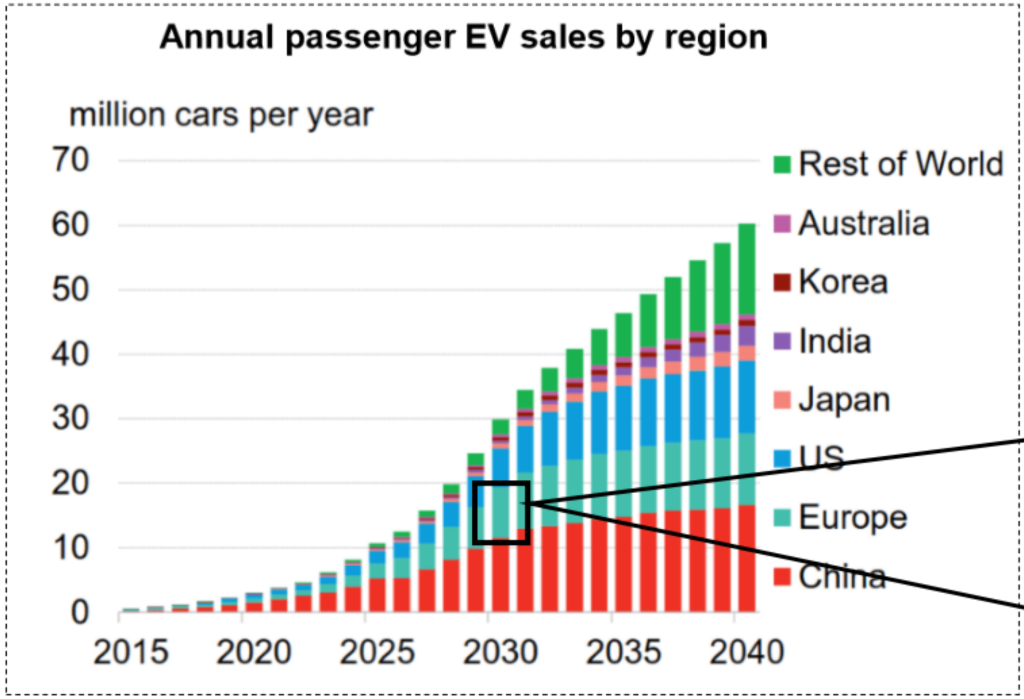
China's dominance in the CRM supply chain



Source: IEA

Electrifying the EU's fleet requires a lot of material

EU EV sales need to ramp up to meet Paris Climate Agreement Targets



Source: BNEF EV outlook 2020

- Projected Sales Growth for EU:
  10 million EVs sold per year by 2030
- Assuming that the average EV for the EU market has a battery pack with a 50 kWh capacity

and

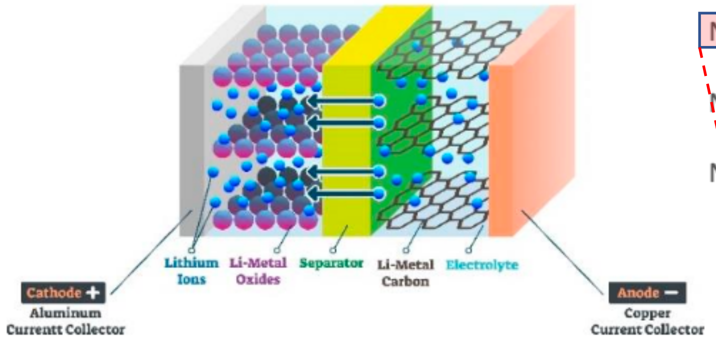
- 1 kWh capacity for an EV requires ~ 0.9 kg of refined lithium chemicals, then 1 average EV requires 45 kg of refined lithium chemicals

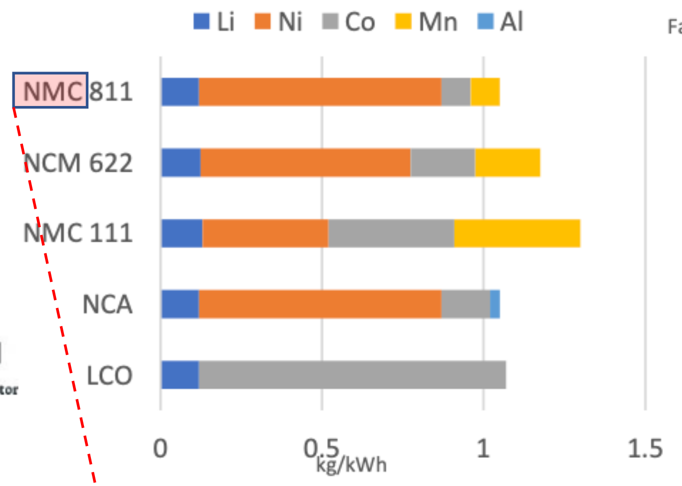
and

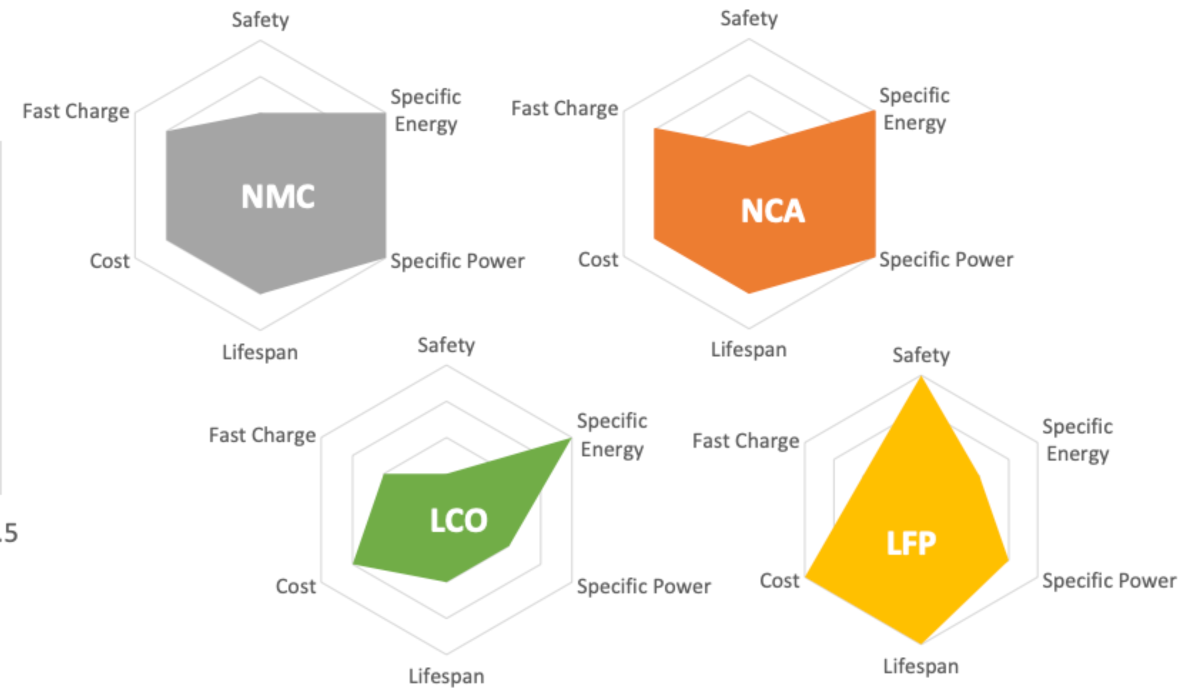
- 10,000,000 EVs by 2030 means Europe requires 450,000 ton of refined lithium chemicals by 2030

For reference:
Global supply of refined lithium chemicals in 2021 was ~500,000 ton

Cathode Chemistry determines which materials will be in high demand

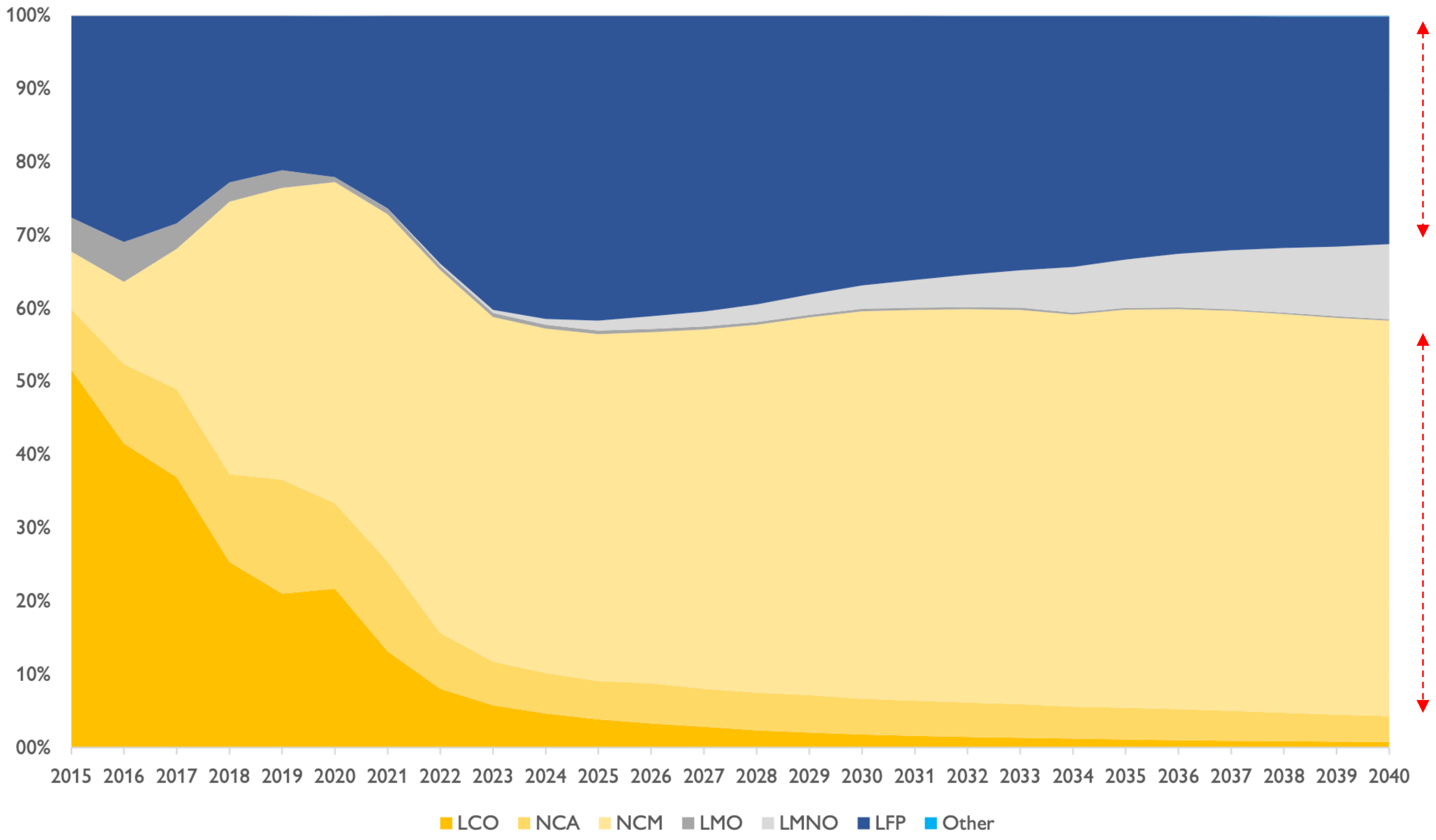






NMC stands for
Nickel, Mangese & Cobalt

NMC batteries projected to remain dominant



Lithium Iron Phosphate (LFP)

- Lower production cost
- Longer cycle life
- Dominant in China

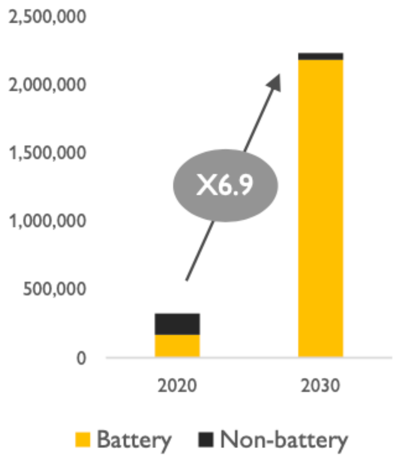
Nickel Manganese Cobalt (NMC)

- Higher energy density
- Longer range
- Dominant in EU / USA

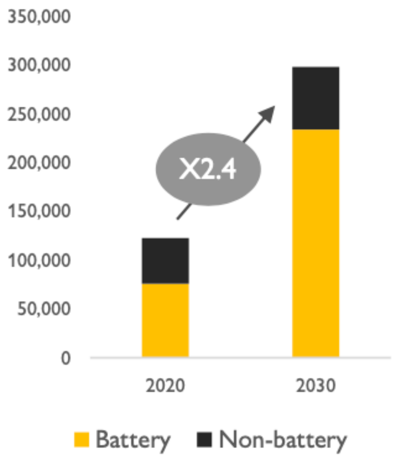
Source: BMI

Which Battery Materials will be in high demand?

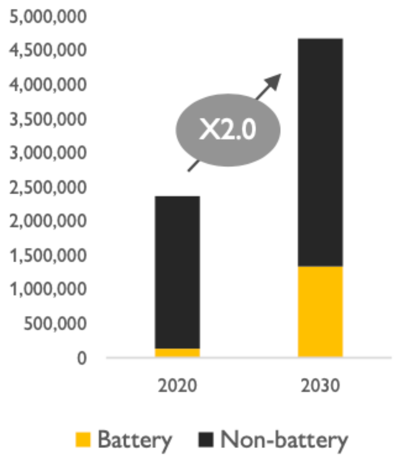
Lithium Demand[1]



Cobalt Demand[2]

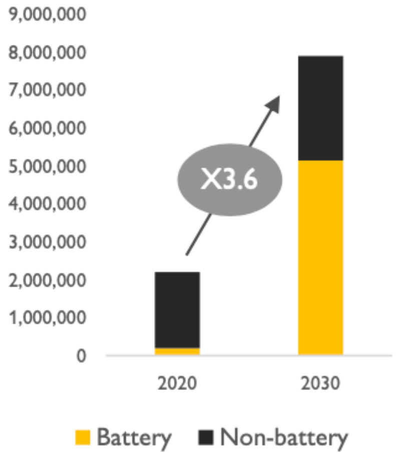


Nickel Demand[3]

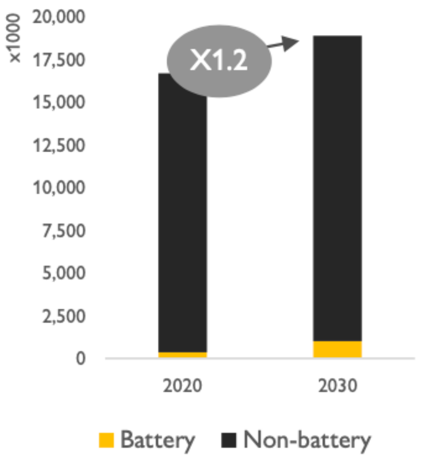


Material found in CCZ deep sea nodules

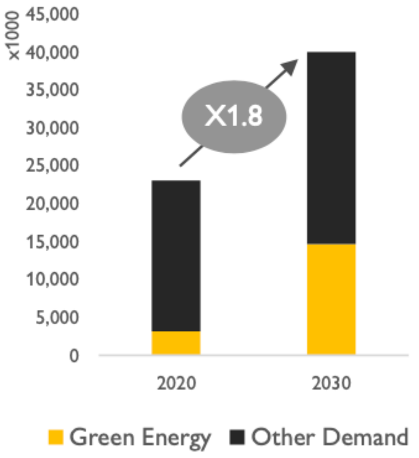
Graphite Demand[4]



Manganese Demand[5]

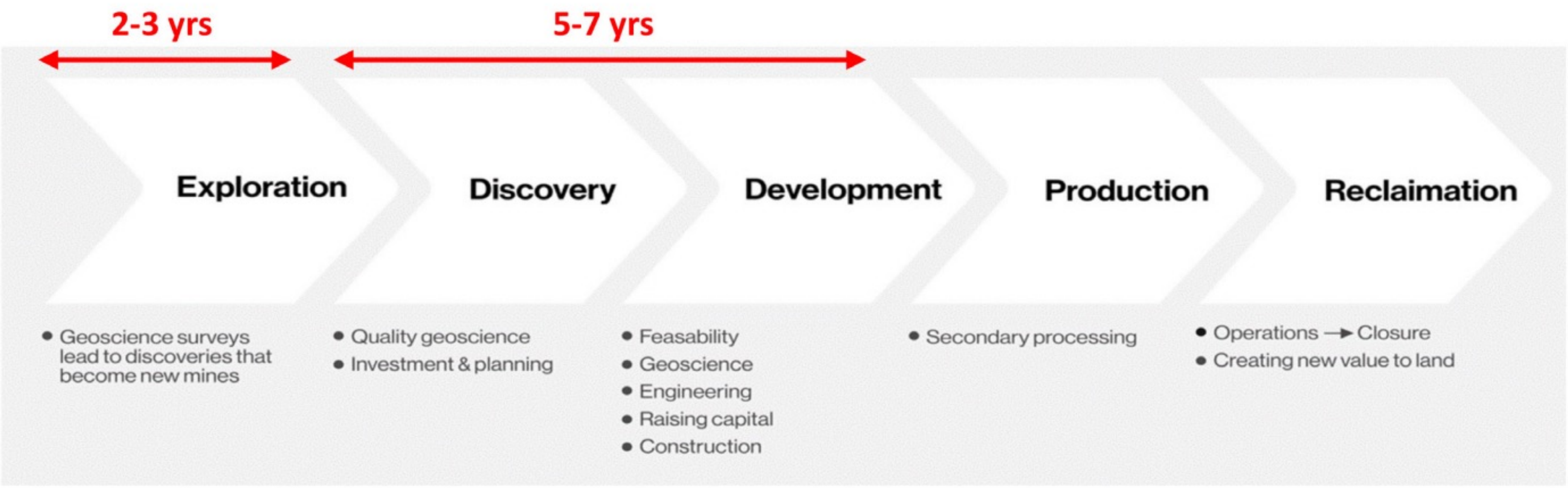


Copper Demand[6]



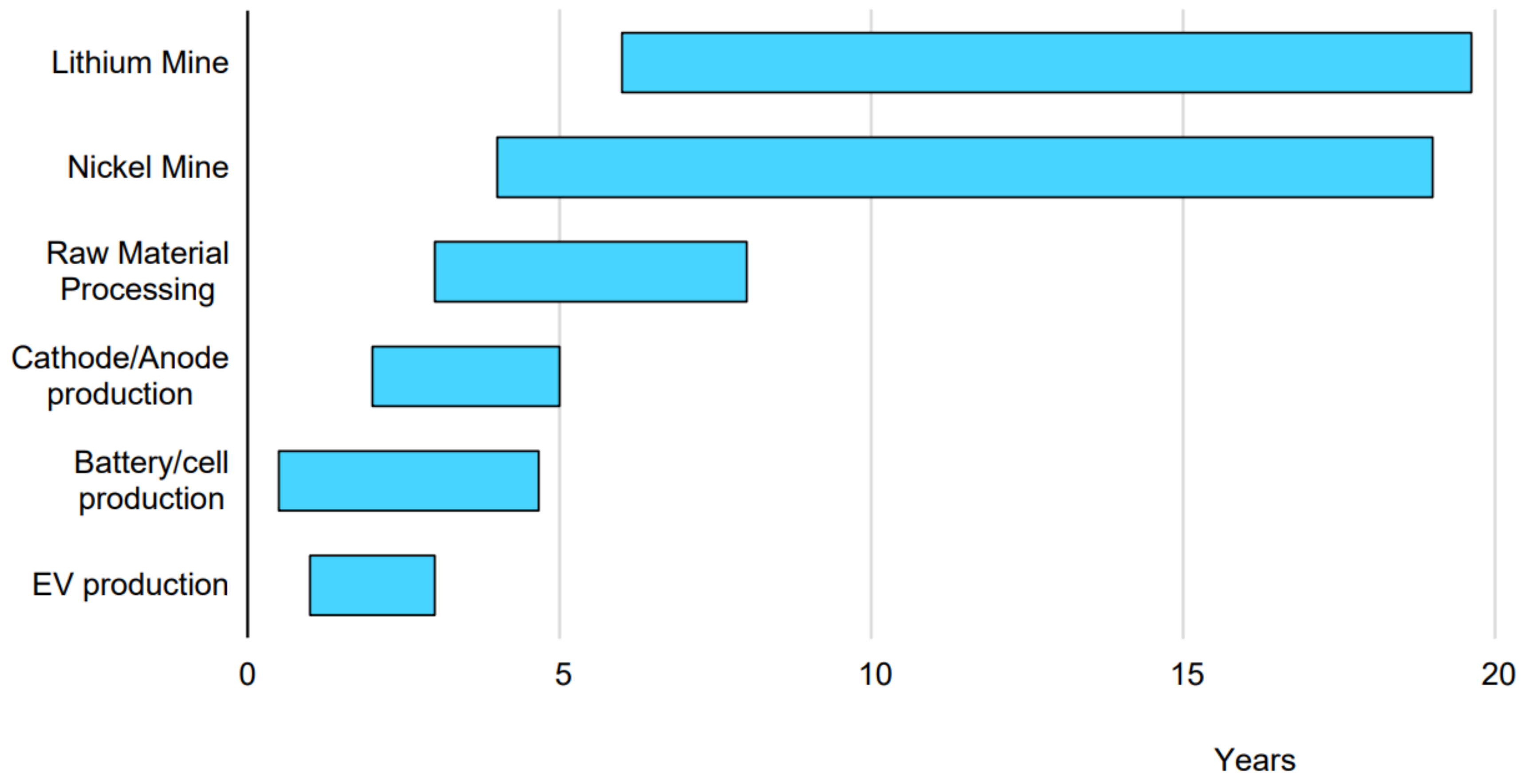
Sources: 1: BMI 2: BMI, 3: BMI. 4: Credit Suisse, 5: combined data, 6: CRU, All data as of 2022

Mining takes time, patience and good fortune

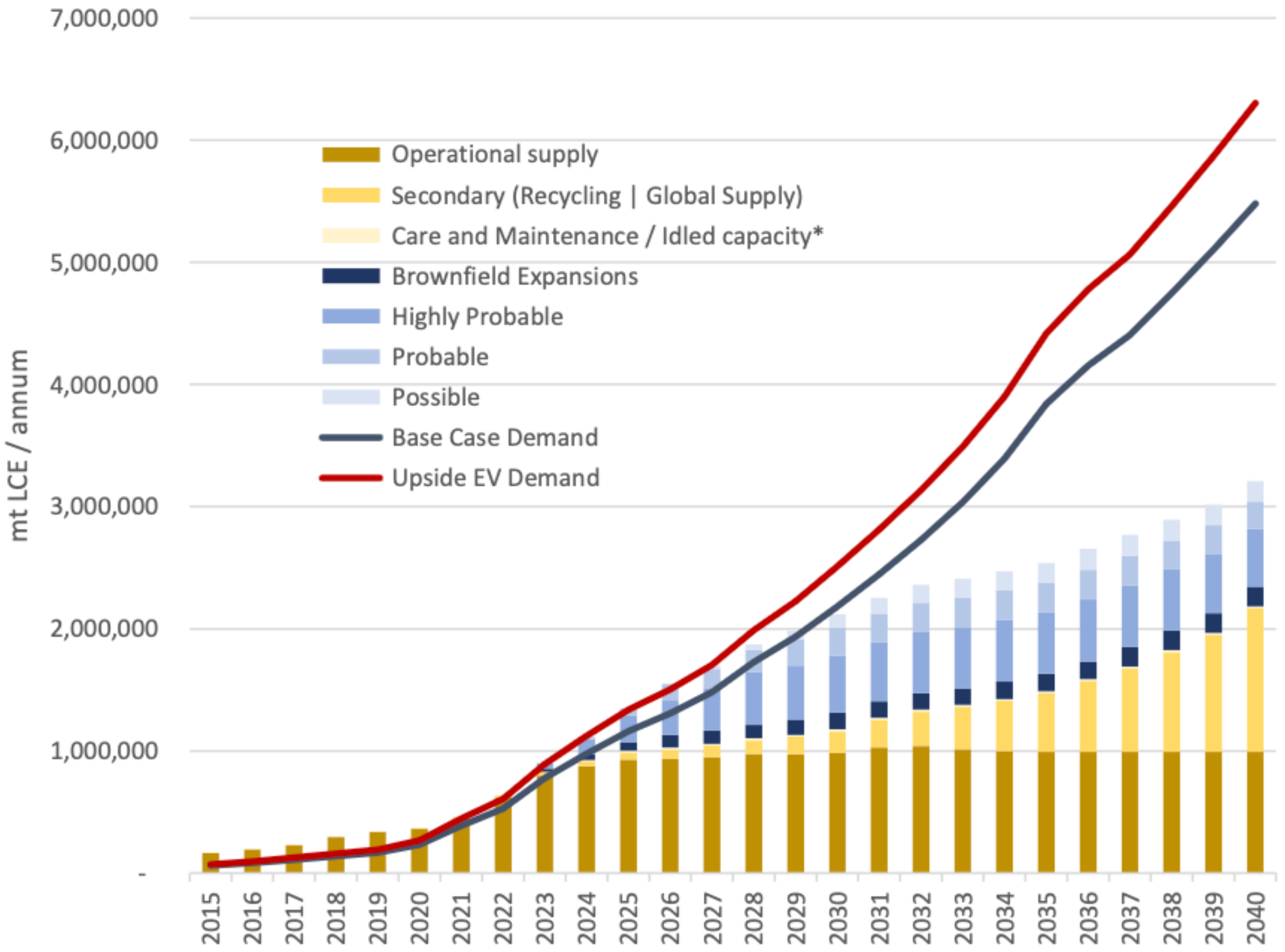


Example of a life cycle for a mining project. Sources: Crux Investor and MRG Intelligence 2021

Road to material production in years



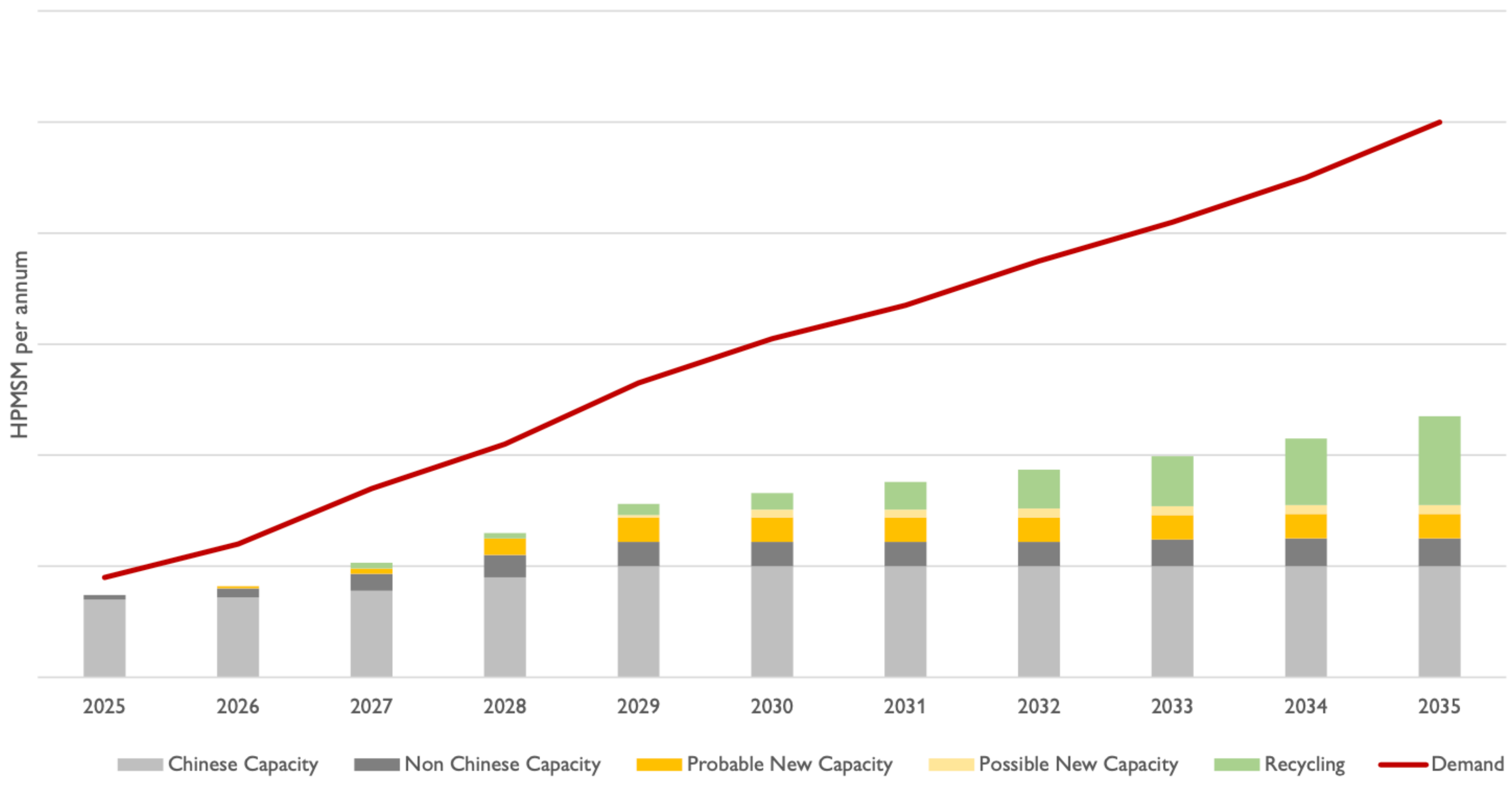
Lithium market balance



Sources: 1: BMI 2: Statista, 3: BMI. All data as of 2022

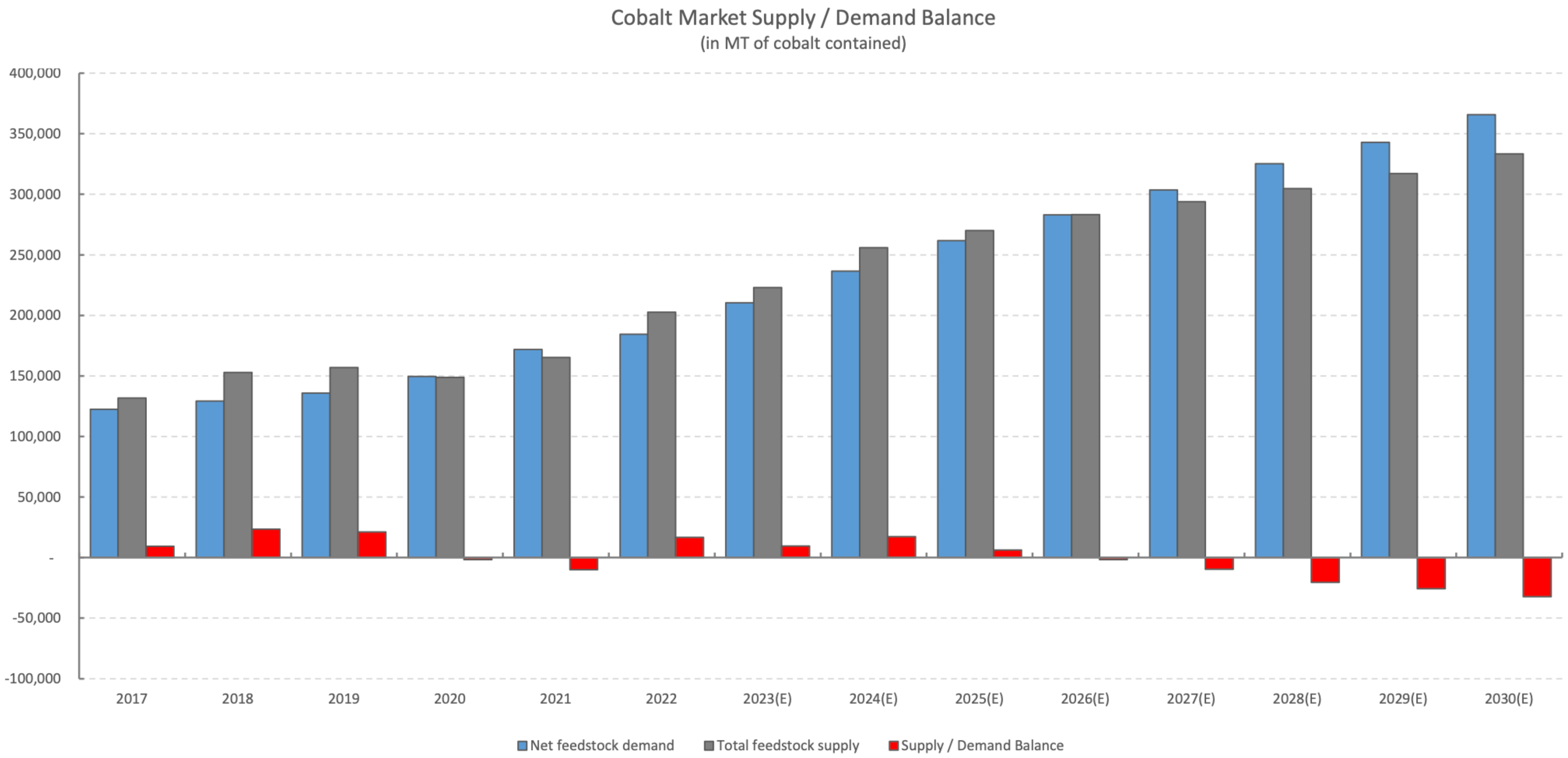
- Supply / demand mismatch even in demand base case
- Larger part of supply will need to come from greenfield projects
- Greenfield projects = high risk of delays or failure

HP Manganese Sulfate market balance



Sources: 1: CPM Group

Market deficit projected in five years



Source: Darton Commodities Ltd. analysis

Why ocean nodules are back in the spotlight

1 All the metals required for leading battery chemistries are found in high concentrations in nodules

	Polymetallic CCZ Nodules (Kg Metal Contained in 4 Tonnes Dry Nodules)	NMC 811 Battery + Cu Connectors (Kg Metal Required for 1 EV)
Nickel	52 kg (1.3%)	56.2 kg
Cobalt	7.2 kg (0.18%)	7.05 kg
Manganese	1,168 kg (29.2%)	6.6 kg
Copper	43 kg (1.08%)	35 kg (battery) + 50 kg (electric harness)

Why ocean nodules are back in the spotlight

2 Typically seabed nodules have high(er) concentrations of nickel, manganese, cobalt and copper

- Higher concentration + reserves size → meeting global electrification demand → CoP21 targets
- Higher concentrations → potential for less waste material → better environmental footprint than onshore
- Onshore, grades are lower → it's becoming tougher to find high grade assets in nickel, copper

Why ocean nodules are back in the spotlight

3 Some Life Cycle Assessments show that seabed mining improve the ESG track record of NMC material

Environmental, social and economic impacts

Cradle-to-gate production of nickel sulfate, manganese sulfate, cobalt sulfate and copper cathode
Serving size **1 billion electric cars**

	Land	Nodules	% change
Climate change			
GWP - CO_2 equivalent emissions, Gt	1.5	0.4	**-70%**
Stored carbon at risk, Gt	9.3	0.6	**-94%**
Nonliving resources			
Ore use, Gt	25	6	**-75%**
Land use, km^2	156,000	9,800	**-94%**
Incl. Forest use, km^2	66,000	5,200	**-92%**
Seabed use, km^2	2,000*	508,000	**+99.6%**
Water use, km^3	45	5	**-89%**
Primary and secondary energy extracted, PJ	24,500	25,300	**+3%**
Waste streams			
Solid waste, Gt	64	0	**-100%**
Terrestrial ecotoxicity, 1,4-DCB equivalent Mt	33	0.5	**-98%**
Freshwater ecotoxicity, 1,4-DCB equivalent Gt	21	0.1	**-99%**
Eutrophication potential, PO4 equivalent Mt	80	0.6	**-99%**
Human & wildlife health			
Human toxicity, 1,4-DCB equivalent Mt	37,000	286	**-99%**
SOx and NOx emissions, Mt	180	18	**-90%**
Human lives at risk, number	1,800	47	**-97%**
Megafauna wildlife at risk, trillion organisms	47	3	**-93%**
Biomass at risk, Mt	568	42	**-93%**
Biodiversity loss risk	Present	Present	
Economic impact			
Nickel sulfate production cost, USD per tonne Ni	14,500	7,700	**-47%**
Jobs created (non-artisanal), worker-years	600,000	150,000	**-75%**

LCA whitepaper 'Where should metals for the Green Transition come from?' Daina Paulikas and others, April 2020

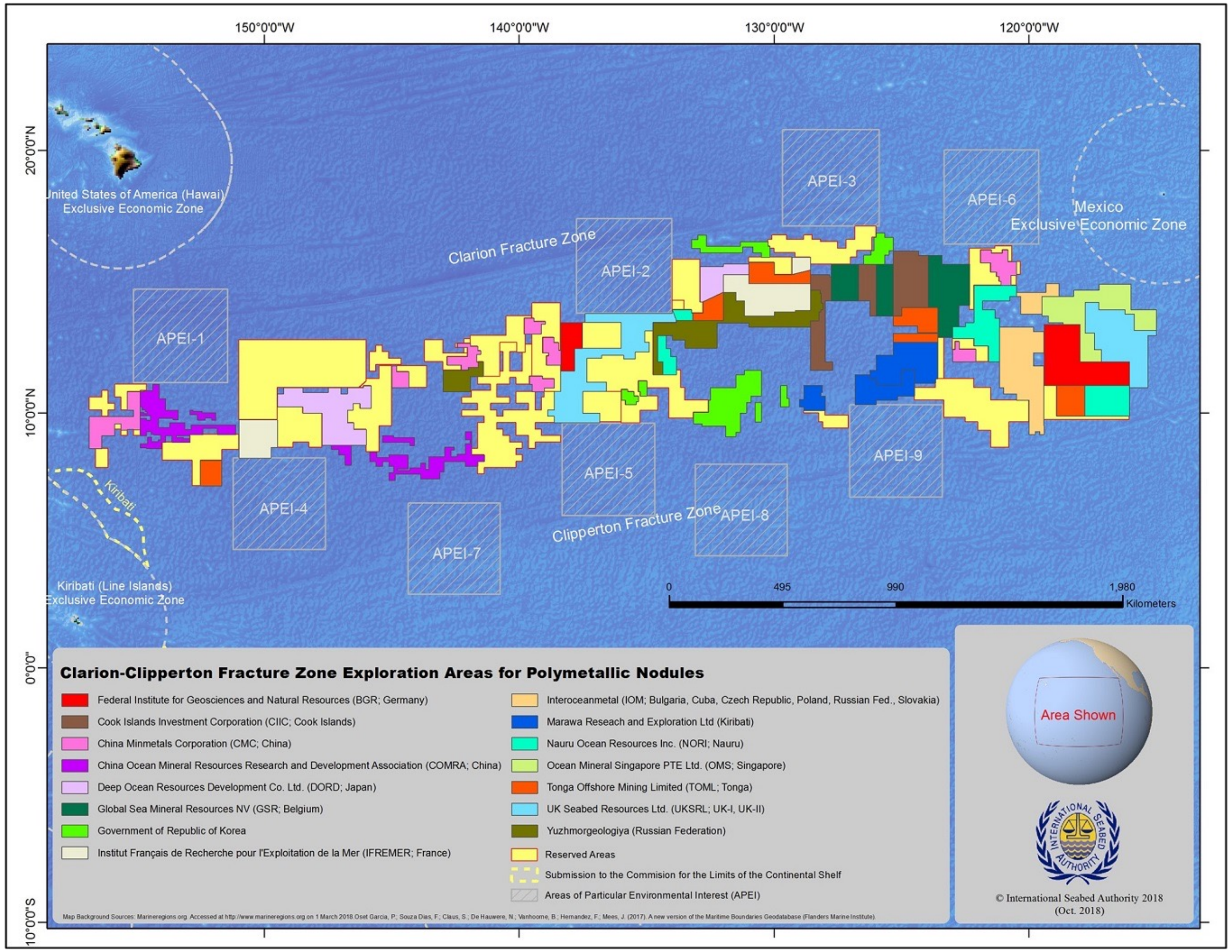
Although long term impacts need to be monitored, we do know that collecting seabed nodules:

- does not required displacement of communities
- Leaves less tailings to be managed
- Offers mining jobs for local communities without the direct exposure to some of the hazards common in onshore mining

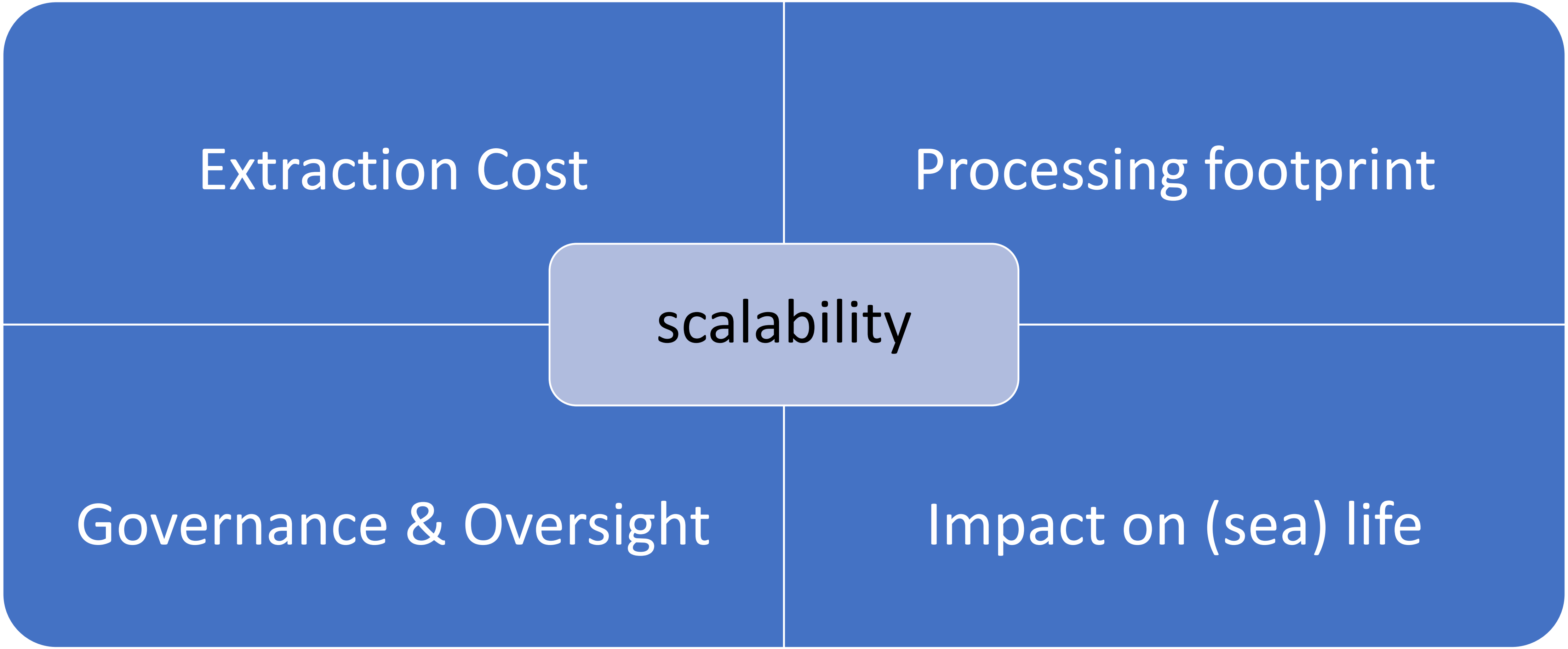
Why ocean nodules are back in the spotlight

4 The Clarion-Clipperton Fraction Zone (CCZ) offers an interesting test case

- Is independent international governance possible?
- What is the impact of exploration and exploitation on sea(bed) life?
- ESG vs geopolitics: who has FOMO?



How scalable is deep sea mining?



Thank you

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