“Lithium“

Interview

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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 Energy (BMWi).

Lithium

„Is the Hype over?“

NO…

It just started again…

LITHIUM

Hard rock (60%)

Brine (40%)

Lithium Carbonate

Lithium Hydroxide

Lithium Bromide

Lithium Sulfate

Lithium Chloride

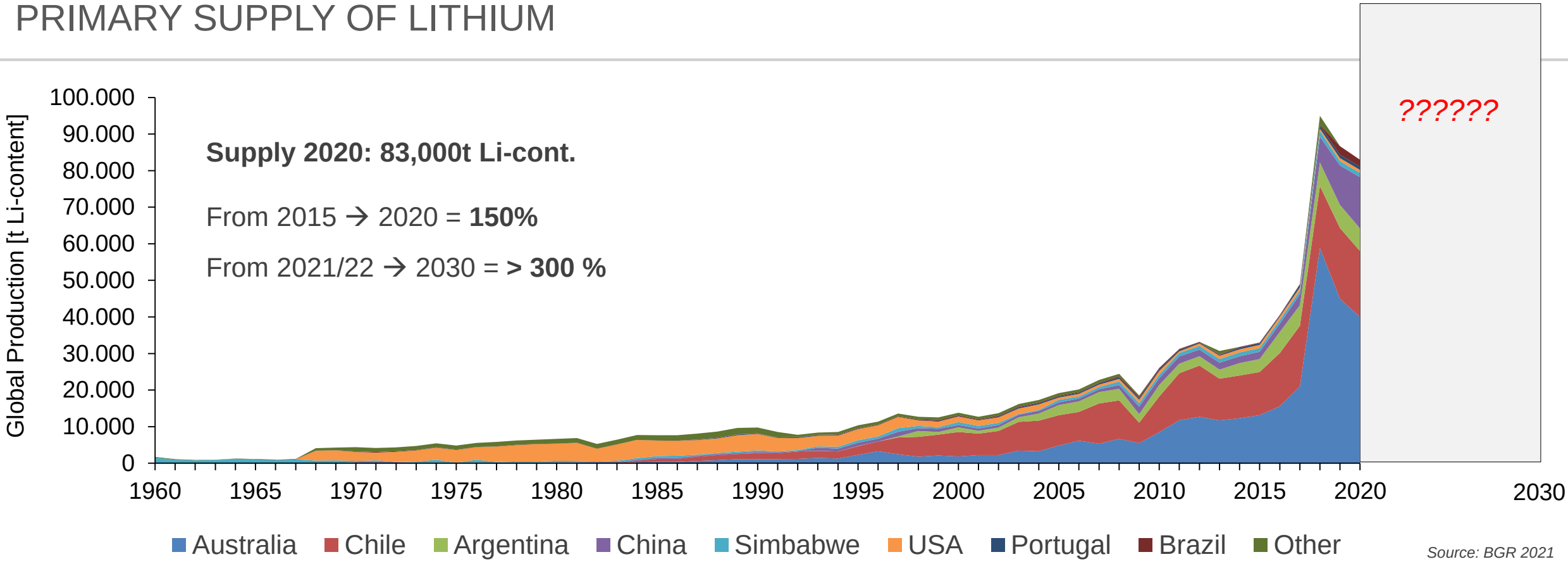
Lithium Peroxide

Lithium Acetate

Lithium Metal

DERA 2017

PRIMARY SUPPLY OF LITHIUM



- Lithium geologically not scarse (global resources: > 110 Mt Lithium).
- Supply has to increase 4 – 6 fold until 2030 (TIMING AND FINANCING ARE KEY) .
- Depending on source (Brine vs. Hardrock) drastically different energy & water consumption (i.e. footprint)

LITHIUM BEARING MINERALS (HARDROCK)

Minerale	Formel	Li-Gehalt (%)	Ø Li-Gehalt Erze (%)
Spodumen	$LiAlSi_2O_6$	1,9–3,7	1,35–3,6
Petalit	$LiAlSi_4O_{10}$	1,6–2,27	1,4–2,2
Lepidolith	$K(Li,Al)_3(Si,Al)_4O_{10}(F,OH)_2$	1,39–3,6	1,4–1,9
Amblygonite	$(Li,Na)AlPO_4(F,OH)$	3,4–4,7	k. A.
Eucryptit	$LiAlSiO_4$	2,1–5,53	2,1–4,4
Bikitaite	$LiAlSi_2O_6 \cdot H_2O$	3,4	k. A.
Hektorit	$Na_{0,3}(Mg,Li)_3Si_4O_{10}(OH)_2$	0,24–0,54	k. A.
Salitolit	$(Li,Na)Al_3(AlSi_3O_{10})(OH_5)$	0,77	k. A.
Swinefordite	$Li(Al,Li,Mg)_4((Si,Al)_4O_{10})_2(OH;F)_4 \cdot nH_2O$	1,74	k. A.
Zinnwaldit[1]	$K(Li,Fe^{2+},Al)_3[(F,OH)_2\|AlSi_3O_{10}]$	0,92–1,85	k. A.
Polylithionit	$KLi_2AlSi_4O_{10}(F,OH)_2$	k. A.	k. A.
Jadarit	$LiNaSiB_3O_7(OH)$	7,3	k. A.

[1] Übergruppe der beiden Endglieder Siderophyllit ($K(Fe^{2+},Al)_3[(F,OH)_2|(Si,Al)_4O_{10}]$) und Polylithionit ($KLi_2Al[F_2|Si_4O_{10}]$)

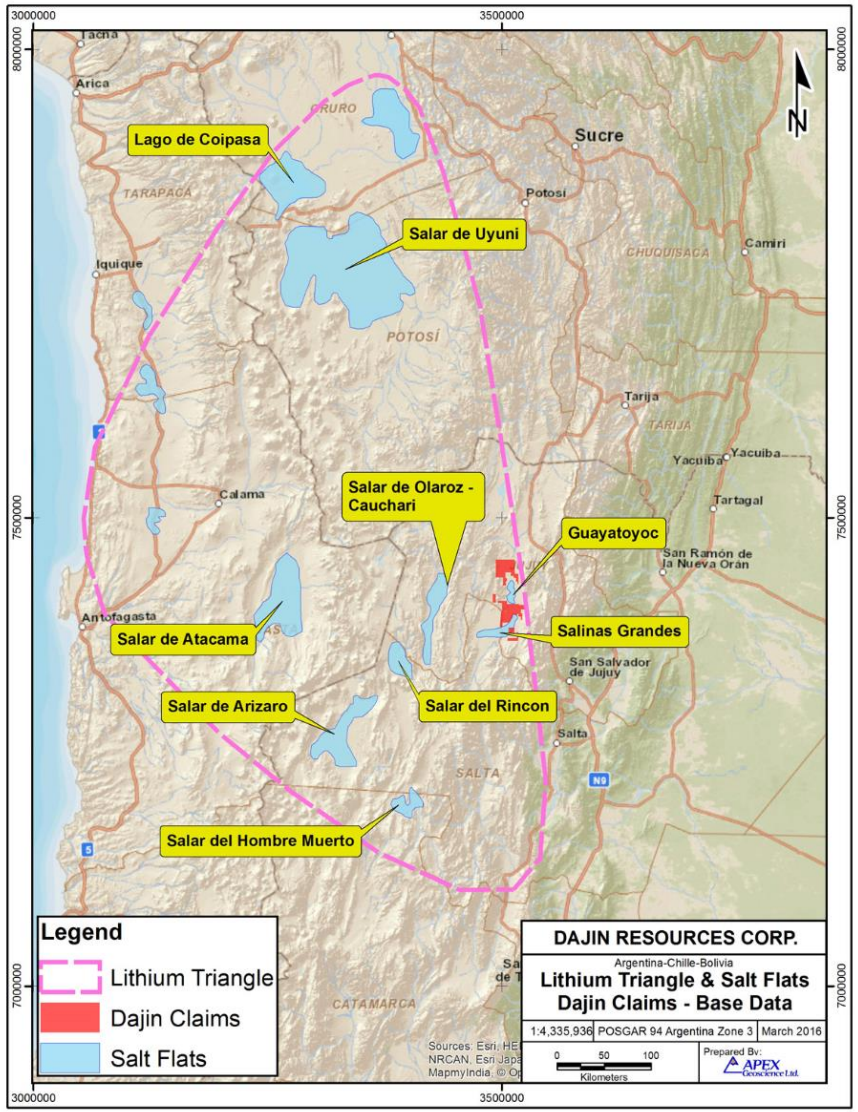
DERA 2019

- *> 200 Li-containing minerals (> 0,002% Li_2O)*
- *25 Li-containing minerals (> 2% Li_2O)*

LITHIUM FROM BRINE DEPOSITS

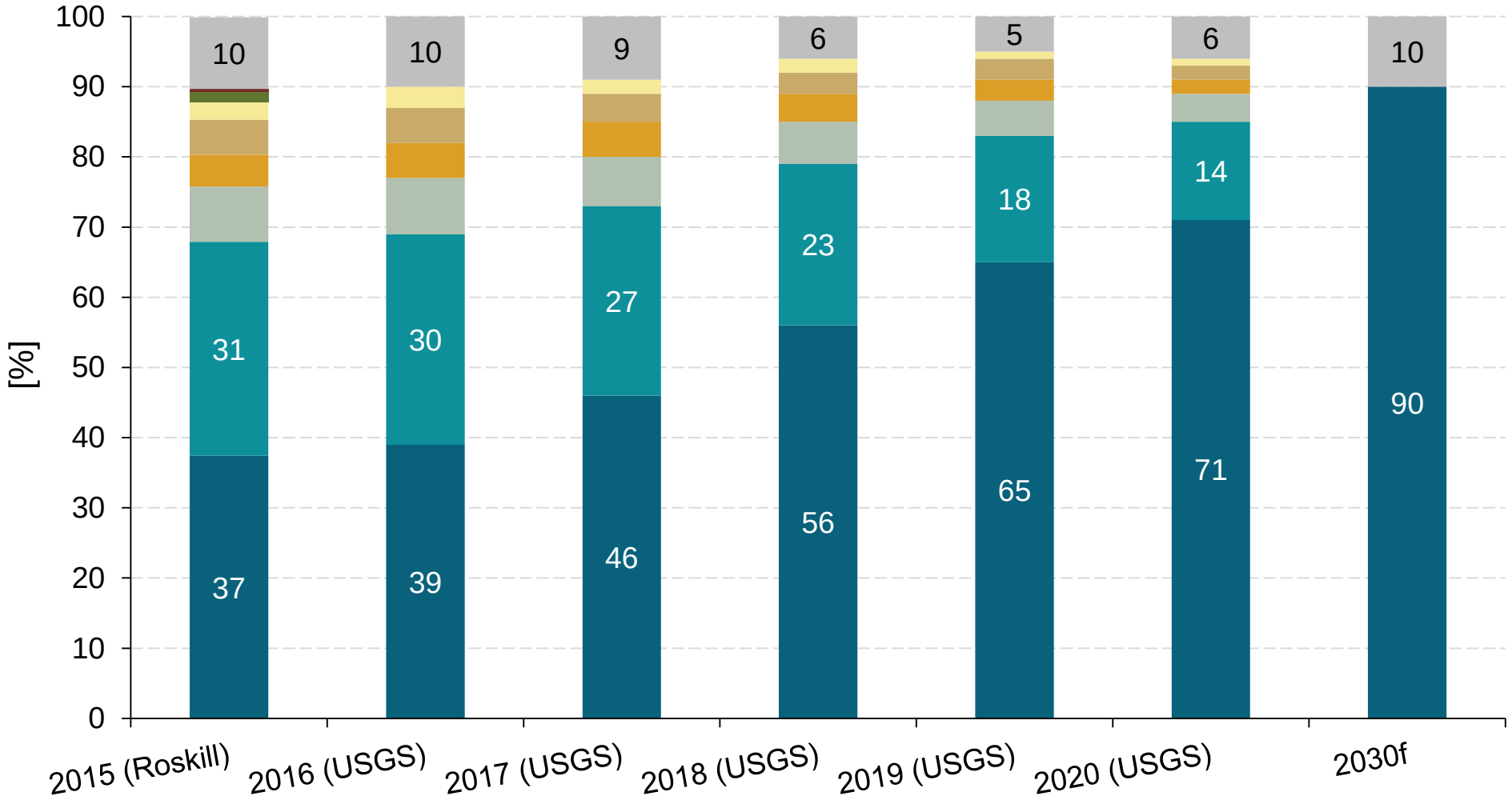
DERA 2016 (Salar de Atacama)

„Each Brine Is Unique“



Vorkommen	Ort	Li Ø (ppm)	Mg Ø (ppm)	K Ø (ppm)	Na Ø (ppm)	SO_4 Ø (ppm)	Cl Ø (ppm)	Mg/Li	K/Li	SO_4/Li
Salare										
Salar de Atacama	Chile	1.570	9.650	23.600	91.000	15.900	189.500	6,15	15,03	10,12
Salar de Maricunga		1.250	8.280	8.869	k. A.	7.200	k. A.	6,63	8,6	5,76
Salar de Hombre Muerto	Argentinien	190 – 900	180 – 1.410	2.400 – 9.700	99.000 – 103.000	5.300 – 11.400	158.000 – 168.000	0,94 – 1,56	12,63 – 10,77	27,89 – 12,66
Salar de Olaroz[1]		610 – 695	1.450[2]	5.730	k. A.	16.287[3]	k. A.	2,37[1]	9,39 – 8,24	26,7[1]
Salar de Rincon		397	3415[2]	7.513	k. A.	12.228[3]	k. A.	8,6	18,9	30,8
Salar des tres Quebradas[4]		858	1.363	7.682	78.782	554	191.289	1,59	8,9	0,65
Salar de Los Angeles		501	1.904[2]	6.206	k. A.	7.315[3]	k. A.	3,8	k. A.	14,6
Sal de Vida		782	1.720[2]	8.653	k. A.	8.993[3]	k. A.	2,2	11,1	11,5
Salar de Cauchari		618	1.792[2]	5.127	k. A.	19.096[3]	k. A.	2,9	8,3	30,9
Salar de Centenario		560	3.260	5.111	k. A.	k. A.	k. A.	5,87	9,20	k. A.
Mariana		300 – 341	k. A.	8.740 – 10.655	k. A.	k. A.	k. A.	k. A.	k. A.	k. A.
Salar de Uyuni	Bolivien	349	6.500	7.200	87.200	8.500	157.100	18,62	20,63	24,35
Clayton Valley	USA	163	190	4.000	46.900	3.400	72.600	1,17	24,54	20,86
Silver Peak		245	343[2]	5.655	k.A	7.571[3]	k.A	1,4	23,1	30,9
Searless Lake		54 – 60	k. A	2.530 – 1.570	110.800 – 118.400	4.610 – 4.440	123.000 – 108.100	k. A.	46,9 – 26,2	85,4 – 74
Great Salt Lake		18	5.000 – 9.700	2.600 – 7.200	37.000 – 87.000	9.400 – 20.000	70.000 – 156.000	277,8 – 538,9	144,4 – 400	522,2 – 1.111,1
Bonneville		57	4.000	5.000	83.000	k. A.	140.000	70,2	87,7	k. A.
Zabuye Caka	China	489	26	16.600	72.900	27.100	123.000	0,05	33,9	55,4
Da Qaidam (Quaidam Becken[5]		182	11.700	3.600	77.700	20.400	141.600	64,3	19,8	112
Taijinaier		310	20.200	4.400	56.300	34.100	134.200	65,2	14,2	110
Totes Meer	Israel	12	3.090	5.600	30.010	610	161.000	257,5	466,7	50,8
Sua Pan	Indien	20	k. A.	2.000	60.000	8.300	70.900	k. A.	100	415
Geothermal Brines										
Salton Sea	USA	100 – 400	700 – 5.700	13.000 – 24.000	50.000 – 70.000	42.000 – 50.000	142.000 – 209.000	7 – 14,3	130 – 240	420 – 500
Paradox Becken		110	30.900	26.700	25.200	22	201.000	281	243	0,2
Cerro Prieto	Mexiko	393	k. A.	36.000	70.000	k. A.	159.000	k. A.	91,6	k. A.
El Tatio Hot Springs	Chile	38	2,2	357	3.620	36	6.470	0,06	9,4	0,95
Cronembourg	Frank-reich	220	145	3.978	32.200	508	61.415	0,66	18,08	2,3
Cesano	Italien	350	12	21.370	63.570	91.010	37.010	0,03	61,1	260,1
Oilfield Brines										
Smackover (1976)	USA	146	2.900	2.400	56.900	375	144.500	19,9	16,4	2,6
Smackover (1984)		170	3.500	2.800	67.000	450	171.700	20,6	16,5	2,6

LITHIUM: IT‘S ALL ABOUT BATTERIES….



In 2030

> 90% Automotive

- Demand per 1,000 GWh

→ 97 kt Lithium (516 kt LCE)

Other
Aluminium
Primary Batteries
Air Treatment
Metallurgical Powders
Polymers
Greases
Glass & Ceramics
Rechargeable Batteries

Source: USGS 2016 – 2021, DERA 2021

EUROPE = FUTURE HOTSPOT OF E-MOBILITY….

Extremely dynamic developments over the past 3 years.

600..700..800..900..1,000 GWh….???

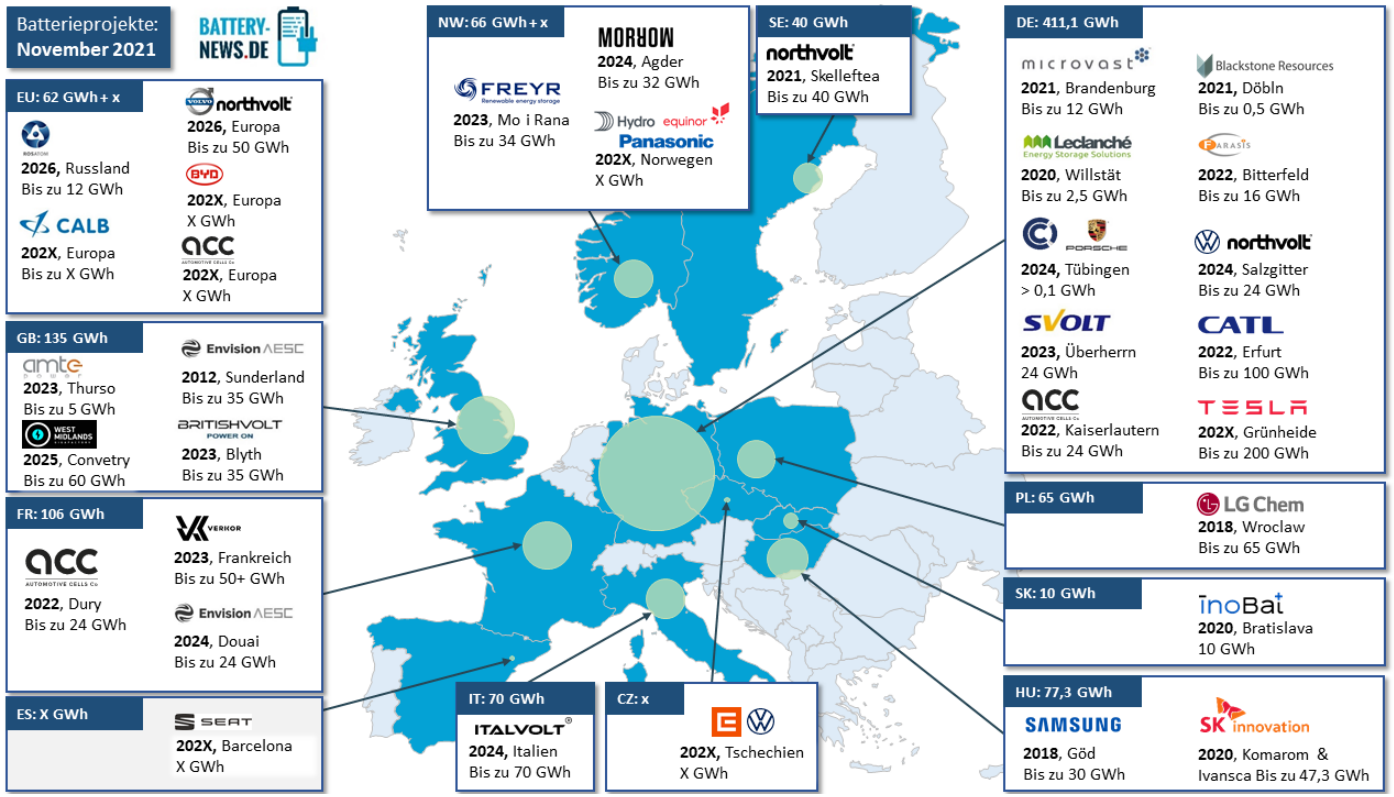
Additionally

→ Volkswagen (total 240GWh***).***

- Southern Europe, Eastern Europe.
- Plus two more to be yet determined.
- Porsche Cooperation with Custom Cells /Varta.

→ ACC (Stellantis).
→ Volvo (Cooperation mit Northvolt).

→ Mercedes Benz (50% electric in 2025, fully electric by 2030).
- 8 Gigafactories globallly (total 200GWh).
- 4 in Europe, 3 in Asia, 1 in the US.



Source: HTTPS://BATTERY-NEWS.DE/INDEX.PHP/2021/11/19/BATTERIEPROJEKTE-IN-EUROPA-STAND-NOVEMBER-2021/

1,000 GW → approx. 100kt Li

EUROPE

- Currently strong dependency for lithium chemicals (i.e.: LiOH, Li_2CO_3).
- Import has a certain CO_2 footprint which depends on the source (Brine vs. Hardrock).
- European lithium demand in 2030 approx. 532kt LCE (≈100kt Li-cont.) [1,000 GWh EV scenario]
- Theoretical capacity of european lithium projects : 130kt LCE (25kt Li- cont.)
- 100% of that capacity enough for approx. 25% of 1,000 GWh demand scenario [Unlikely]
- Additionally /non EU member projects): Serbia (Jadar, Rio Tinto; Valjevo), Bosnia (Lapore).
- Import dependance will remain but could be eased to a certain extend.
- Secondary supply as an alternative (5 – 25 % in 2030) ?

LITHIUM KEY TAKEAWAYS

- Chemicals market with few major players. China dominant in the downstream sector.
- Current lithium prices on all time high levels (additionally high price volatility).
- Lithium demand for batteries (EVs) as major driver (**≈ 90% of total lithium demand in 2030**)
- Primary lithium supply has to increase from **80kt** in 2020 to **>350kt** in 2030 (**>300%**).
- Potential supply gap towards 2030 if no action from industry.
- Lithium is geologically not scarse. **Sufficient supply depends on timely development and investors!**
- Mine development and especially refining capacity development strongly underinvested.
- Mine lead time 4 - 10year. Refining lead time 12 – 24 months.
- CAPEX for 15 – 25kt LCE capacity approx. 300 - 500 Mio. € depending on location etc.
- 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. Hardrock). **ESG issues** (high CO_2 emissions, mine and processing wastes).