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Lithium Outlook to 2030

- A global perspective -

Michael Schmidt
German Mineral Resources Agency (DERA)
at Federal Institute for Geosciences and Natural Resources

Federal Ministry
for Economic Affairs
and Climate Action

The Federal Institute for Geosciences and Natural Resources is the central geoscientific authority providing advice to the German Federal Government in all geo-relevant questions. It is subordinate to the Federal Ministry for Economic Affairs and Climate Action (BMWK).

GERMAN MINERAL RESOURCES AGENCY (DERA) AT BGR

- Federal Institute for Geosciences and Natural Resources (BGR):
  Central authority providing advice to the German Government in all geo-relevant questions.
- Subordinate to the Federal Ministry for Economic Affairs and Climate Action (BMWK).

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

LITHIUM – CURRENT SUPPLY SCHEME

Source: AMG Lithium 2022

Hard Rock (60 %)
Spodumene based

Source: SQM 2022

Brine (40 %)

Source: EnBW 2022

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

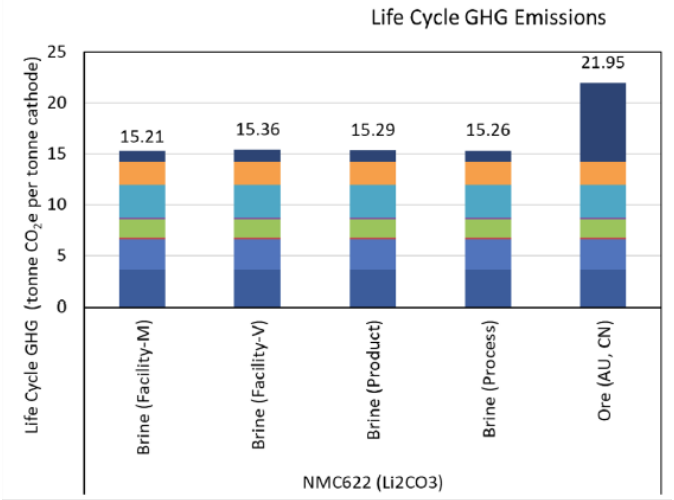
Resources, Conservation & Recycling

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



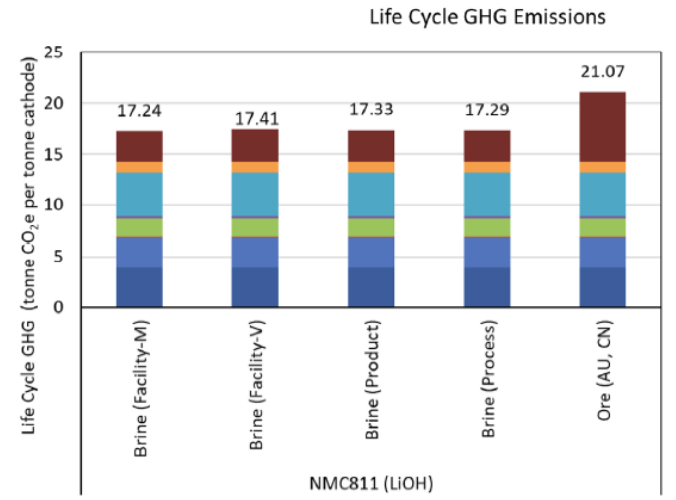
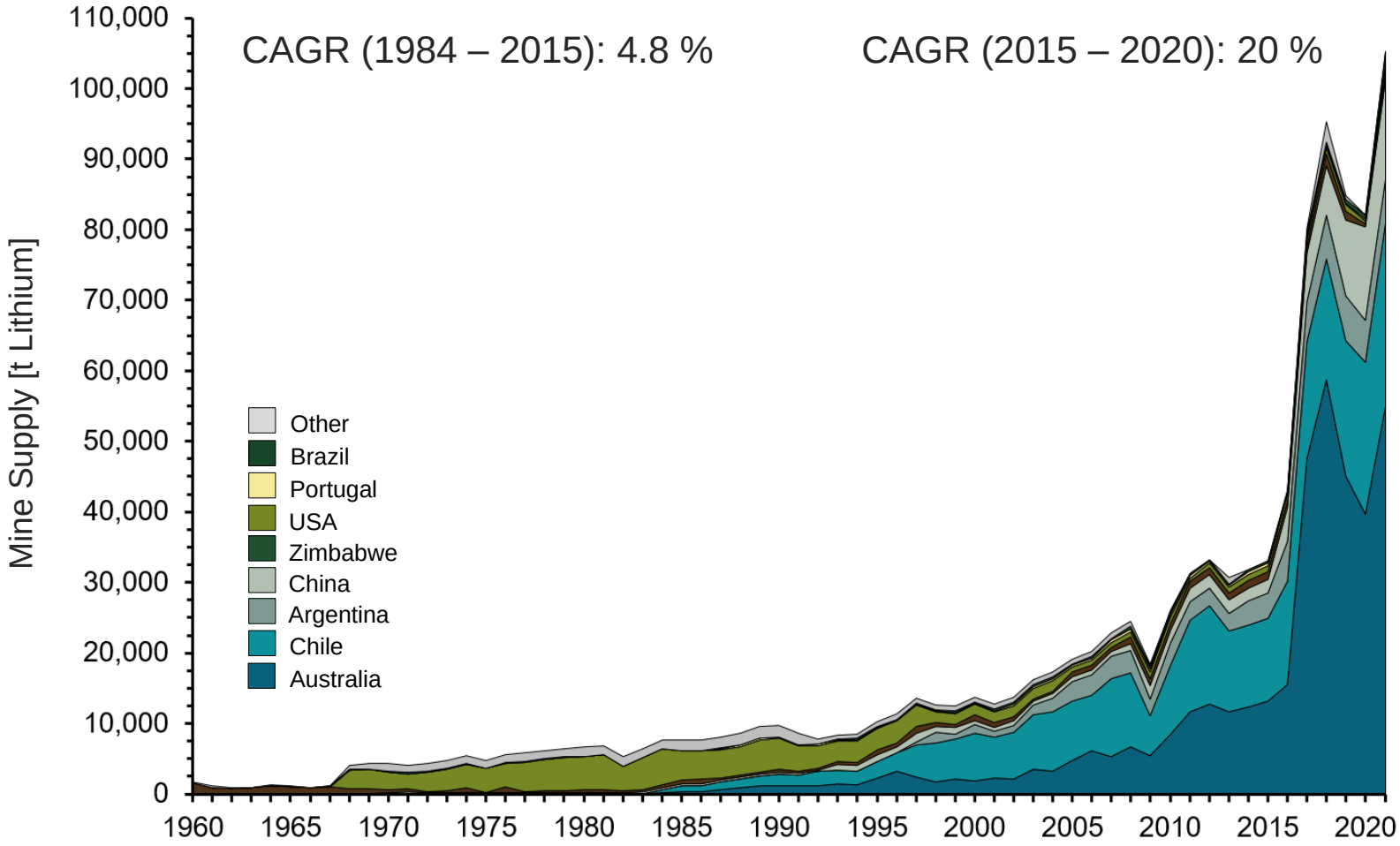


Table 6
Results of LCA for lithium concentrates and chemical products from brine and ore.

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

SUPPLY 2020



CAGR China
(1984 – 2015): **6.6 %**
(2015 – 2020): **46 %**
Share 2020: **16.2 %**

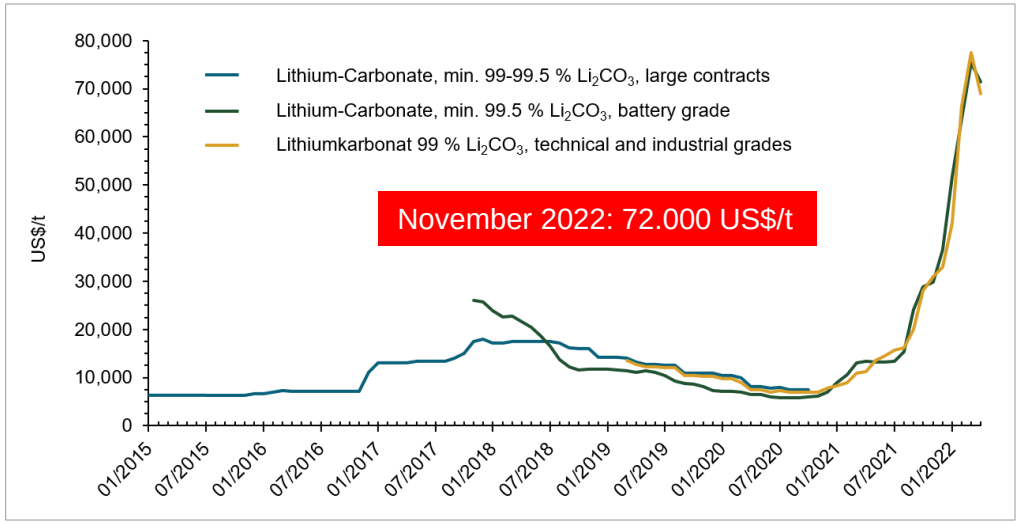
CAGR Argentina
(1984 – 2015): **30.1 %**
(2015 – 2020): **10.9 %**
Share 2020: **7.2 %**

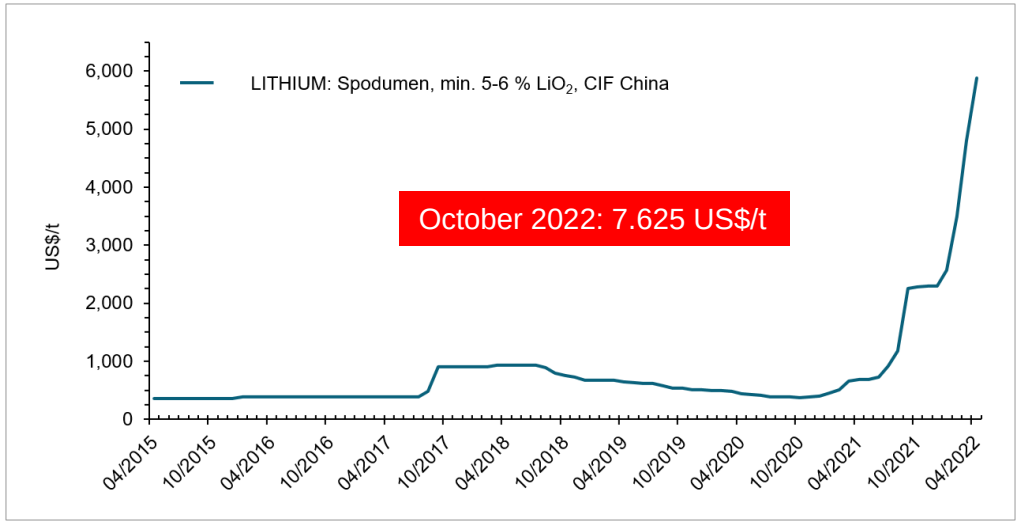
CAGR Chile
(1984 – 2015): **11.6 %**
(2015 – 2020): **12.8 %**
Share 2020: **26.2 %**

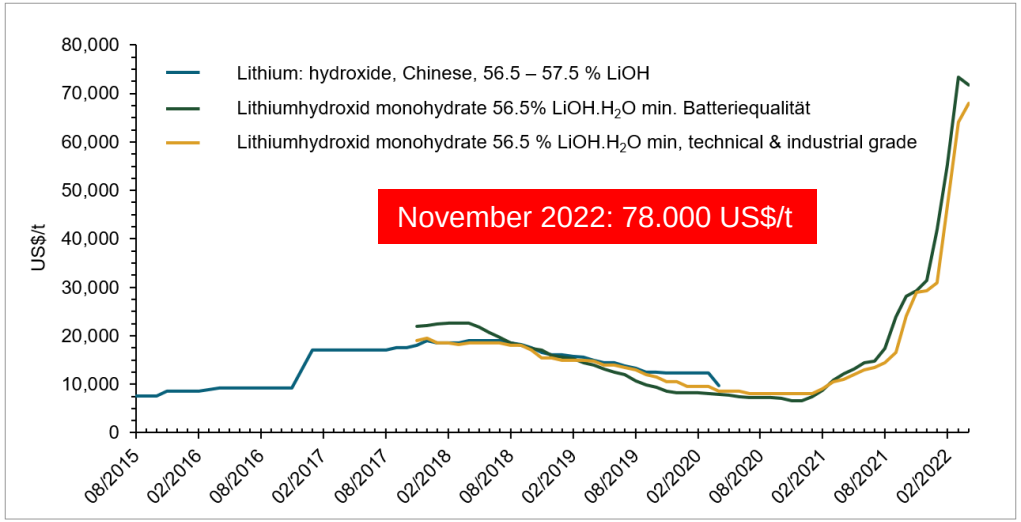
CAGR Australia
(1984 – 2015): **13.3 %**
(2015 – 2020): **24.7 %**
Share 2020: **48.4 %**

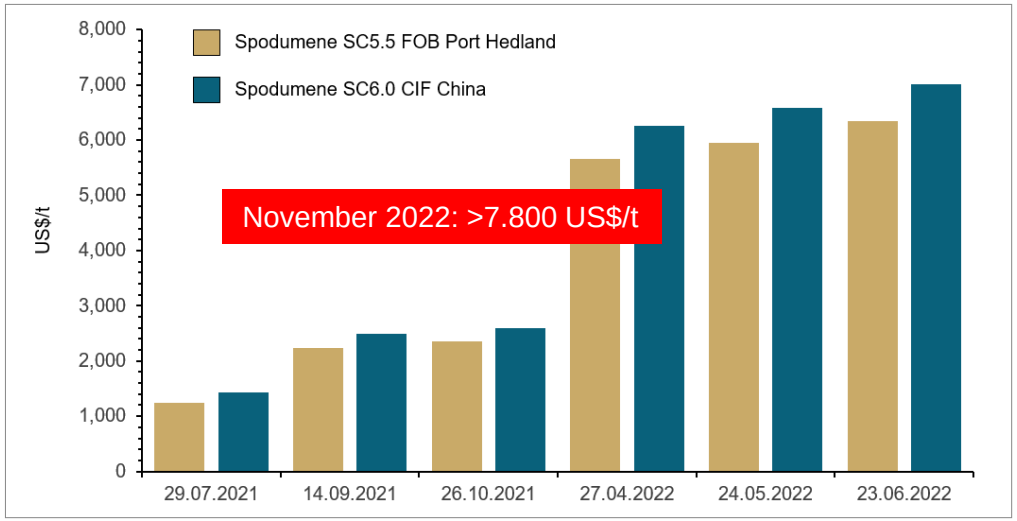
Source: BGR 2022

PRICE DEVELOPMENT





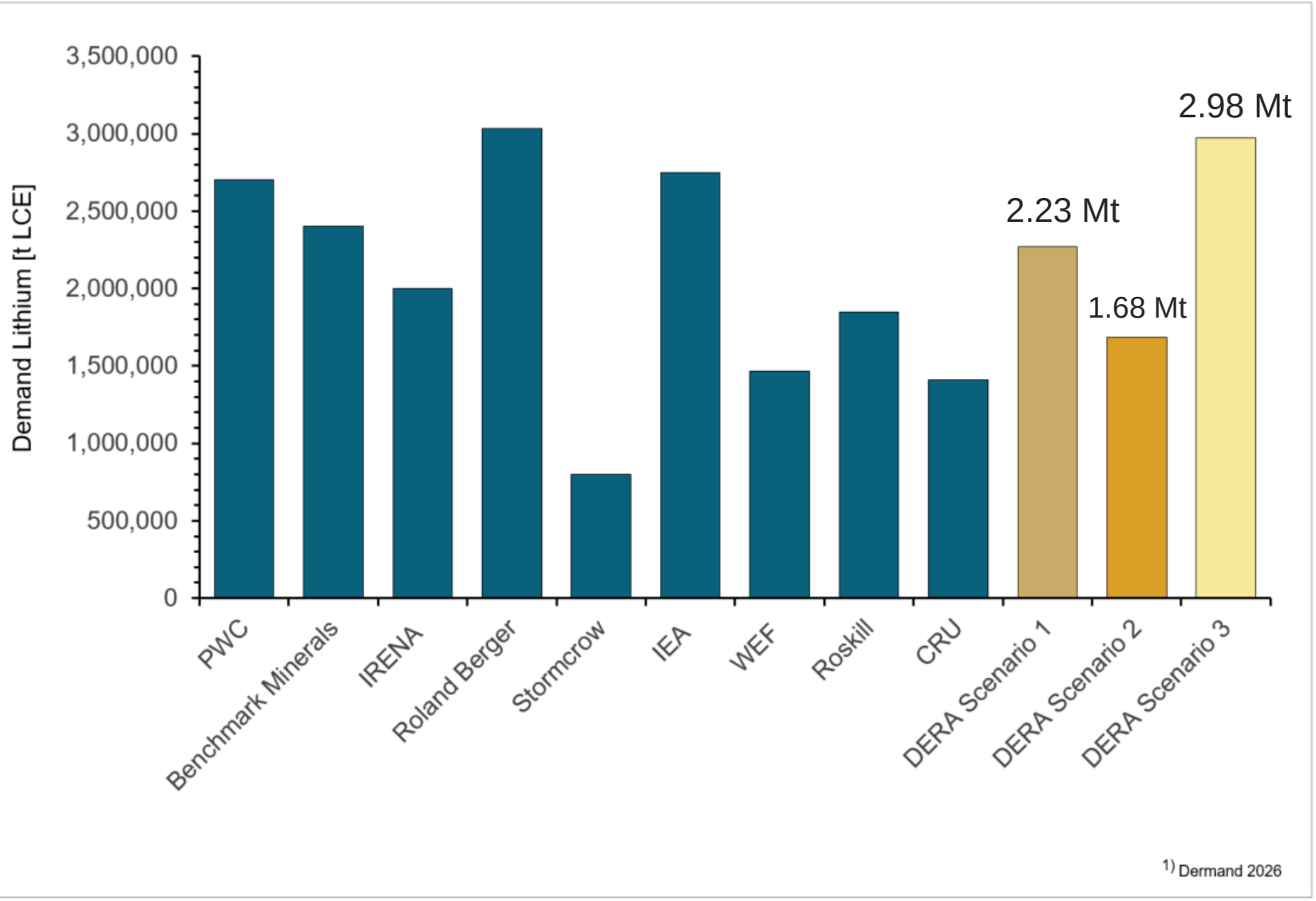




Source: BGR 2022

Source: Pilbara Minerals 2022

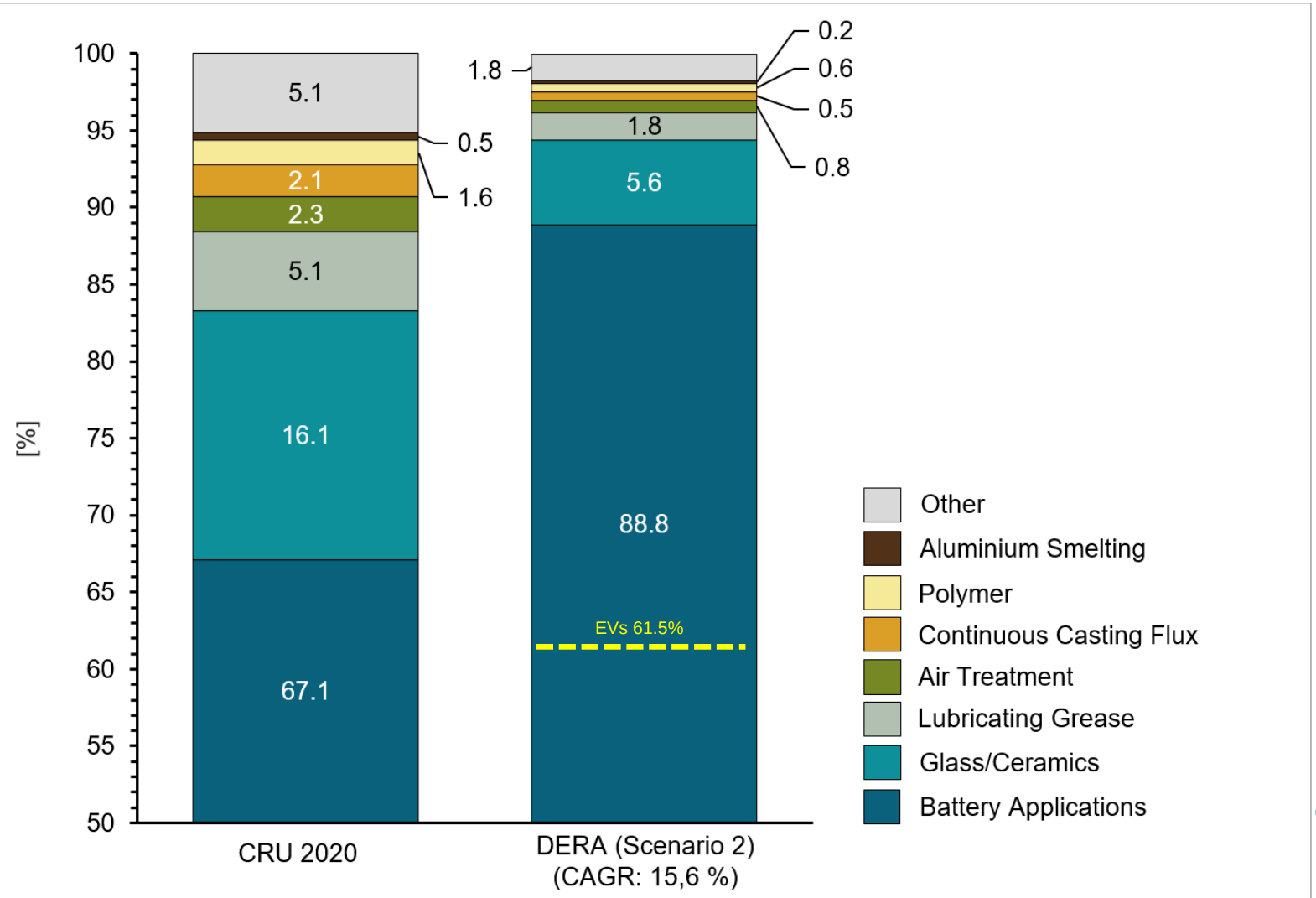
DEMAND 2030 (WHO KNOWS….)



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.

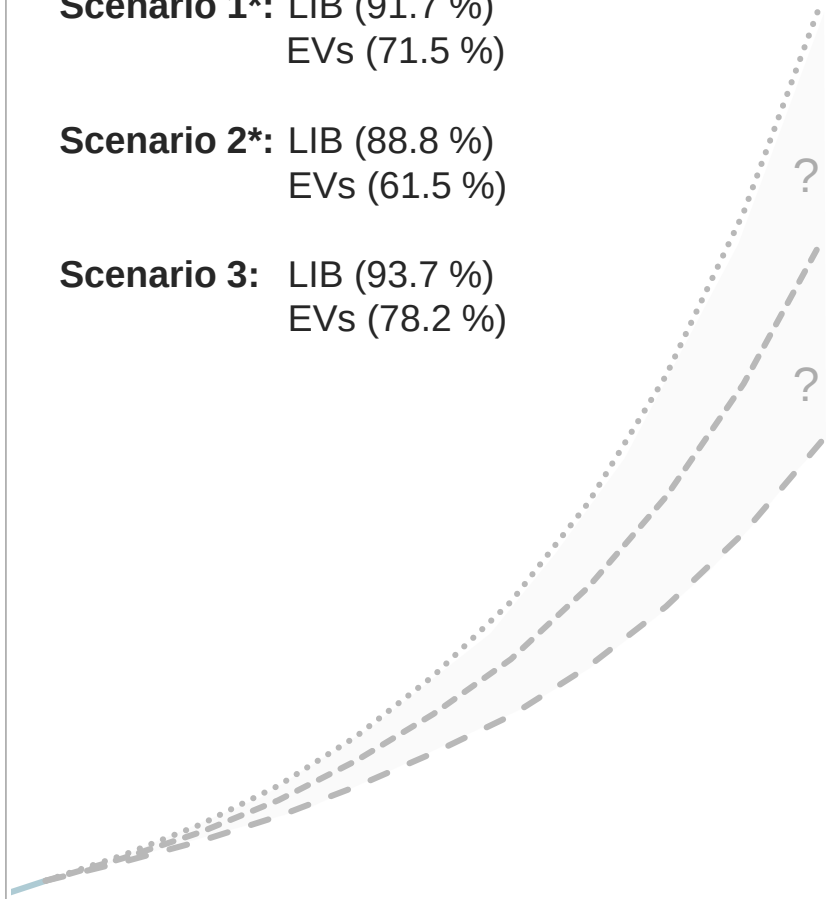
DEMAND 2030



Scenario 1*: LIB (91.7 %)
EVs (71.5 %)

Scenario 2*: LIB (88.8 %)
EVs (61.5 %)

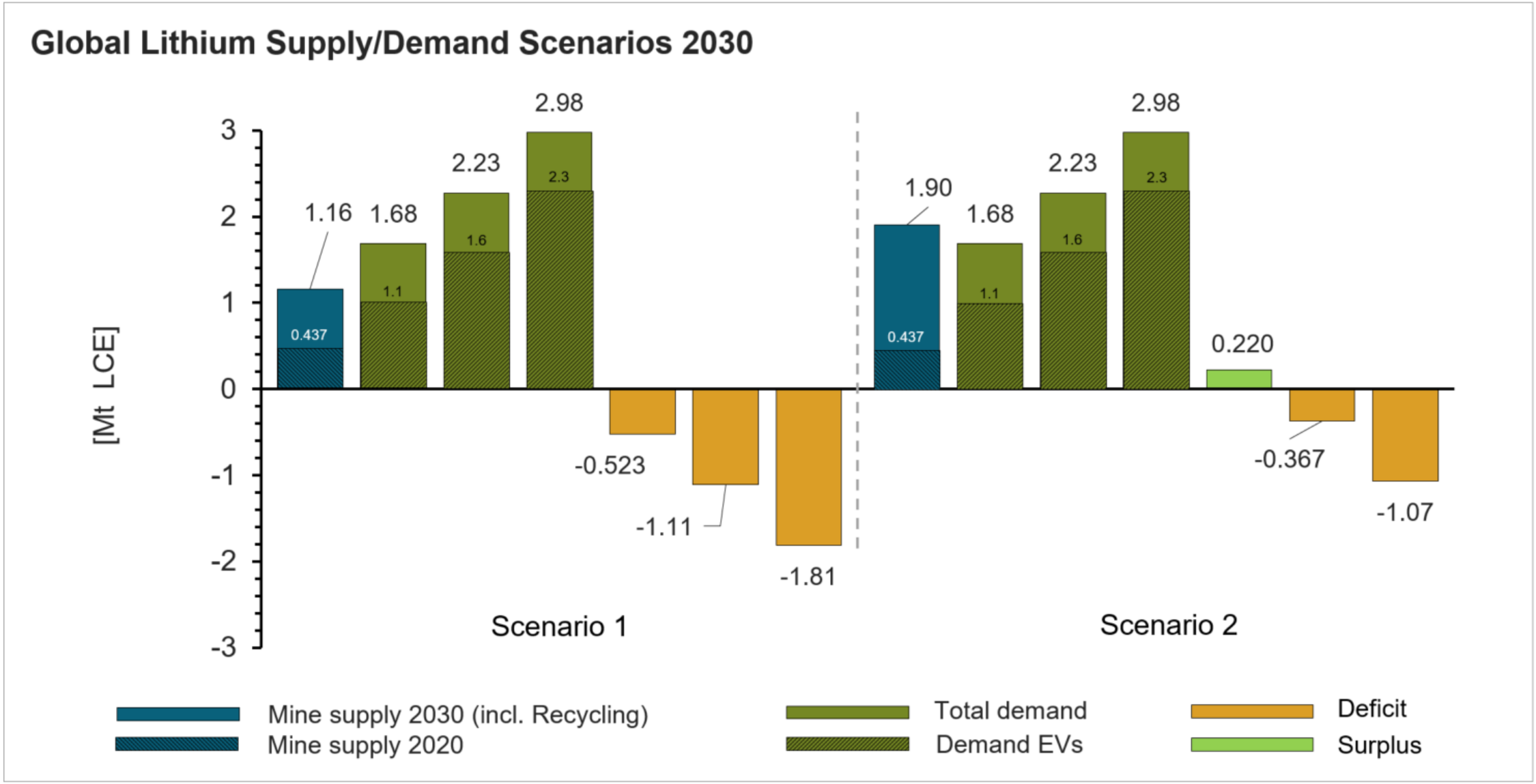
Scenario 3: LIB (93.7 %)
EVs (78.2 %)



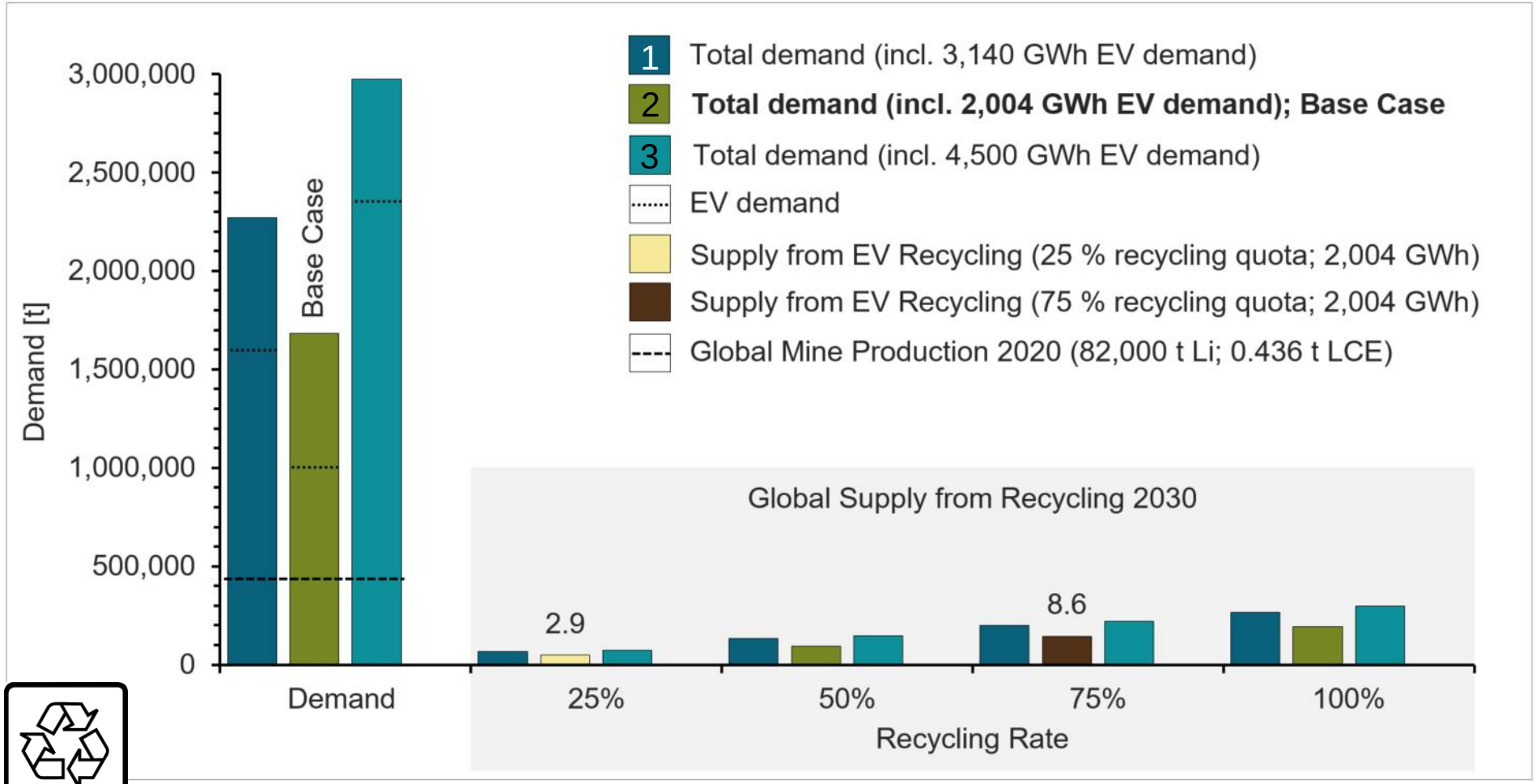
** Demand scenario 1 and 2 based on SSP1 and SSP2 for EV penetration (Shared Socioeconomic Pathway)*

Source: BGR 2022

SUPPLY/DEMAND SCENARIOS IN A NUTSHELL



GLOBAL SECONDARY SUPPLY FROM SPENT EV BATTERIES



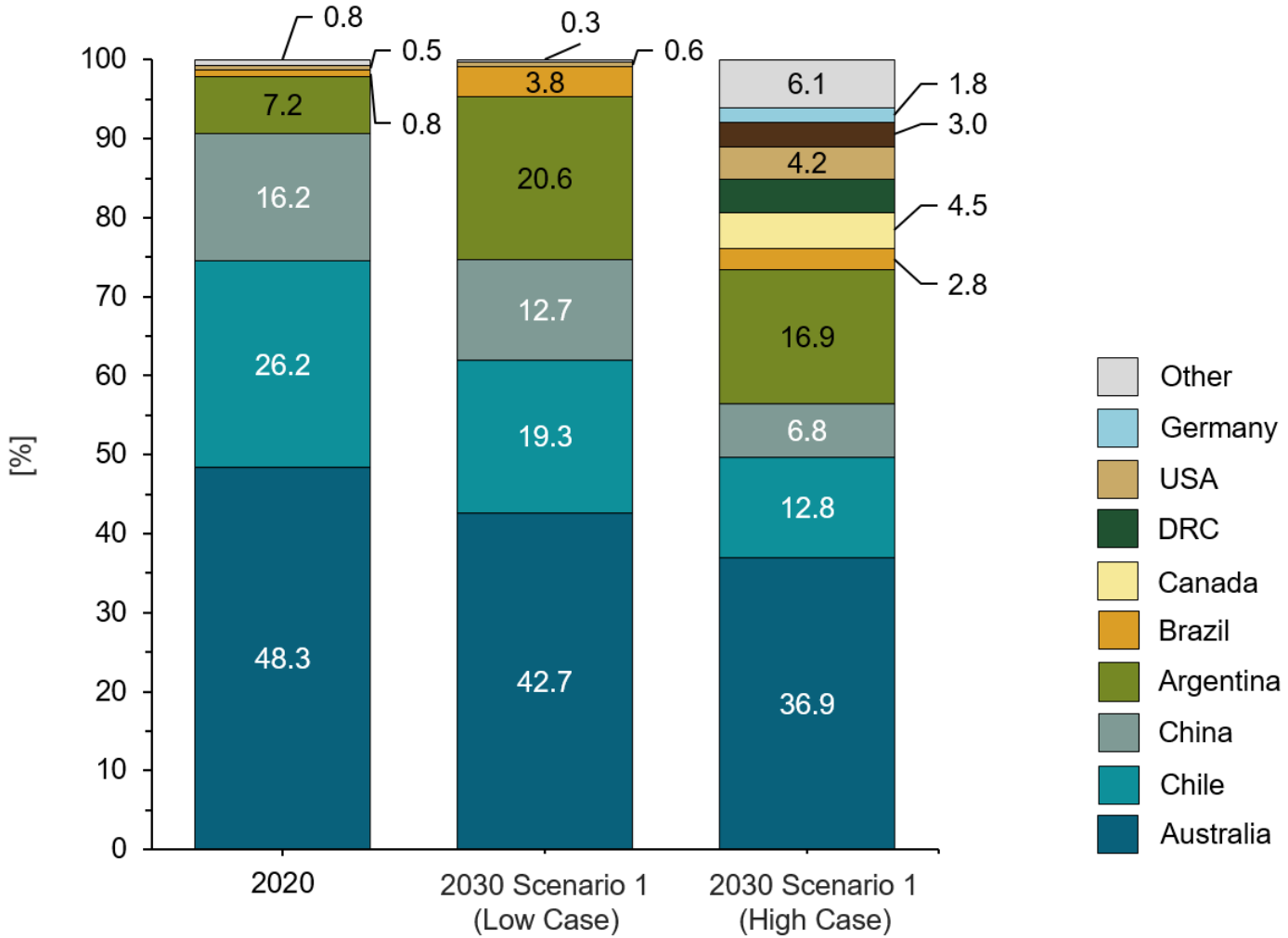
Li-ion

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.

SUPPLY 2030



Scenario 1

HHI: 2,795

GLR: 0.74

H/B = 53.7 % / 46.4 %

Scenario 2

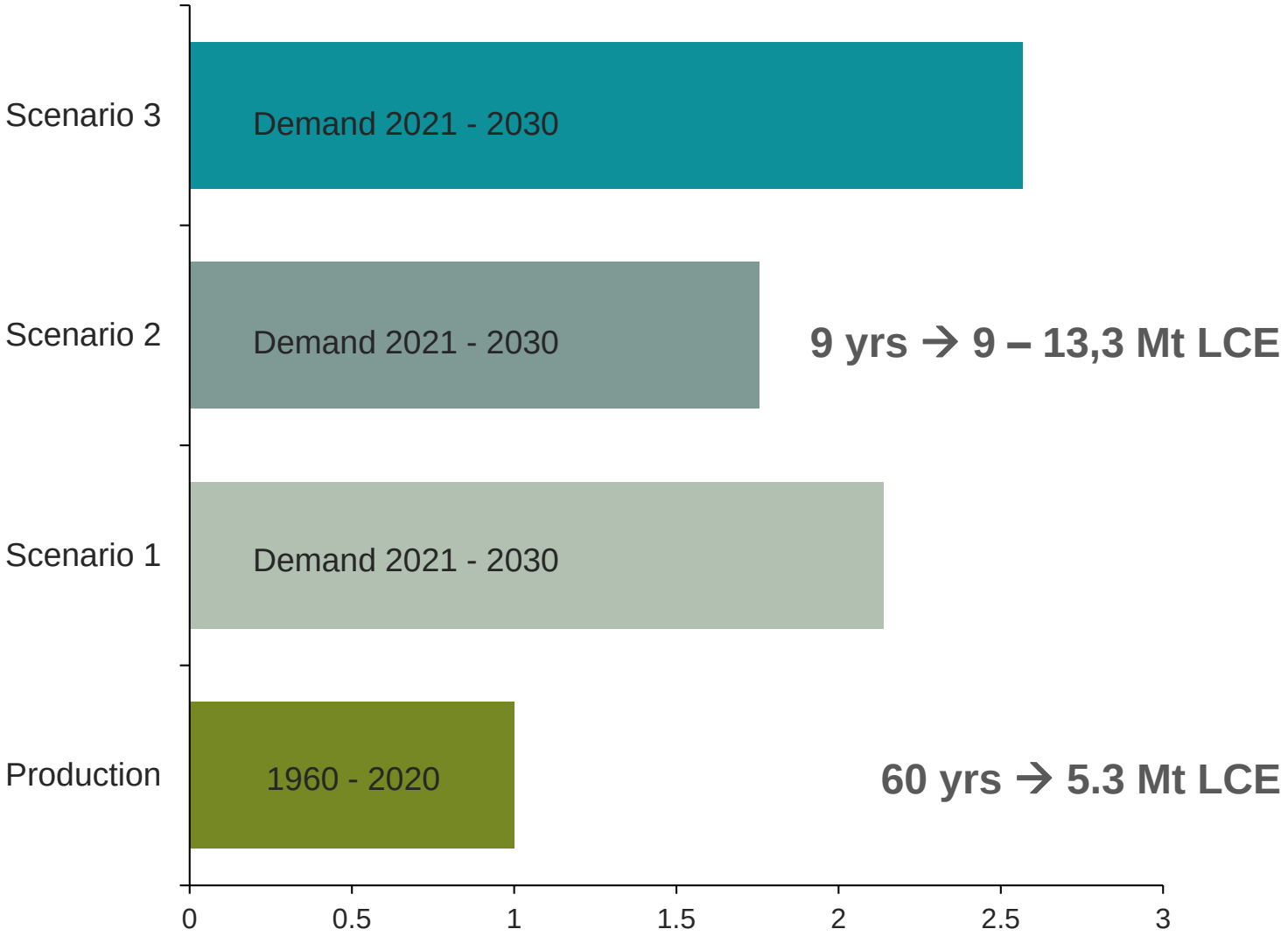
HHI: 1,938

GLR: 0.69

H/B = 62.6 % / 37 %

Source: BGR 2022

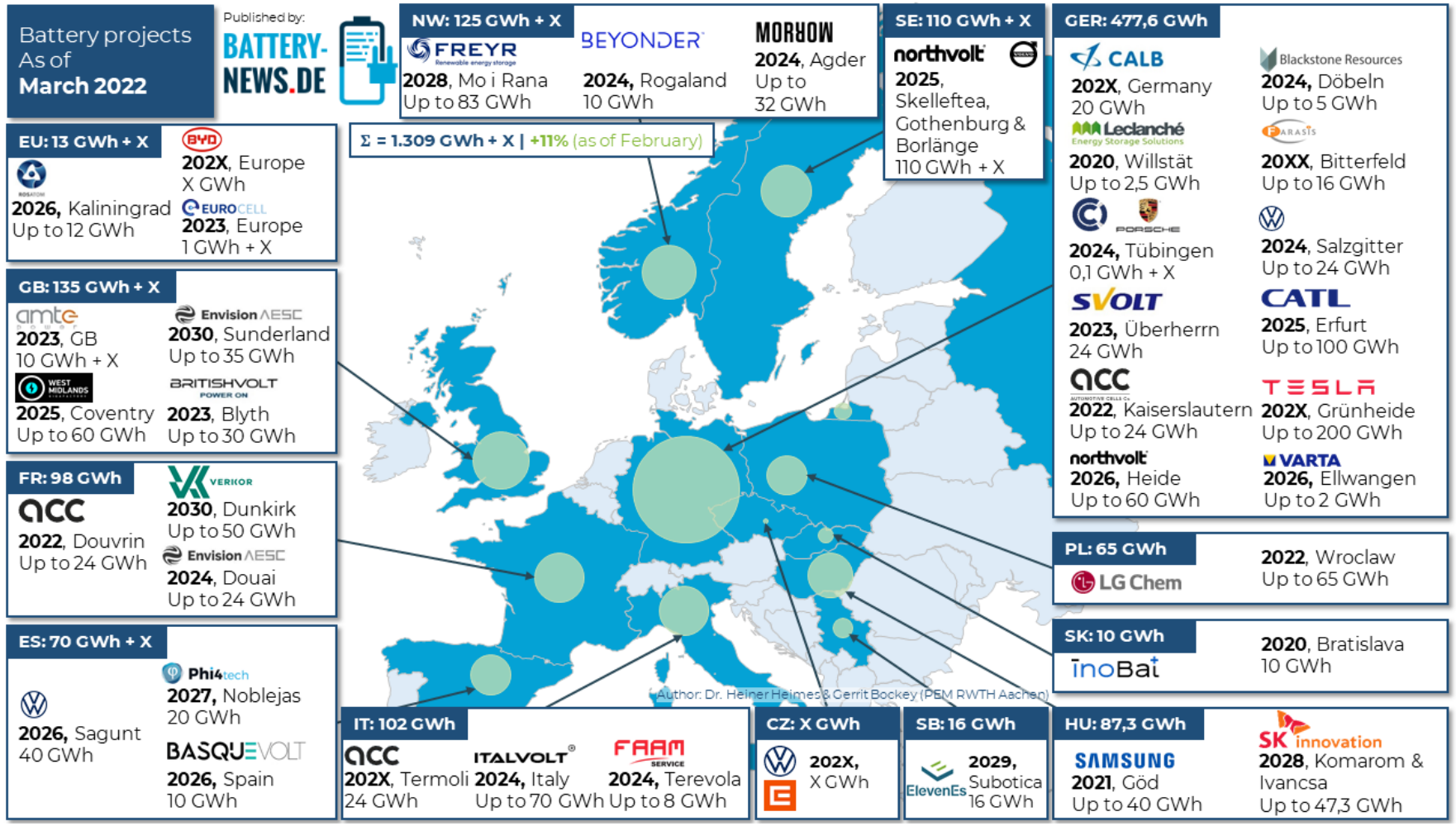
IS THE HYPE OVER?



9 yrs → 9 – 13,3 Mt LCE

60 yrs → 5.3 Mt LCE

EUROPE AS A NEW EV INDUSTRY HOTSPOT



Demand 2030

@ 1.309 GWh = **127,300 t***
678,000 t LCE

@ 1.000 GWh = **97,140 t***
517,000 t LCE

@ 1.000 GWh = **72,500 t***
(75 % utilisation)
386,000 t LCE

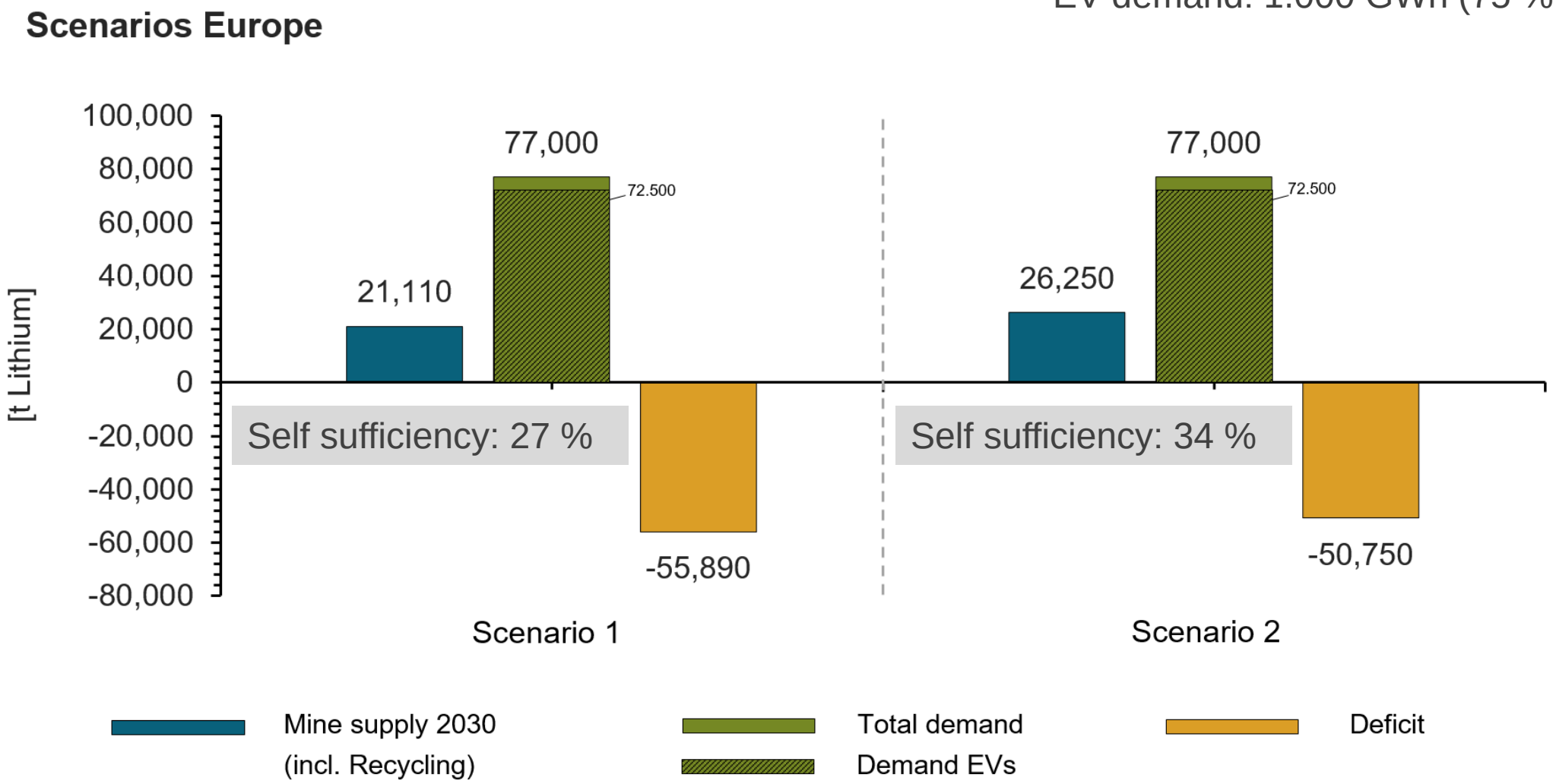
Base Case

Source: https://battery-news.de/index.php/2022/03/18/batterieprojekte-in-europa-stand-maerz-2022/

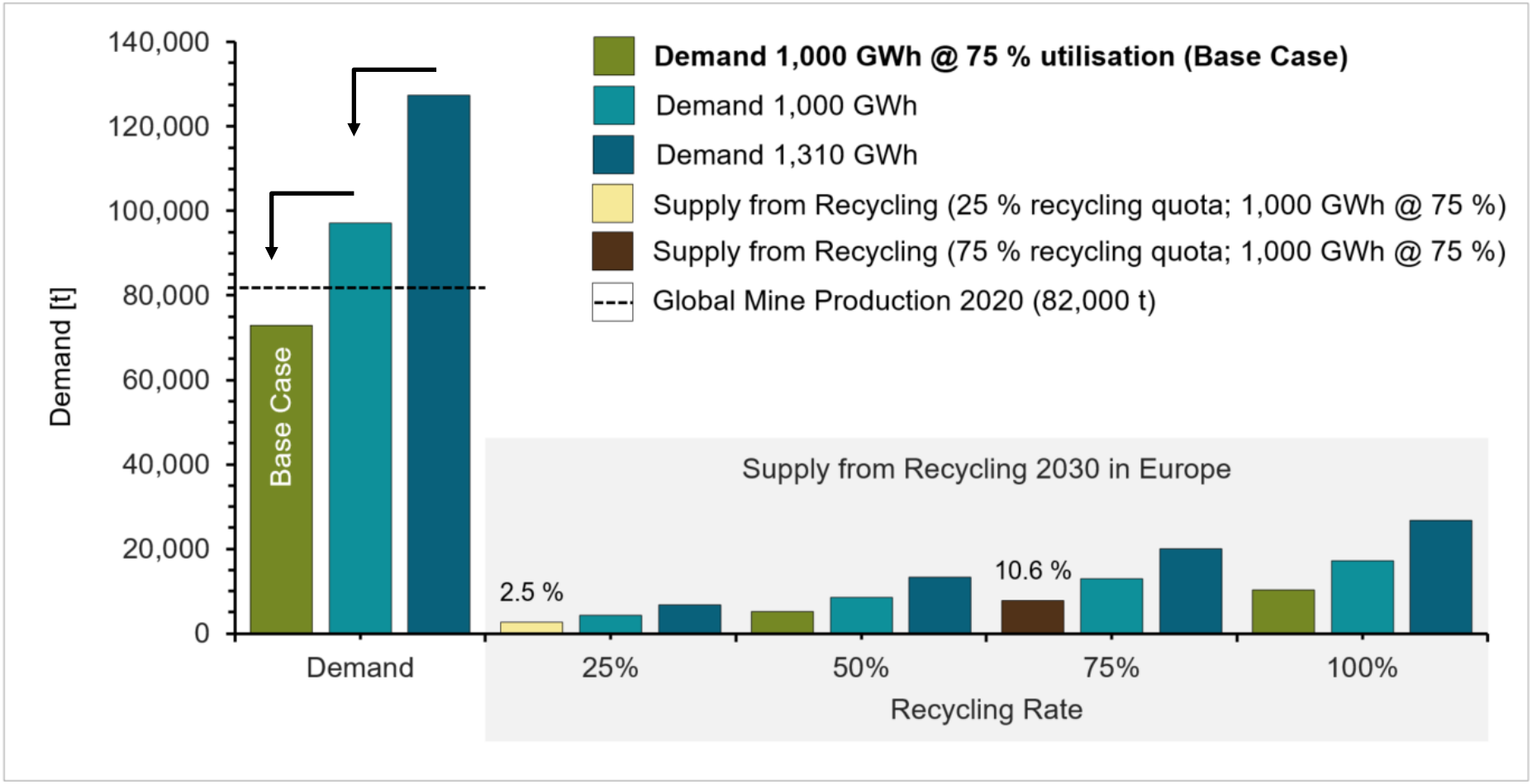
** Based on internal assumptions for cathode chemistry, cathode mix towards 2030, vehicle size and battery size.*

SUPPLY/DEMAND: A EUROPEAN PERSPECTIVE

EV demand: 1.000 GWh (75 % utilisation)



SUPPLY/DEMAND: A EUROPEAN PERSPECTIVE (SECONDARY SUPPLY)



EU Targets 2030/2035

- Key assumptions equal to global scenarios.
- **70 %** LIB collection rate
- **70 %** Lithium recovery rate
- **4 %** secondary lithium content in LIB (2030)
- **10 %** secondary lithium content in LIB (2035)

FINAL THOUGHTS - THE GREAT DISCONNECT -

- The Lithium market is a specialty chemicals market and not conventional mining.
- Surplus in mine supply 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).

November 22nd 2022

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- *A global perspective* –

Thank You

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