Raw Materials for the Energy Transition

-New challenges-

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GERMAN MINERAL RESOURCES AGENCY (DERA) AT BGR

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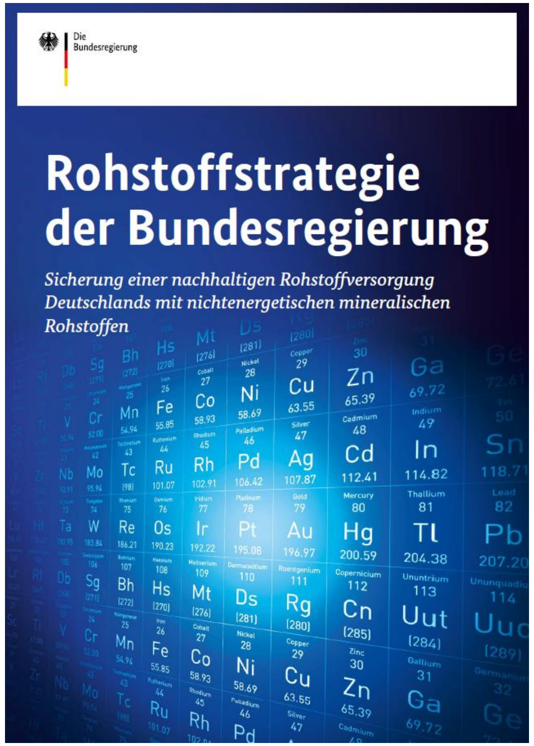


https://www.deutsche-rohstoffagentur.de/DERA/DE/Home/dra_node.html
https://www.bgr.bund.de/DE/Home/homepage_node.html

https://www.bmwi.de/Redaktion/DE/Artikel/Industrie/rohstoffstrategie-bundesregierung.html

GLOBAL CHALLENGES...

- War in Ukraine
- High energy and raw material prices
- Price volatilities
- Energy security/transition in Europe
- Rising inflation/interest rates
- Euro weakness
- Recession concerns
- Skills shortages
- Zero Covid Strategy China
- China's changing supplier role
- Taiwan ?
- Latin America ?
- Logistics problems and supply bottlenecks
- Transformation of the economy - High-Tech Metals → **More raw materials**!
- Climate Change...
- Additional headaches (Supply Chain Act, EU Chemicals Regulation, Reach)

RAW MATERIALS FOR THE ENERGY TRANSITION

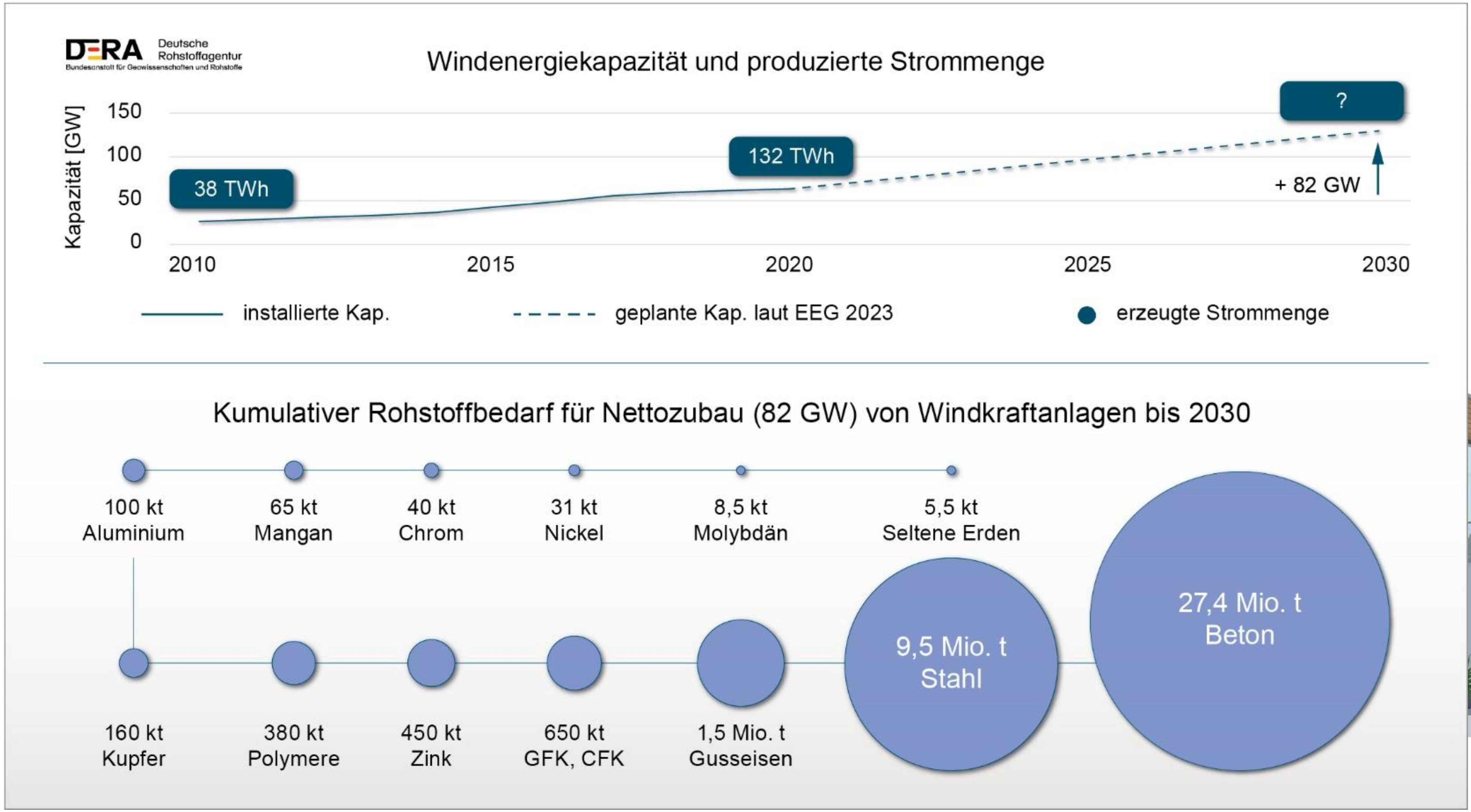
Thin Film Photovoltaics: Glass, Steel, Concrete, Aluminium, Silicon, Copper, Plastics & (Indium, Gallium, Cadmium, Selenium, Tellurium)

Wind Turbines:
Onshore: Concrete, Steel, Polymers, Fibreglass, Aluminium, Copper & REE

Offshore: Stainless steel, Copper, Lead, Steel, Plastics, High Alloy Steels, Special Concretes & REE

E-mobility: Li-Ion-Batteries: Lithium, Cobalt, Nickel, Manganese, Graphite, Aluminium, Copper, Plastics plus X

RAW MATERIAL REQUIREMENTS FOR WIND ENERGY (GERMANY)



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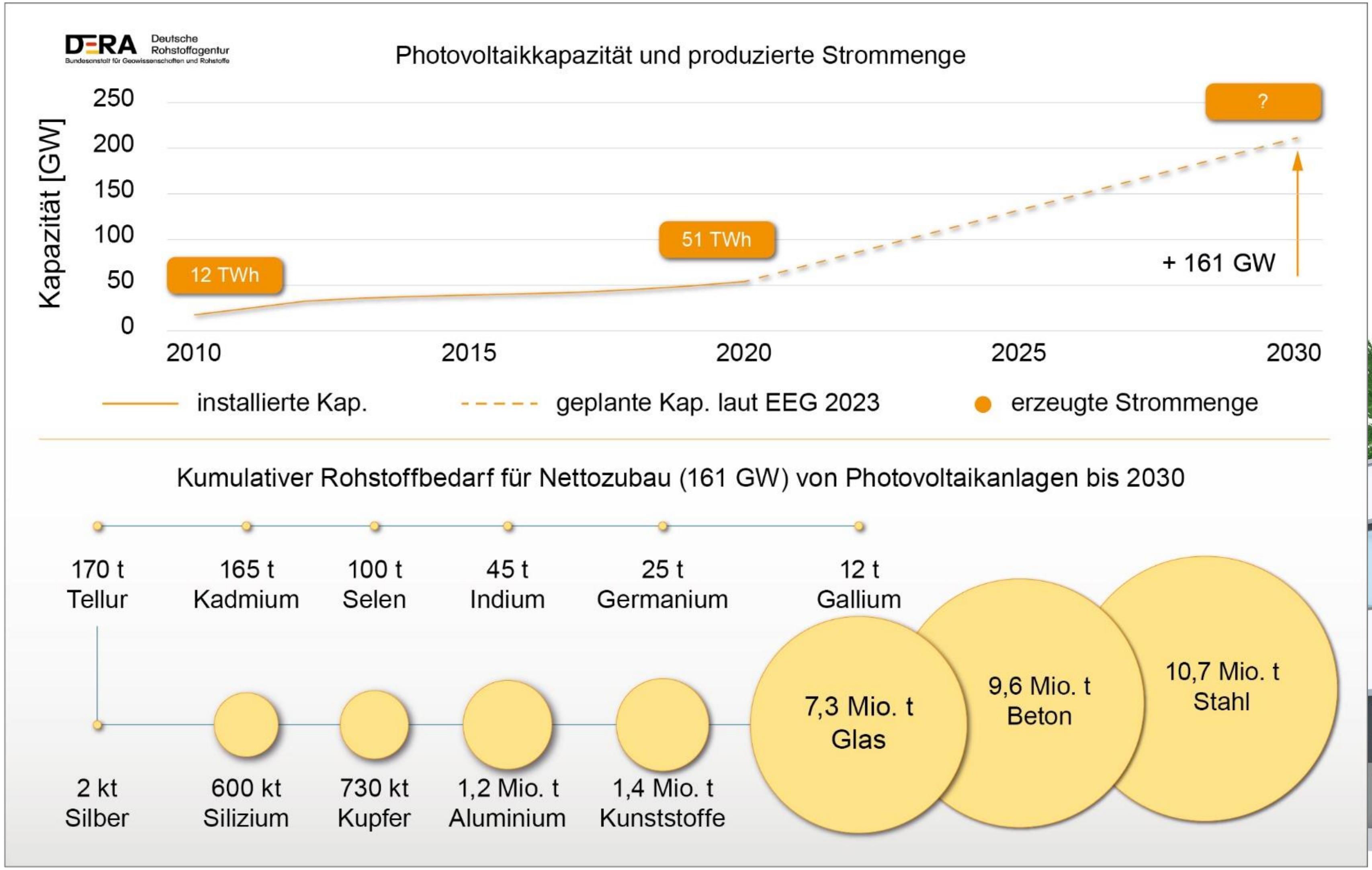
RAW MATERIAL REQUIREMENTS FOR PHOTOVOLTAICS (GERMANY)



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INFLUENCE OF FUTURE TECHNOLOGIES ON THE DEMAND FOR RAW MATERIALS

Motor:

Copper, Aluminium, Magnesium, Lead, Zinc, Nickel, Iron

Permanent Magnets:

REE (Dy, Nd, Pr, Tb), Copper, Iron

Body:

Aluminum, Magnesium, Zinc, Nickel, Iron, Plastics, Composites, Carbon Fibre

Source: BMW 2017

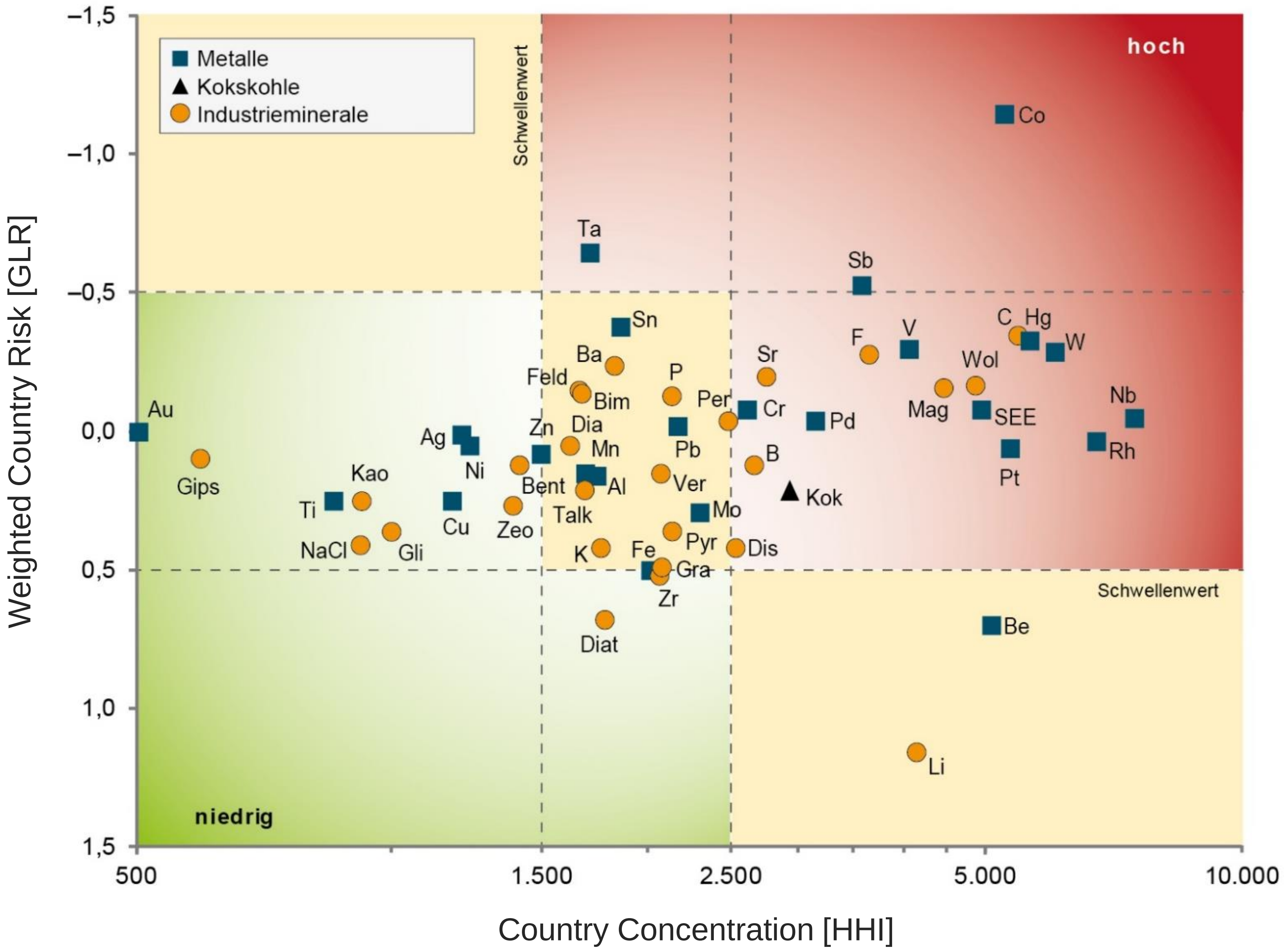
Electronics:

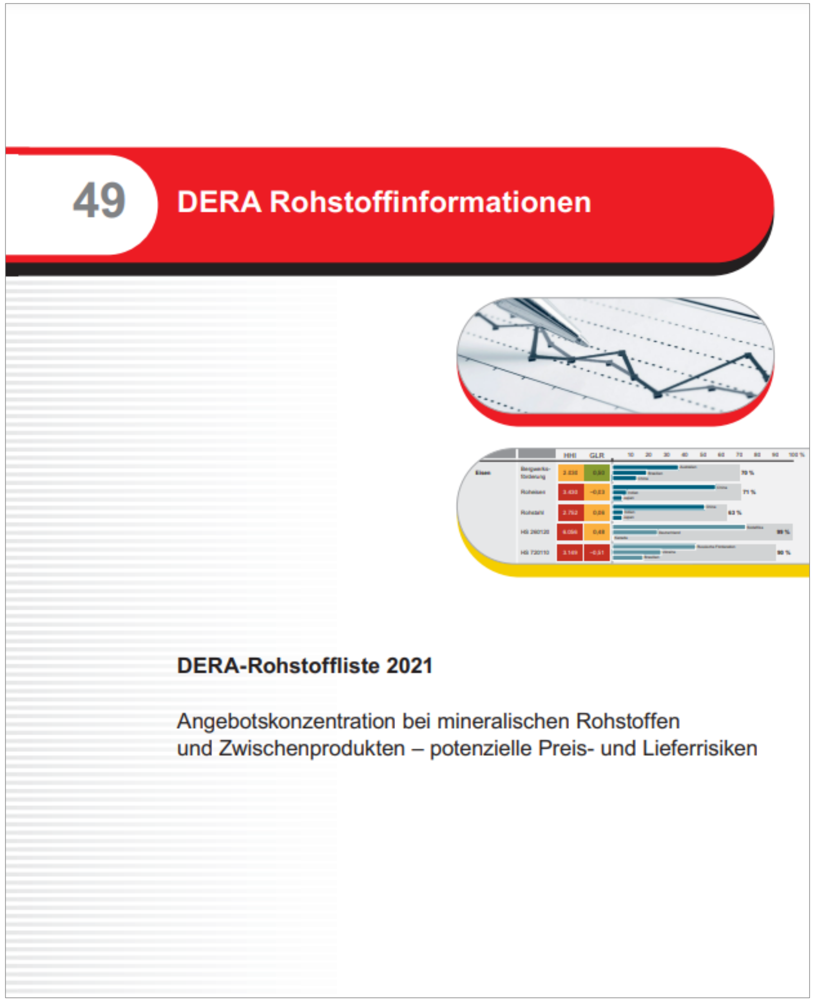
Gold, Silver, Germanium, Indium; Silicon

Traction Battery :

Li-Ionen-Battery: Lithium, Cobalt, Nickel, Manganese, Copper, Graphite

DERA CRITICAL RAW MATERIALS LIST 2021





Source: BGR 2021

LITHIUM – CURRENT SUPPLY SCHEME

Source: AMG Lithium 2022

Source: SQM 2022

Source: EnBW 2022

Hard Rock (60 %)
- Spodumene based
- Australia No.1

Brine (40 %)
- Chile No. 1

Geothermal Brines
(xx % in 20xx)

Different sources yield the same products through different processing routes, thus different environmental footprints.

SUSTAINABILITY

Contents lists available at ScienceDirect

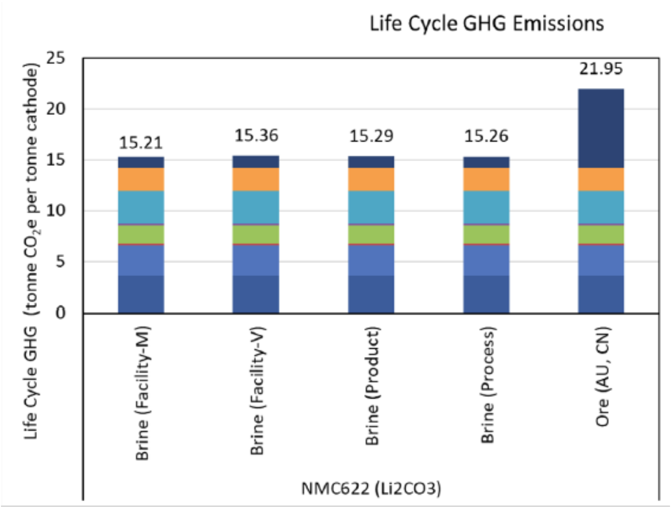
Resources, Conservation & Recycling

journal homepage: www.elsevier.com/locate/resconrec

Full length article

Energy, greenhouse gas, and water life cycle analysis of lithium carbonate and lithium hydroxide monohydrate from brine and ore resources and their use in lithium ion battery cathodes and lithium ion batteries

Jarod C. Kelly *, Michael Wang, Qiang Dai, Olumide Winjobi



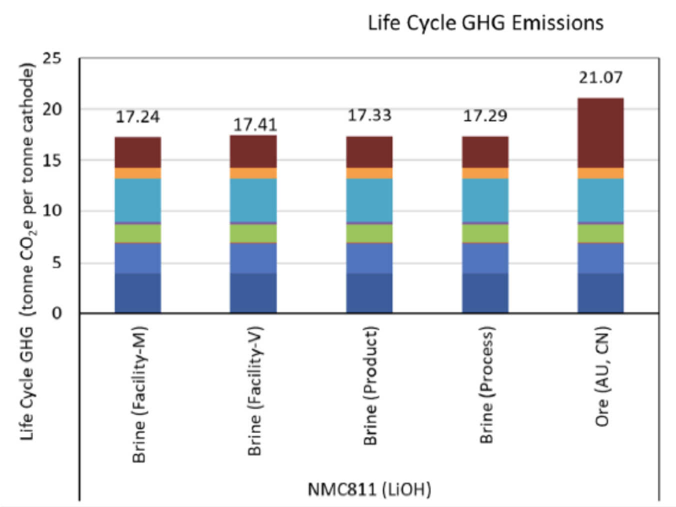
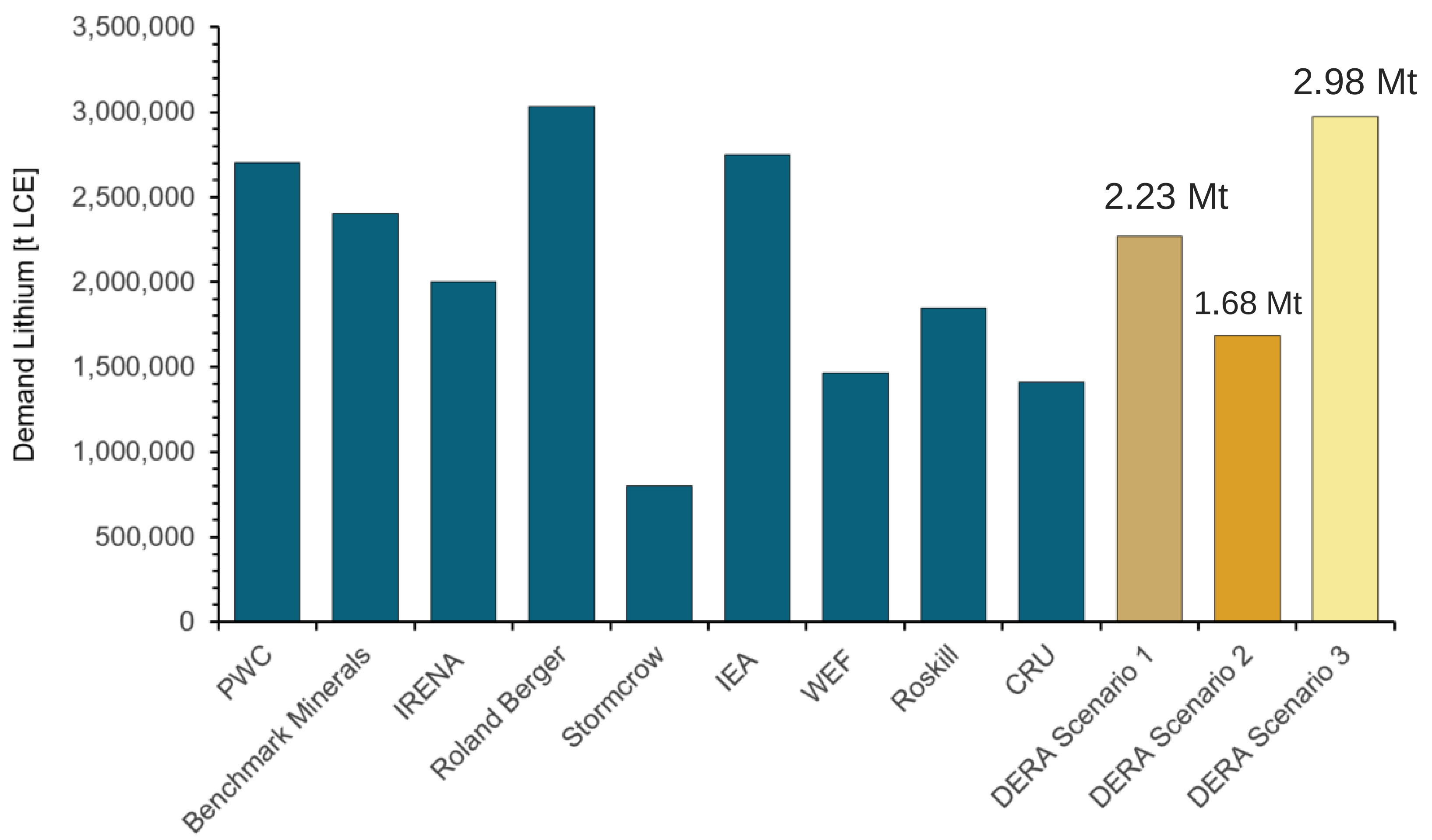


Table 6
Results of LCA for lithium concentrates and chemical products from brine and ore.

Lithium source	Stage of evaluation	GHG emissions	Energy consumption	Freshwater consumption
Brine	Lithium concentration	0.08–0.18 g CO_2e/tonne lithium concentrate	1300–2800 MJ/ tonne lithium concentrate	2.95–7.30 m^3/tonne lithium concentrate
	Production of Li_2CO_3 from lithium concentrate*	2.7 – 3.1 tonne CO_2e/ tonne Li_2CO_3	30,000–36,000 MJ/tonne Li_2CO_3	15.5 – 32.8 m^3/tonne Li_2CO_3
	Production of $LiOH•H_2O$ from lithium concentrate	6.9 – 7.3 tonne CO_2e /tonne $LiOH•H_2O$	76,600–82,900 MJ/tonne $LiOH•H_2O$	31–50 m^3/ tonne $LiOH•H_2O$
Ore	Spodumene concentration	~0.42 tonne CO_2e/tonne spodumene	5500 MJ/tonne spodumene	3.4 m^3/tonne spodumene
	Production of Li_2CO_3 from spodumene*	20.4 tonne CO_2e/tonne Li_2CO_3	218,000 MJ/ tonne Li_2CO_3	77 m^3/tonne Li_2CO_3
	Production of $LiOH•H_2O$ from spodumene	15.7 tonne CO_2e/tonne $LiOH•H_2O$	187,200 MJ/ tonne $LiOH•H_2O$	69 m^3/tonne $LiOH•H_2O$

Source: https://www.sciencedirect.com/science/article/pii/S0921344921003712

DEMAND 2030 (WHO KNOWS….)

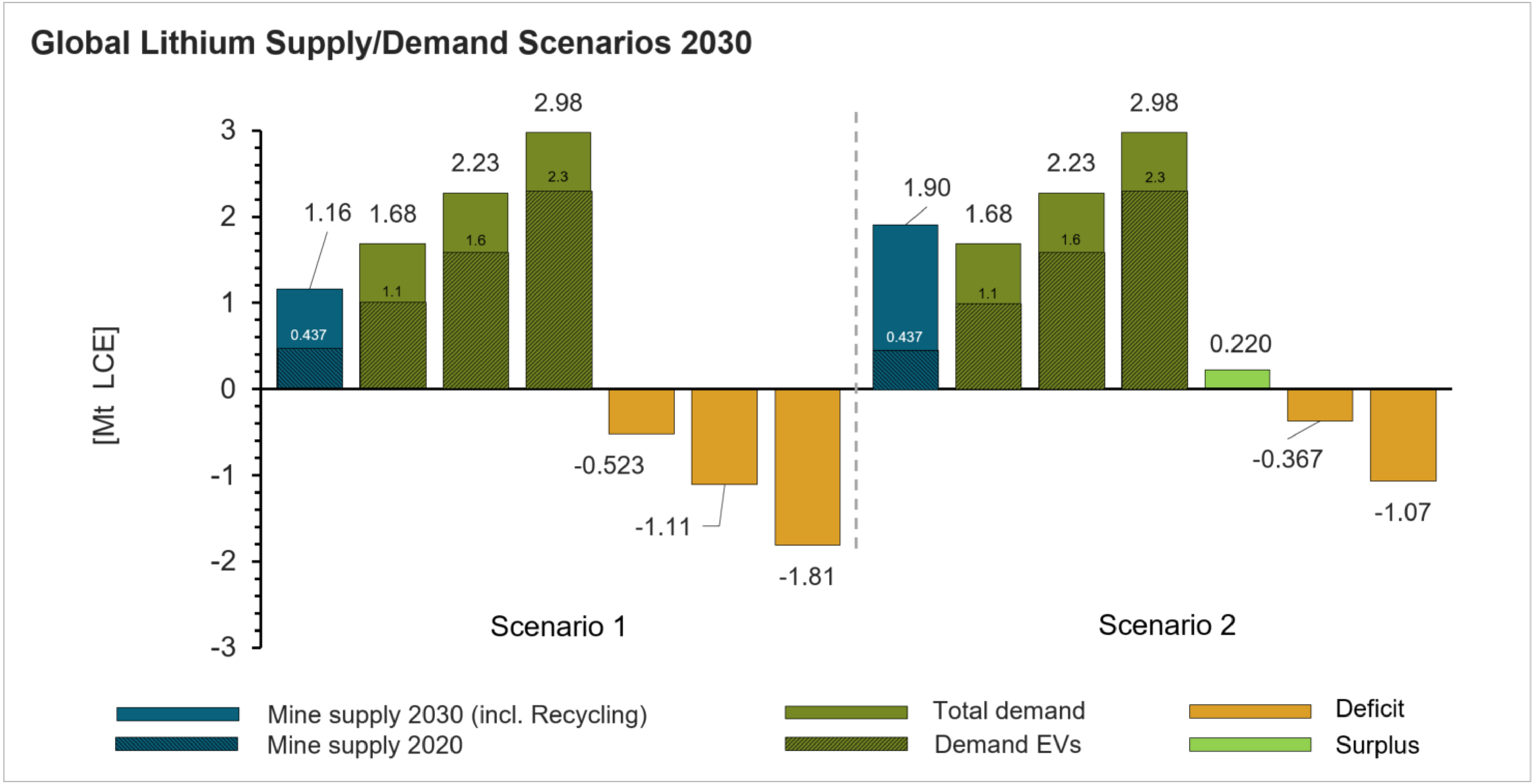


1) Dermand 2026

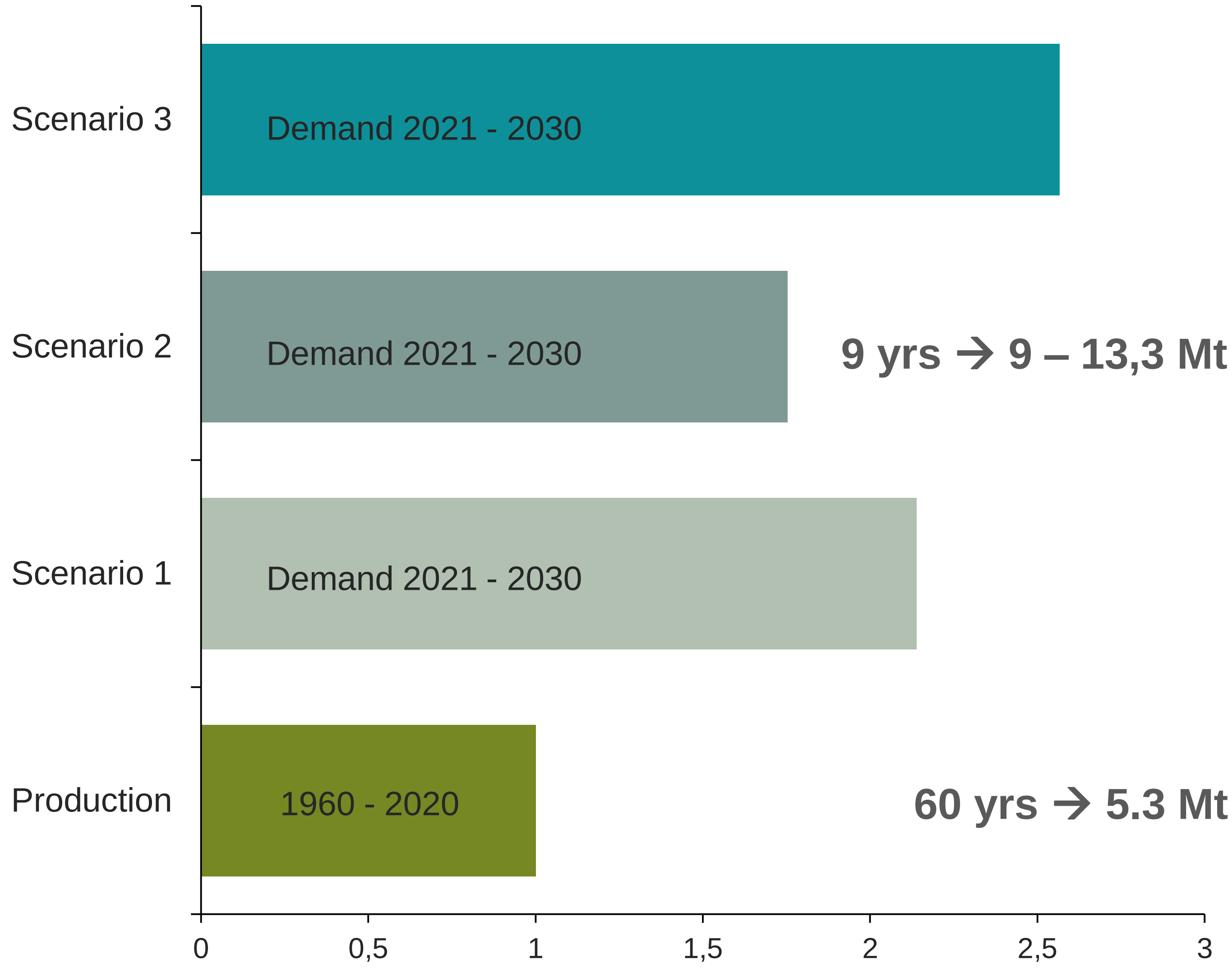
Quo Vadis E-Mobility??

- Extremely dynamic developments.
- Demand will be dominated by LIB.
- E-Mobility as major demand driver.
- China is key.
- EU and USA strong development.
- Regulatory frameworks will impact growth thus demand.
- Customer acceptance and infrastructure are important factors.
- Technological advances play a role.
- Sustainable use of lithium as demand driver (E-SUV vs. small cars).
- Global economy, inflation and energy crisis.
- War in Ukraine.

SUPPLY/DEMAND SCENARIOS IN A NUTSHELL



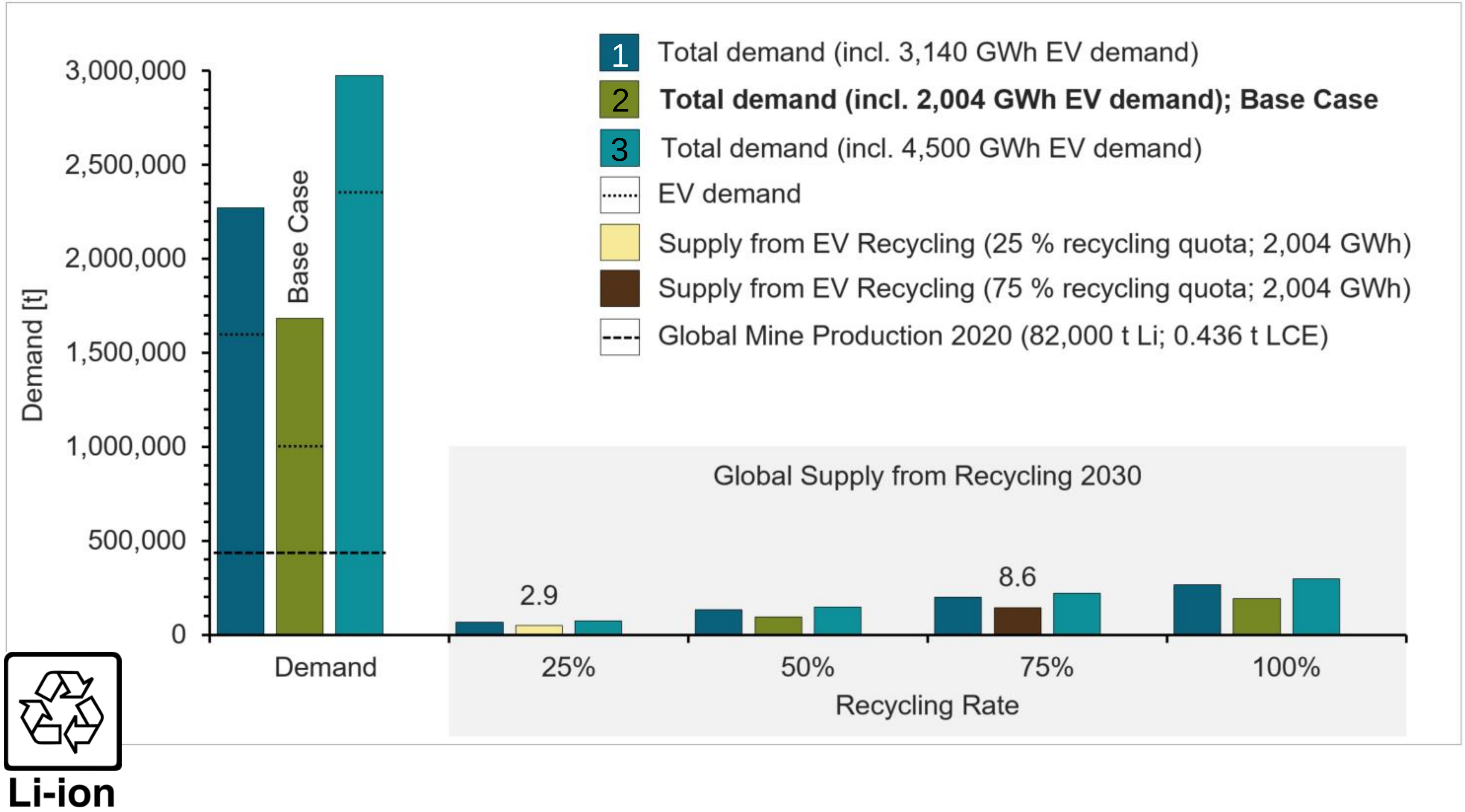
IS THE HYPE OVER?



9 yrs → 9 – 13,3 Mt LCE

60 yrs → 5.3 Mt LCE

GLOBAL SECONDARY SUPPLY FROM SPENT EV BATTERIES



Key assumptions

- EV Batteries only.
- Return matrix based on demand 2020 – 2030
- 50 % return after 8 yrs.
- 60 % return after 10 yrs.
- 90 % return after 12 yrs.
- 10 % lost due to…
- Collection rate of 70 %.
- Recycling rate 25 %, 75 %.
- No secondary life.
- Material suitable for LIB.
- Processes are economically and ecoligically viable.

Demand scenario 1 and 2 based on SSP1 and SSP2 for EV penetration (Shared Socioeconomic Pathway), Demand scenario 3 based on DERA assumptions for EV penetration.

FINAL THOUGHTS - THE GREAT DISCONNECT -

- The Lithium market is a specialty chemicals market and not conventional mining.
- Mine surplus does **NOT** necessarily translate into sufficent chemical supply.
- Announced mine capacity is **NOT** equal to refining (chemical) capacity.
- Announced capacities and timelines of projects are „numbers“ and sometimes wishfull thinking.
- Derived chemical supply may or may not be directly suitable for downstream applications (batteries).
- Between **54 %** and **63 %** of supply in 2030 will be hard rock based.
- This material needs to be converted into lithium chemicals. → **Mostly China**
- Therefore conversion capacity of spodumene will be key for future supply.
- Sustainability issues (Hard rock vs. Brine vs. Geothermal Brines).
- Many new brine based projects plan to introduce DLE technology for production that is yet not comercially applied in the industry.
- Supply uncertainties in many countries due to legal and regulatory developments (i.e. Mexico, Bolivia, Chile)

FINAL THOUGHTS - THE GREAT DISCONNECT -

- Few major global players and China is dominant in the downstream sector with a clear strategy.
- Current lithium prices on all-time high levels (high price volatility).
- Lithium demand for batteries (EVs) as major driver (≈ 90 % of total lithium demand in 2030)
- Primary lithium supply has to increase 4 to 7 fold.
- Demand projections difficult due to market dynamics (320 – 560 kt Lithium in 2030) [**1.7 – 3 Mt LCE**)
- Supply gap towards 2030 if no action from industry. Hard rock will dominate the market in 2030.
- Lithium is geologically not scarse. **Sufficient supply depends on timely development and investment.**
- Mine lead time 4 - 10 years. Refining lead time 12 – 24 months.
- Secondary supply will have to contribute and needs to be developed now (**DESIGN FOR RECYCLING**).
- Production and import of lithium chemicals has a certain water and CO_2 footprint which varies and depends mostly on the source (Brine vs. Hard Rock). ESG issues (high CO_2 emissions, mine and processing wastes).

New report: Cooperation Opportunities For German Companies In The Chilean Raw Materials Sector

Content:

- Raw materials overview
- Resource potential
- Mining country Chile
- Trade data
- Contact information for:
  - Engangements
  - Licensing
  - Market entry
  - Financing

Joint work between

CAMCHAL CAMARA CHILENO-ALEMANA

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THANK YOU

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