



## Batterie: die Achillesferse der Elektromobilität?

Roadmap Elektromobilität, 05.02.2021

Christian Ochsenbein  
Head Swiss Battery Technology Center  
Switzerland Innovation Park Biel/Bienne

# Rückblick

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## 15 wissenschaftliche Labore



### BFH – Battery and Storage Systems Lab

The BFH Energy Storage Research Centre provides a unique source of technical and commercial expertise. It serves as a subject-matter expert on storage applications in the energy and mobility sector and works with its partners to generate impetus for developments.



### CSEM – Battery Systems

CSEM is a Swiss research and technology organization (RTO) with +35 years of technology development and transfer to industry. This activity has accelerated innovation, particularly in the strategic fields of digitalization, precision manufacturing, and sustainable energy.



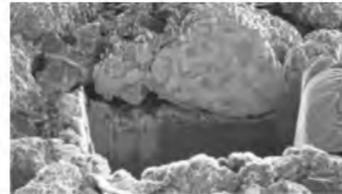
### Empa – Laboratory Materials for Energy Conversion

Empa is an interdisciplinary research institute of the ETH Domain, conducting cutting-edge research on materials science and technology for the benefit of industry and the well-being of society. The laboratory Materials for Energy Conversion focuses on materials and device innovation for sustainable energy conversion and storage technologies.



### UniNE – Institute of Management

The chair for innovation management at the University of Neuchâtel's Institute of Management has expertise in the collaboration between research and industry partners in the fields of strategy and innovation.



### Empa – Reliability Center

The Reliability Center operates a knowledge and equipment pool to perform research, tests and inspections for industry, academic institutions and public authorities.



### EPFL – Distributed Electrical Systems Laboratory

The research activities of the Distributed Electrical Systems Laboratory (DESL) refer to the development of smart grid concept solutions in order to efficiently deliver sustainable, economic and secure electricity supply.



### ETHZ – High Power Electronic Systems Lab

The research at the High Power Electronic Systems Lab (HPE) focusses generally on the design, modelling, and optimization of high power converter systems required for example in future energy distribution systems for integrating renewable energy sources or in electric mobility applications.



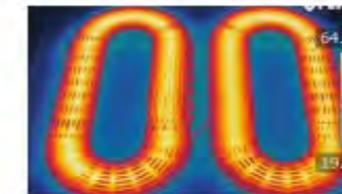
### Ökozentrum

Ökozentrum develops functional models in the field of electromobility, stationary battery storage, accumulator systems and PV for customers from industry and research. We support you from the vision to small product series.



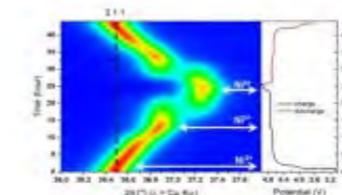
### OST – Battery Research & E-Mobility

The Battery Research & E-Mobility Group of OST (Eastern Switzerland University of Applied Sciences - formerly NTB) is working in the field of electro mobility, battery research and charging technology since 2007.



### OST – Power Electronics Laboratory

The Power Electronics Laboratory at the OST was established in 2008 and offers comprehensive expertise in the field of switched mode power conversion. One of the focuses is placed on battery charging for electro mobility and stationary applications.



### PSI – Electrochemistry Laboratory

The Electrochemistry Laboratory (ECL), established 1988, is part of the Energy and Environment Research Division at the Paul Scherrer Institute. PSI's Electrochemistry Laboratory is Switzerland's largest Center for Electrochemical Research.

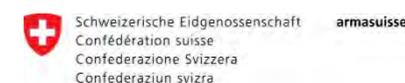


### SIPBB – Swiss Battery Technology Center

The Switzerland Innovation Park Biel/Bienne (SIPBB) supports start-ups in the development of marketable products. The Swiss Battery Technology Center brings a unique mix of experts from research and development.

# iBATT

Swiss innovations for Battery Applications and Technologies



## Executive committee

- President
- Vice President
- ExeCom member
- ExeCom member
- ExeCom member

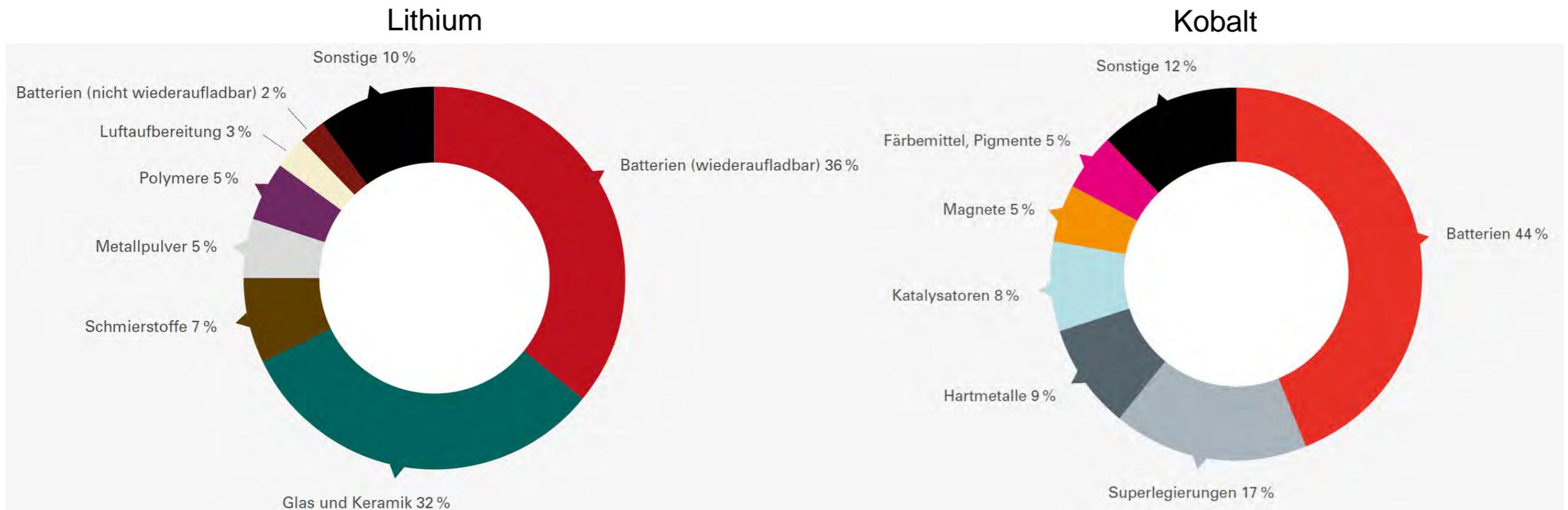
- Prof. Dr. Andrea Vezzini, BFH
- Dr. Andreas Hutter, CSEM
- Dr. Corsin Battaglia, EMPA
- Christian Ochsenbein, SIPBB
- Michael Sattler, Ökozentrum



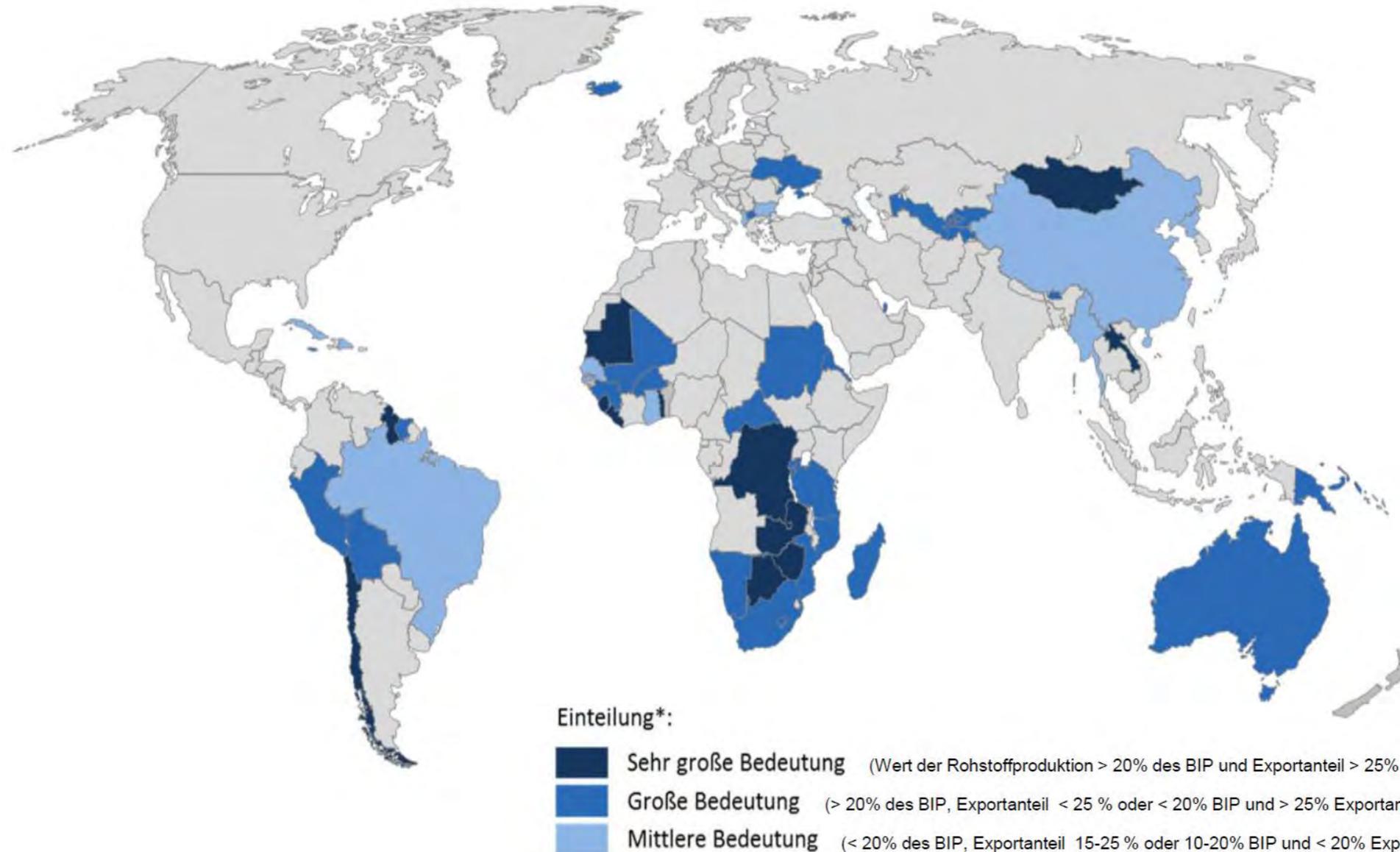
# Batteriematerialien: Beispiel VW iD3



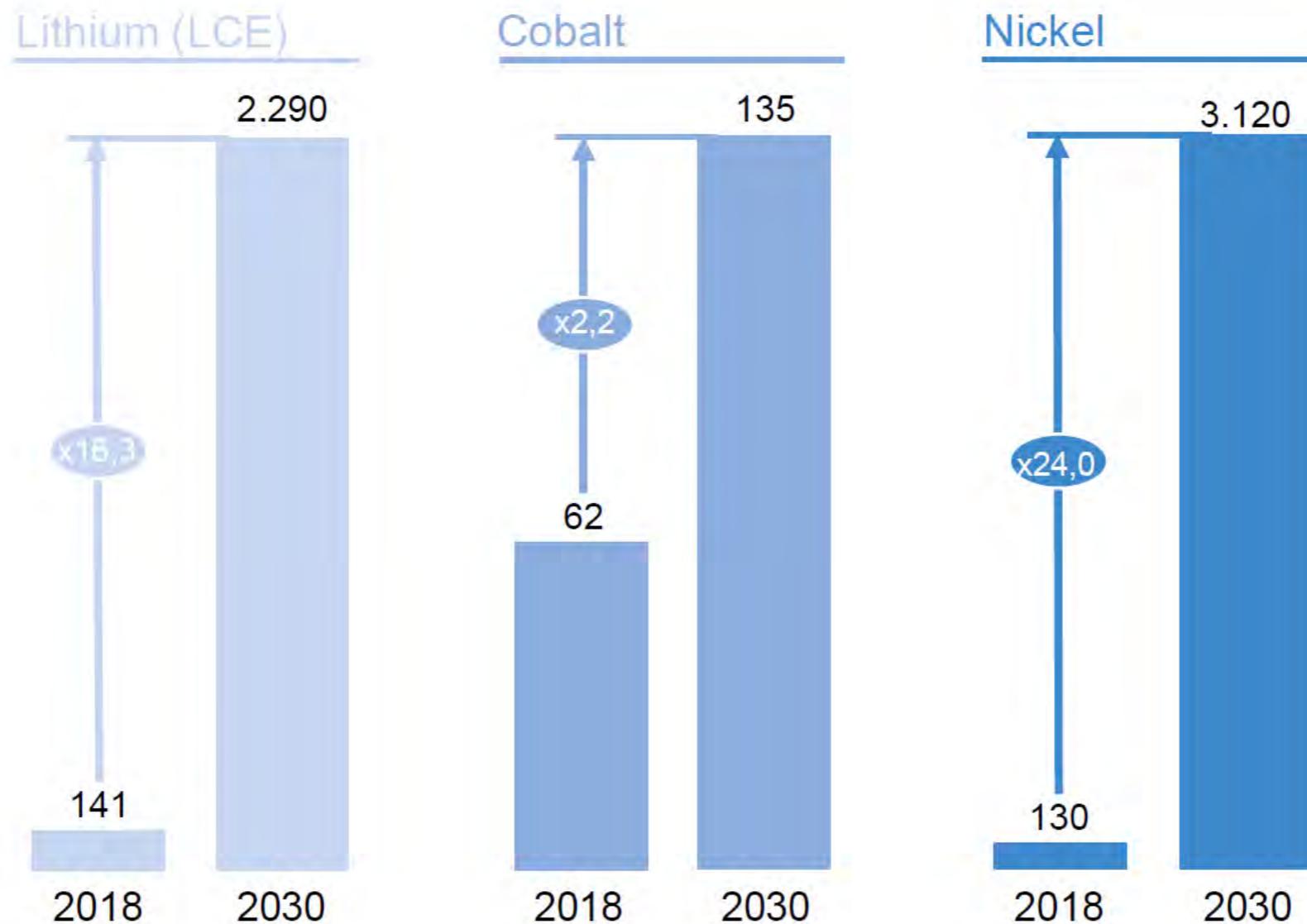
# Verwendung von Lithium und Kobalt



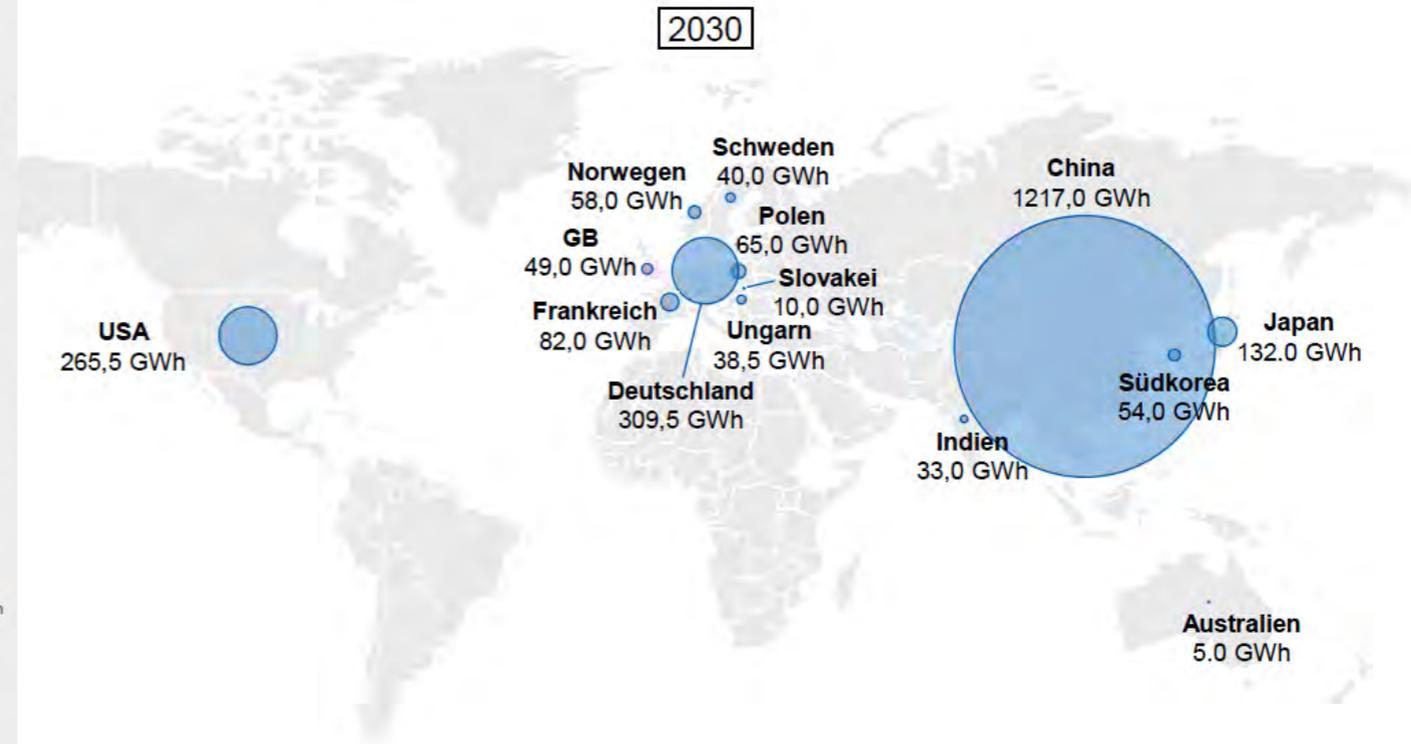
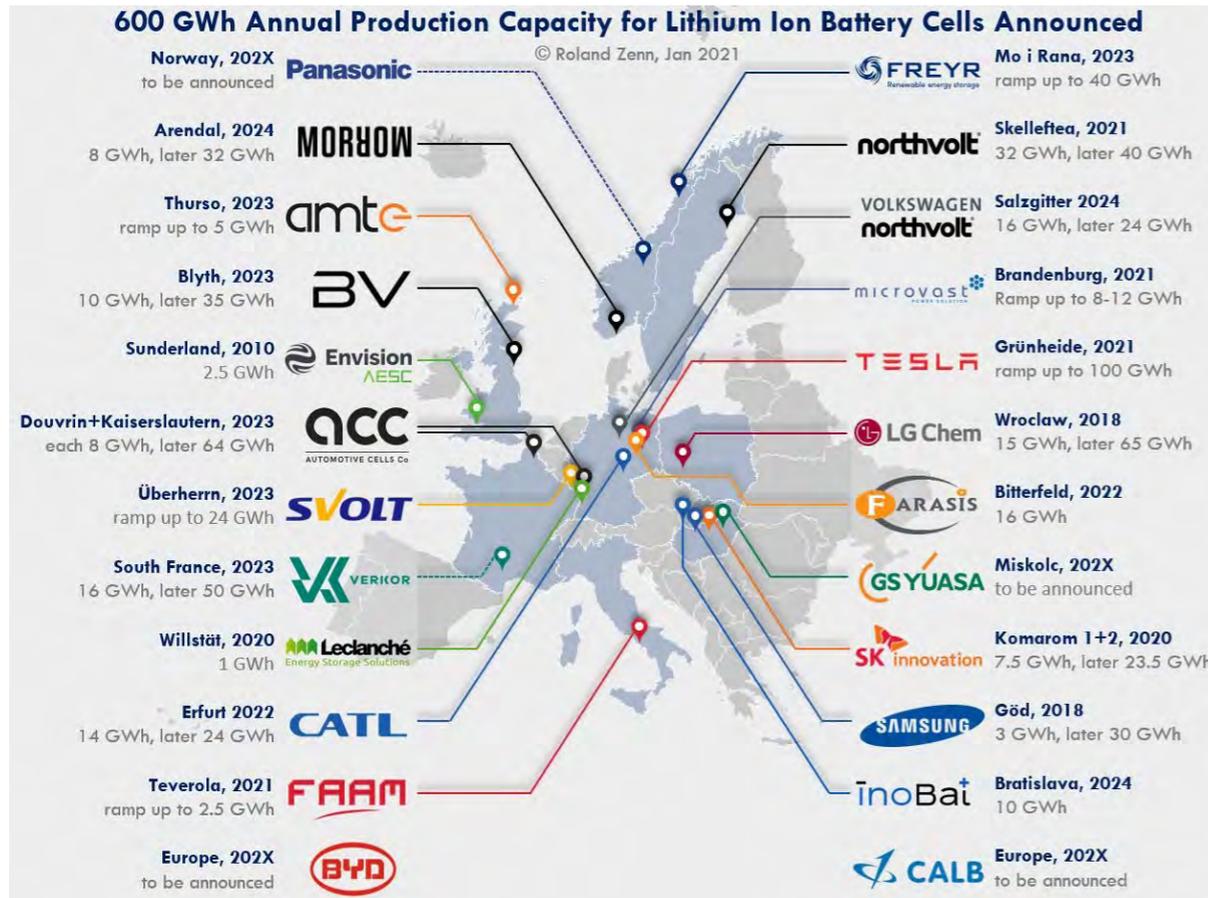
# Wirtschaftliche Bedeutung der Bergbausektors



# Nachfrage nach Lithium, Cobalt, Nickel in 2030



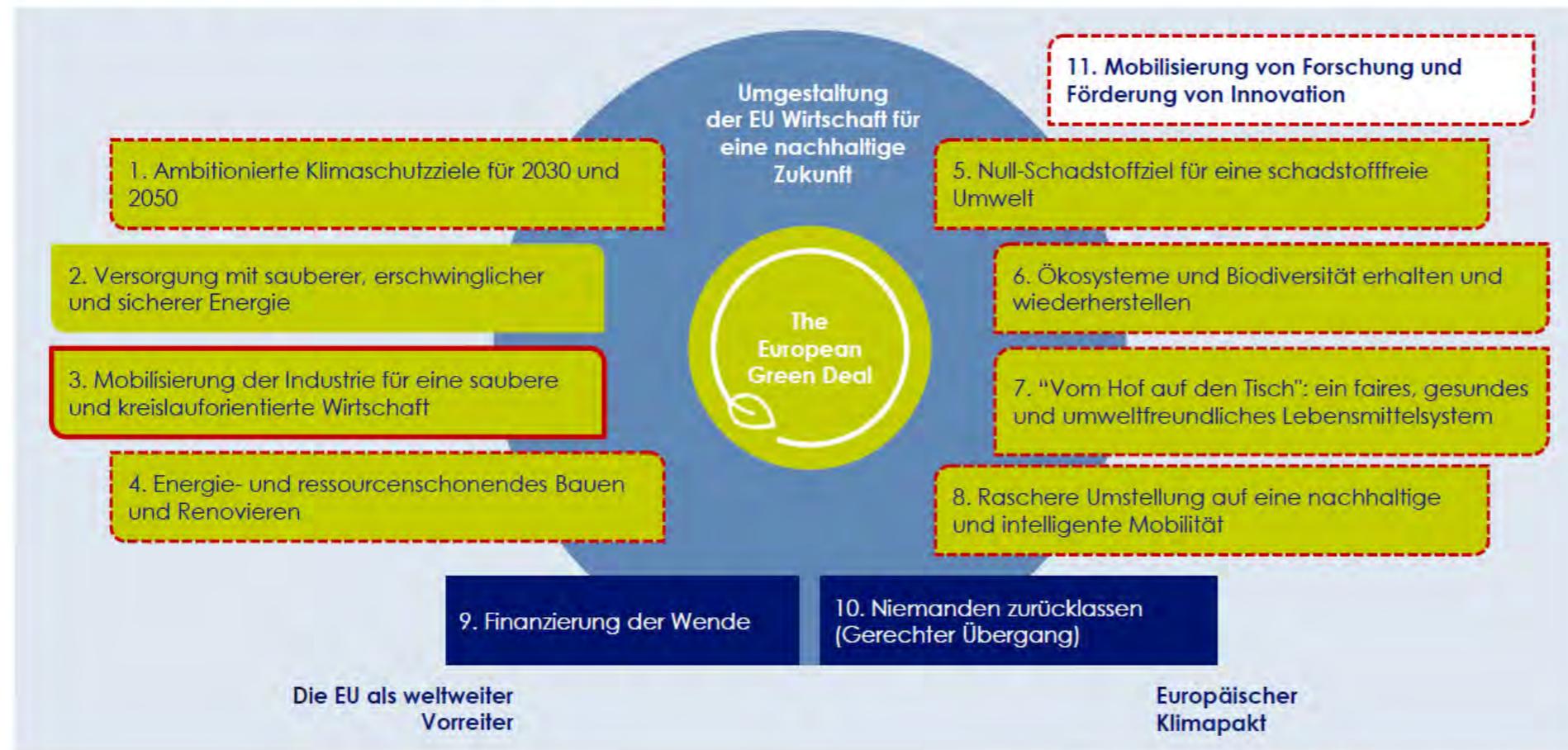
# Batterieproduktion: Europa Nr. 2 nach China



Quelle: Roland Zenn, Jan 2021, Trends im Lithium-Ionen-Batteriemarkt, VDE Renewables, 10.2020

# Circular Economy als effektive Massnahme für Klima- und Ressourcenschutz

## Übersicht zu European Green Deal (EGD)



## Anmerkungen

- "Das alte Wachstumsmodell, das auf fossilen Energien und Verschmutzung gründet, hat sich überlebt. **Gefragt ist nun eine Strategie für ein Wachstum, das mehr zurückgibt, als es wegnimmt.** Der Europäische Grüne Deal ist unsere neue Wachstumsstrategie"- Ursula von der Leyen (EU-Kommissionspräsidentin)
- Die Circular Economy spielt eine **zentrale Rolle für das Erreichen des Ziels der Treibhausgasneutralität bis 2050**

# Recycling: Ausgangslage

HEUTE



Blei Batterie

Li-Ionen Batterie

Alkaline Batterie

NiMH Batterie

Lithium Primärbatterie



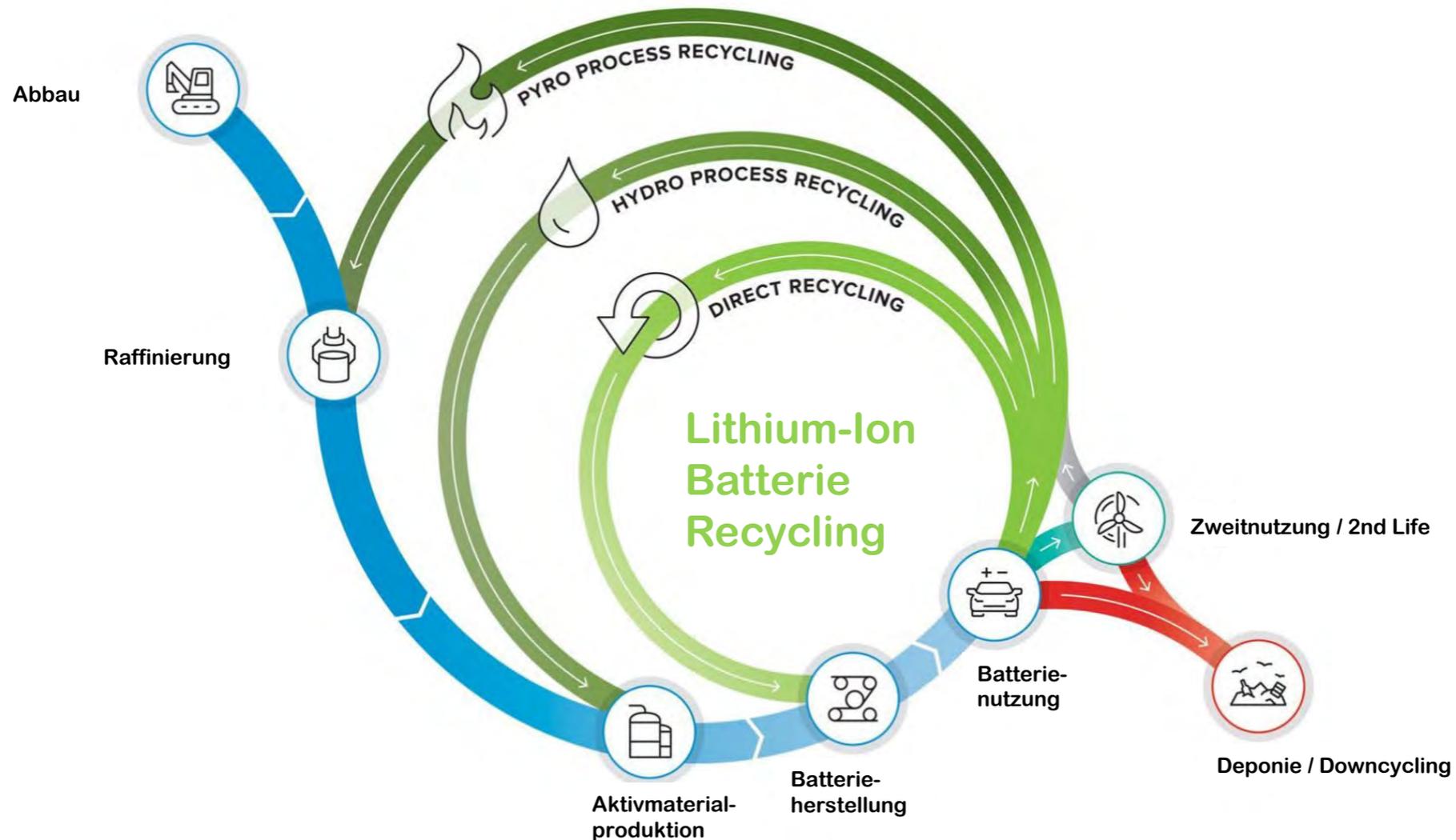
MORGEN



Li-Ionen Batterie

Materialzusammensetzung bekannt

# Produktkreislauf einer Lithium-Ionen-Batterie



# Hydrometallurgie am effektivsten zur Wertstoffrückgewinnung

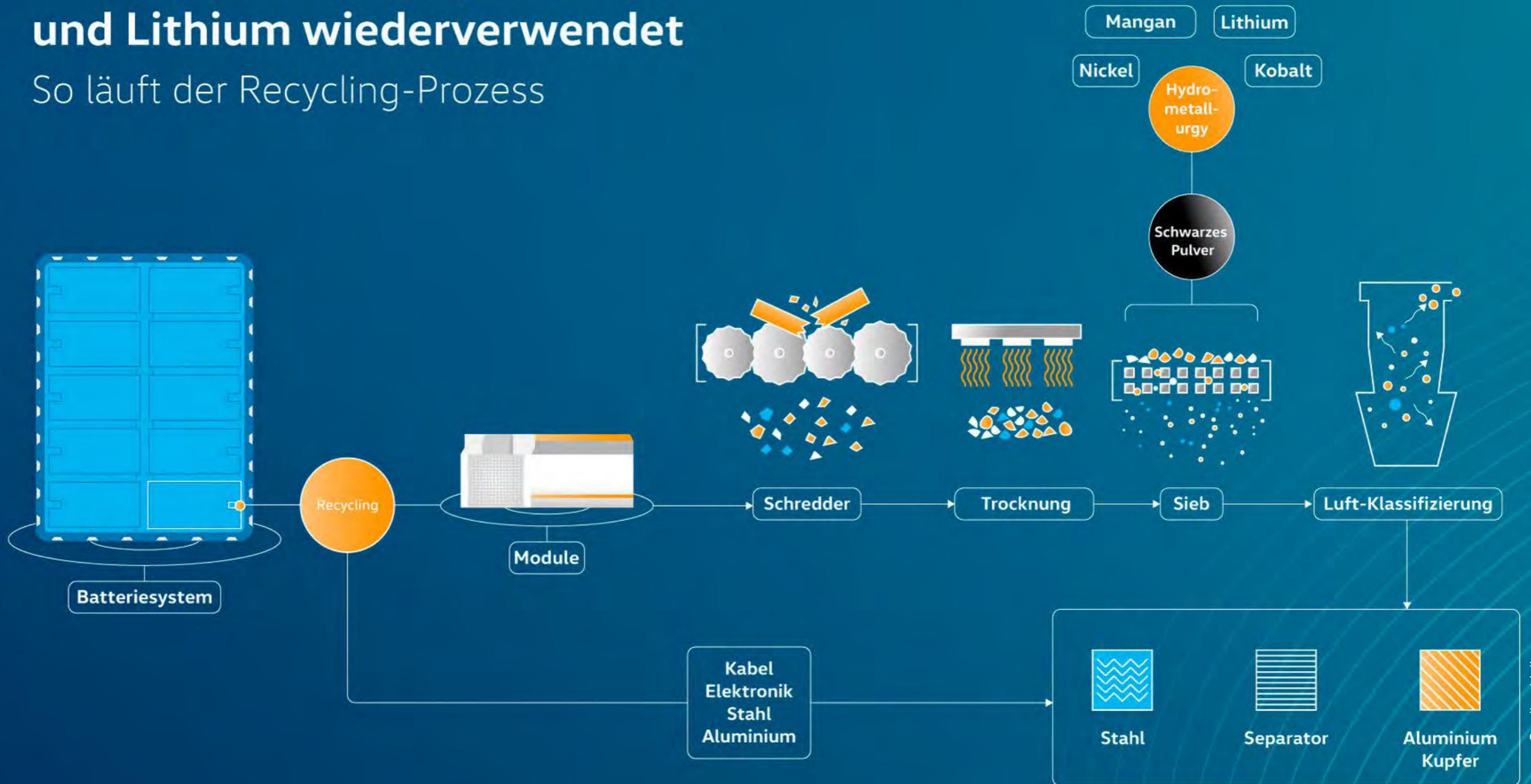
Chemical component	Li	Ni	Co	Cu	C
Pyrolysis	0%	40 – 60%	40 – 60%	n.c.	0%
Pyrolysis - Hydrometallurgical	50 – 60%	> 95%	> 95%	> 95%	0%
Mechanical - Pyrolysis (slag)	0%	40 – 60%	40 – 60%	n.c.	0%
<b>Mechanical - Hydrometallurgical (black-mass)</b>	<b>&gt; 90%</b>	<b>&gt; 99%</b>	<b>&gt; 99%</b>	<b>&gt; 99%</b>	0%

Source Roland Berger research; selected companies

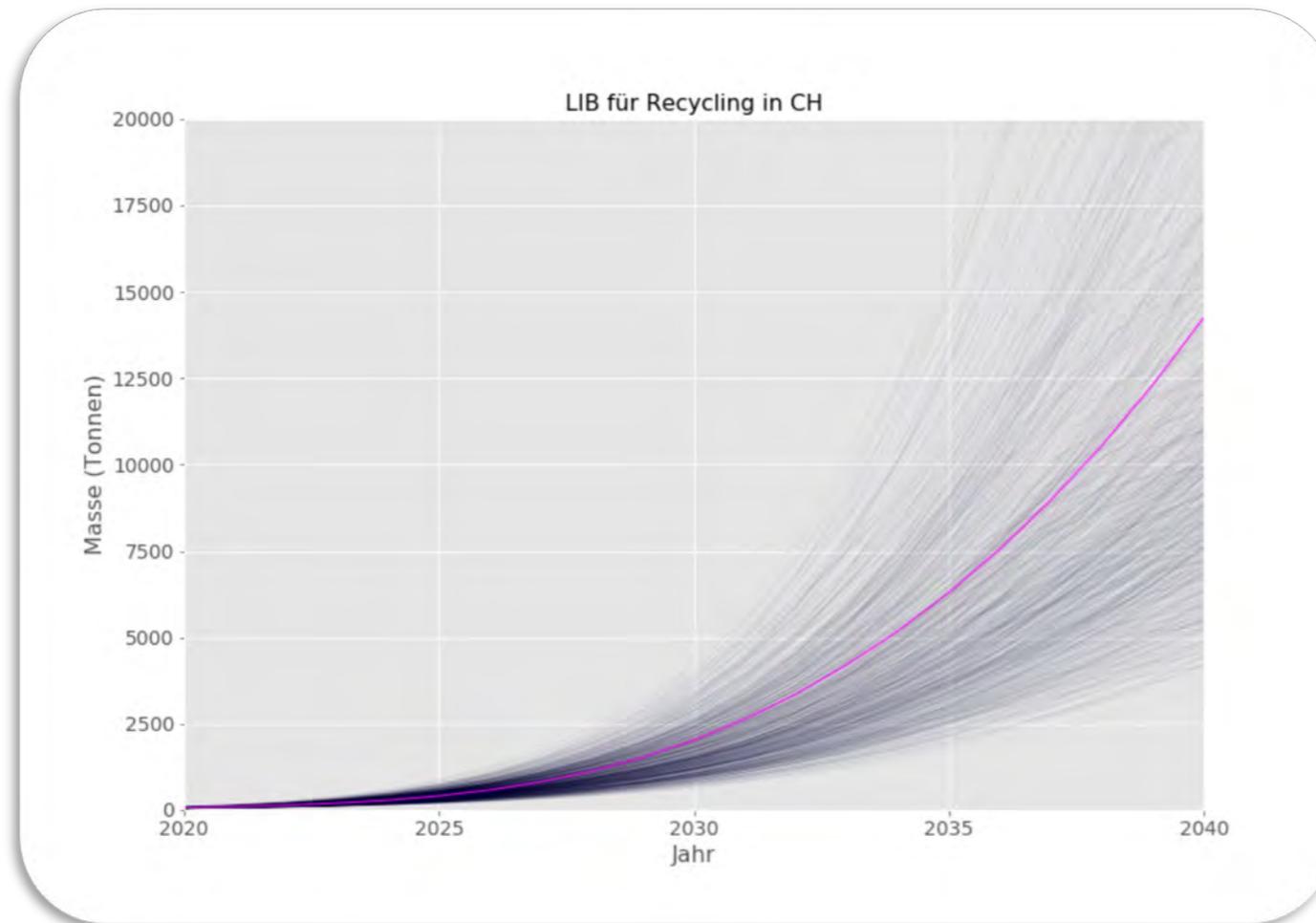
<sup>1</sup> All recovery rates measured at end of recycling process

# Kobalt, Nickel, Mangan und Lithium wiederverwendet

So läuft der Recycling-Prozess



# erwartete Masse an EOL Fahrzeugbatterien



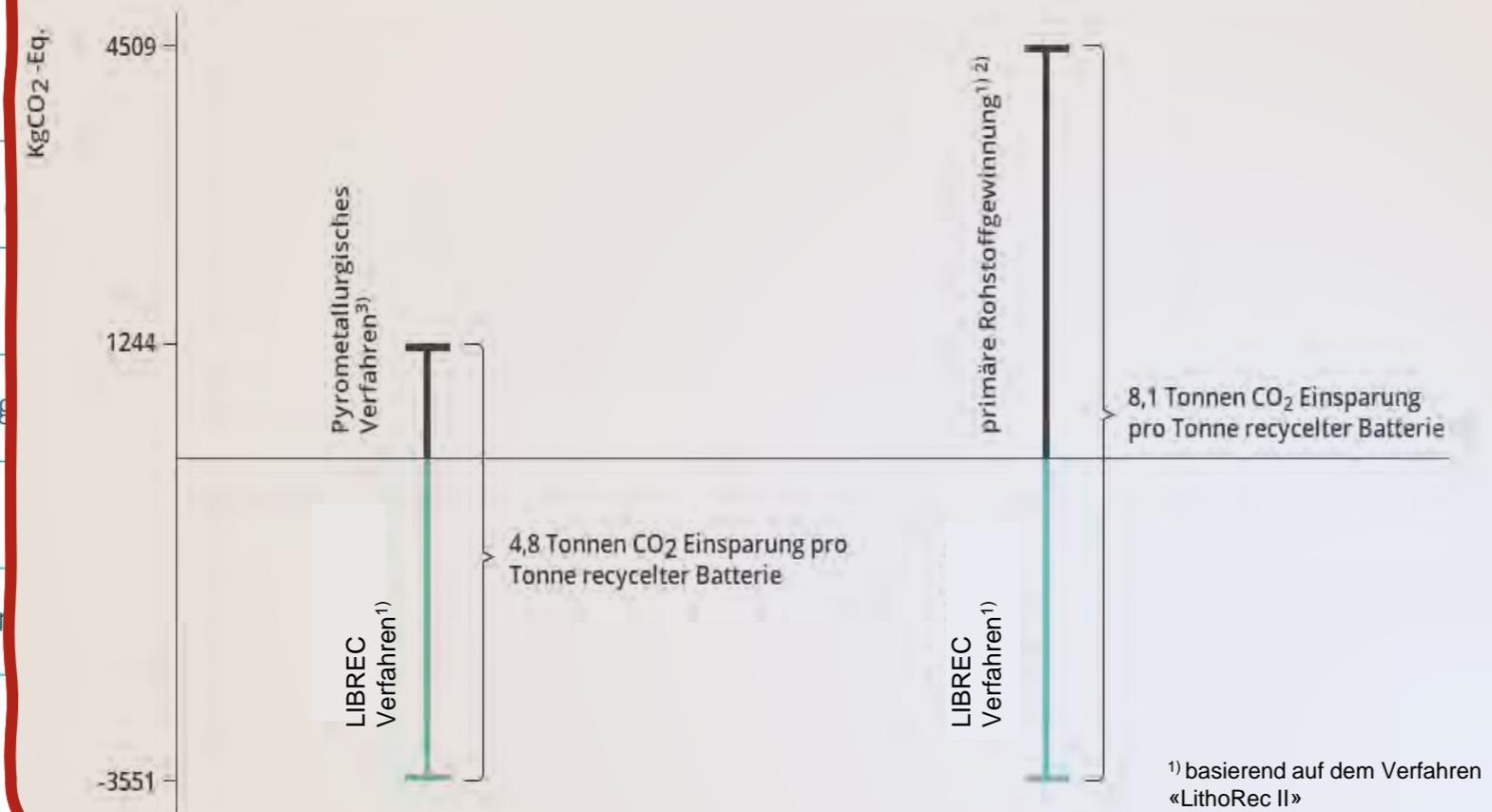
— Szenarien EMPA  
— Grundlage für LIBREC-  
Geschäftsmodell

## EMPA-Daten: Modellierte Variablen

Anfangsbestand  
Marktanteile  
Ausfall/Ersatz  
Lebensdauer  
Anteil Export  
Anteil 'second life'

# Recycling-Lösung für die Schweiz

CO<sub>2</sub> Einsparung im Vergleich zu pyrometallurgischen Verfahren und Primärproduktion



Recycling am selben Ort

3 CHF/kg



- Besitzer & Garagen
- Autoverwerter
- Unvollständiges Recycling
- Autoshredder
- Recycling oder Deponie in



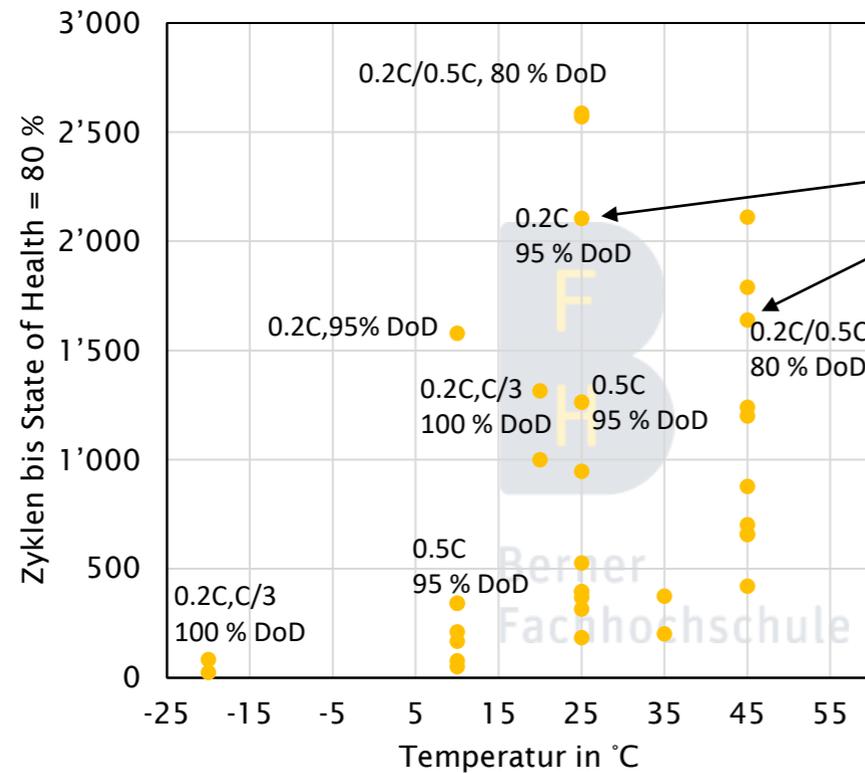
**Swiss  
Battery  
Technology  
Center**

Vielen Dank!  
[christian.ochsenbein@sipbb.ch](mailto:christian.ochsenbein@sipbb.ch)

# Back-up Slides

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# Batteriealterung: Messresultate BFH



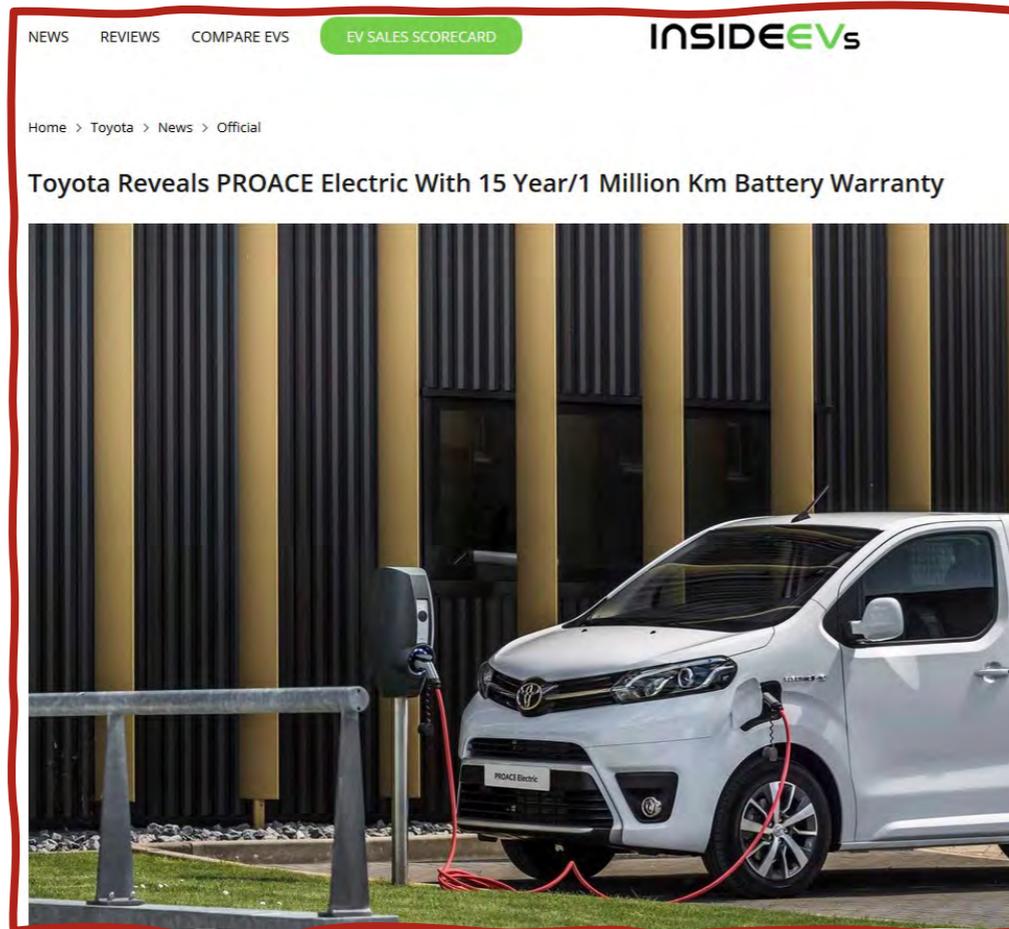
Quelle: Lebensdauertests im Auftrag der Industrie am BFH-Zentrum Energiespeicherung

## Beispiel Opel Ampera-e mit 60-kWh-Batterie:

- ▶ Realistische WLTP-Reichweite: 380 km (100 %)
- ▶ 1'500 Zyklen (5 h Fahrt, 5 h Aufladen bei 25–45 °C)  
→ 300 km/Fahrt → 450'000 km Lebensdauer
- ▶ Offiziell sind 8 Jahre und 160'000 km garantiert
- ▶ BMW verlängert Garantie auf i3-Akku seit Anfang 2020 von 100'000 auf 160'000 km und 8 Jahre

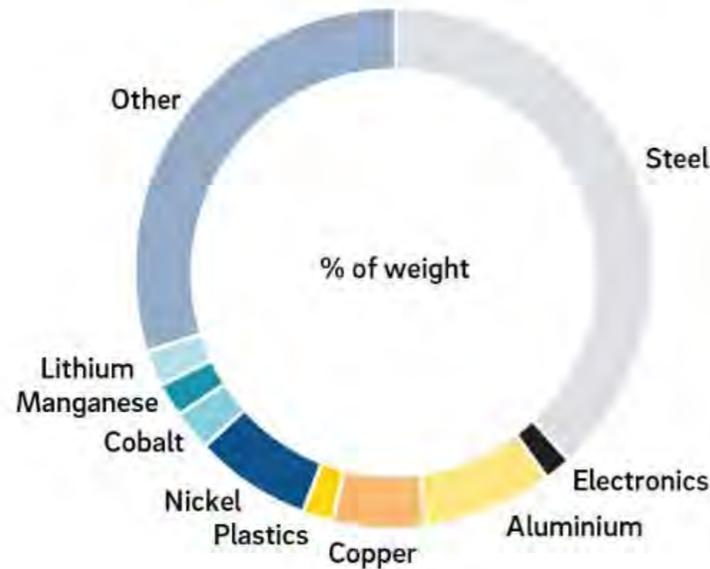
Quelle: BFH-Zentrum Energiespeicherung

# Batteriealterung



# Business Modell

**BATTERY PACK MATERIALS COMPOSITION**



**RECYCLING VALUES**

	Weight [kg/kWh]	USD/kg	A USD/kWh	B USD/kWh
Steel	2.9	0.45	1.3	1.3
Electronics	0.1	0.54	0.1	0.1
Aluminum	0.6	1.71	1.0	1.0
Copper	0.4	5.68	2.5	2.5
Plastics	0.2	-0.11	-0.0	-0.0
Nickel	0.5	9.79 <sup>2</sup>	5.2 <sup>2</sup>	24 <sup>3</sup>
Cobalt	0.2	20.45 <sup>2</sup>	3.5 <sup>2</sup>	
Lithium	0.2	9.21 <sup>2</sup>	1.4 <sup>2</sup>	
Manganese	0.2	1.44 <sup>2</sup>	0.3 <sup>2</sup>	
Other	2.2	-1.12	-2.5	-2.5
<b>Total</b>	<b>7.5</b>		<b>-13</b>	<b>-27<sup>3</sup></b>

**RECYCLING COSTS**

	USD/kg	A USD/kWh	B USD/kWh
Diagnostics & removal	0.31	2.4	2.4
Recycling logistics	0.38	2.8	2.8
Mechanical treatment	0.1 - 0.3 <sup>3</sup>	1.1	2.2 <sup>3</sup>
Hydro-metallurgy	0.3 - 0.6 <sup>3</sup>	2.2	4.5 <sup>3</sup>
<b>Total</b>		<b>-9</b>	<b>-12<sup>3</sup></b>

**A** Battery graded material    **B** Precursor

**Value pool**  
 Δ of 4 – 18 USD/kWh /10a lifetime  
 =0.4-1.8 USD/kWh p.a.

Source Roland Berger estimates

<sup>1</sup> Based on volume OEM pack using NCM622    <sup>2</sup> Estimated at 70% of 2019 stock prize, with 95% efficiency of recycling

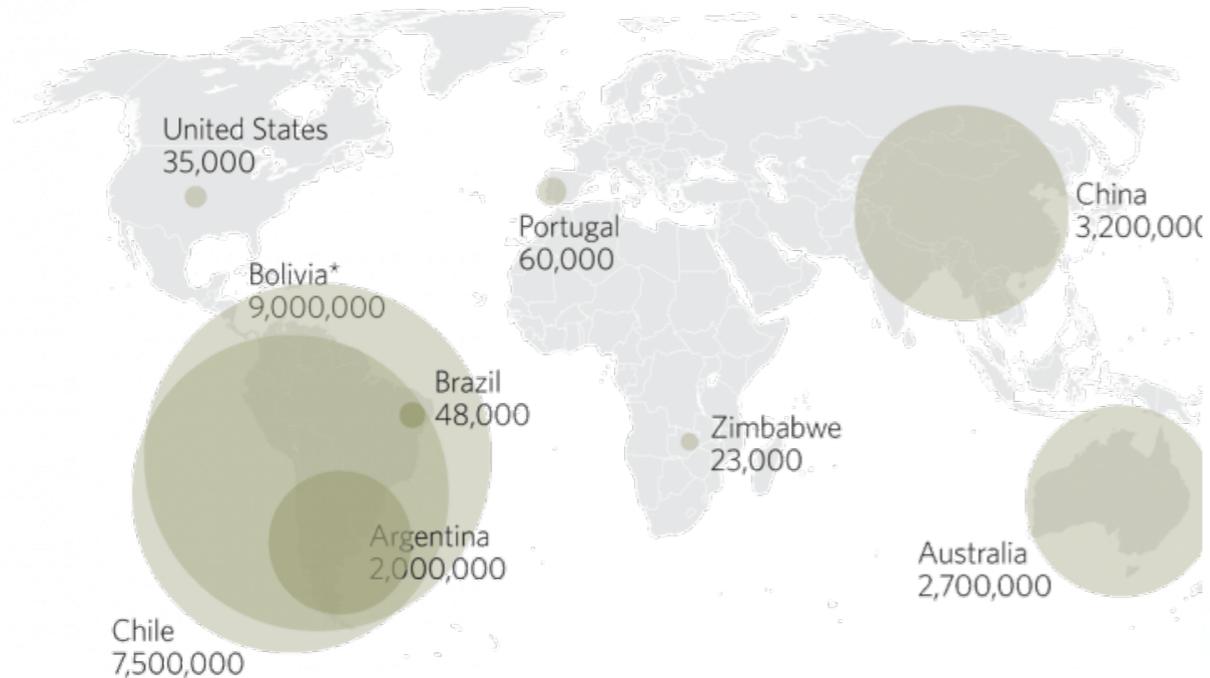
<sup>3</sup> Hydrometallurgical recycling of NCM811 and LiOH at -95% efficiency    Note: Differences to "Total" due to rounding errors



## Lithium Reserves

Lithium has been front and center in the next-energy revolution, as it remains a key component for current battery technology. But even if and when the world moves away from lithium-ion batteries specifically, the element will remain a key component in future successors, including some solid state batteries, lithium-sulfur batteries and lithium metal batteries. Sodium and magnesium, however, could one day supplant lithium, as they share similar electronic properties to the metal but are more abundant and less expensive.

Metric tons



\*Bolivian figures are for resources. Resources are inherently more speculative than reserves and indicate that more exploration is needed before the reserve amount can be determined.

## Cobalt Reserves

Cobalt is a key raw material for many lithium-ion battery chemistries. At present, global reserves and production are heavily concentrated in the politically unstable Democratic Republic of the Congo. Its importance, however, could shrink, as some current batteries do not use cobalt at all, while research breakthroughs could reduce and eventually eliminate the demand for the metal.

Metric tons

