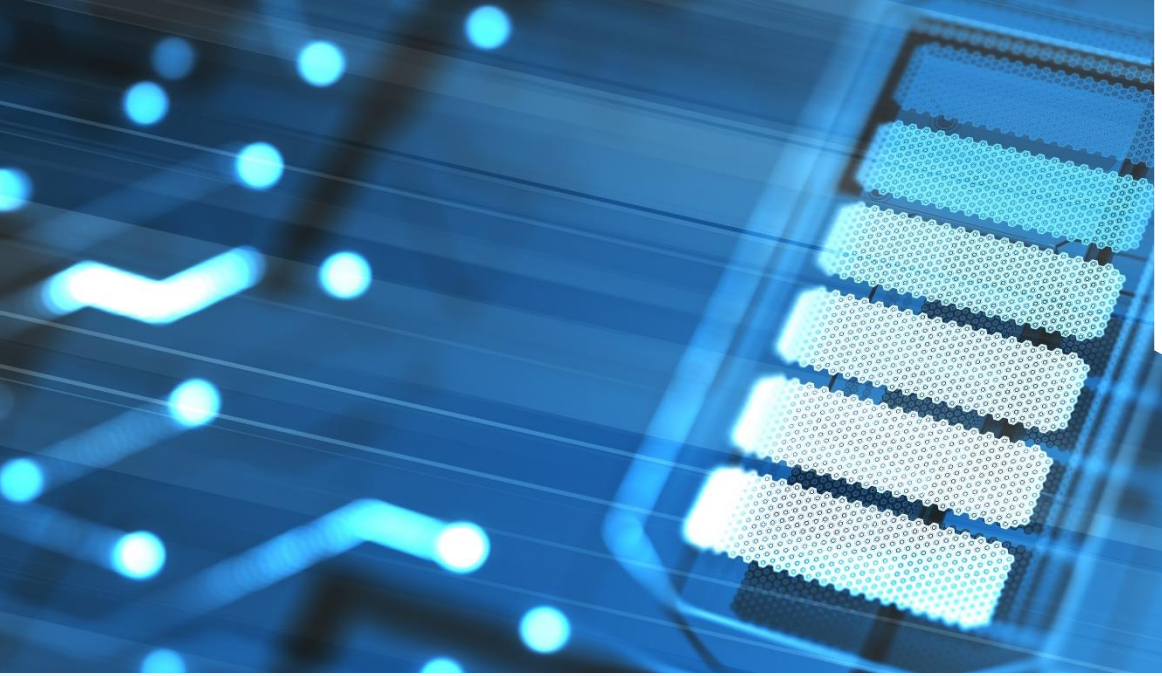


HIU HELMHOLTZ INSTITUTE ULM
Electrochemical Energy Storage

Tugce Ates

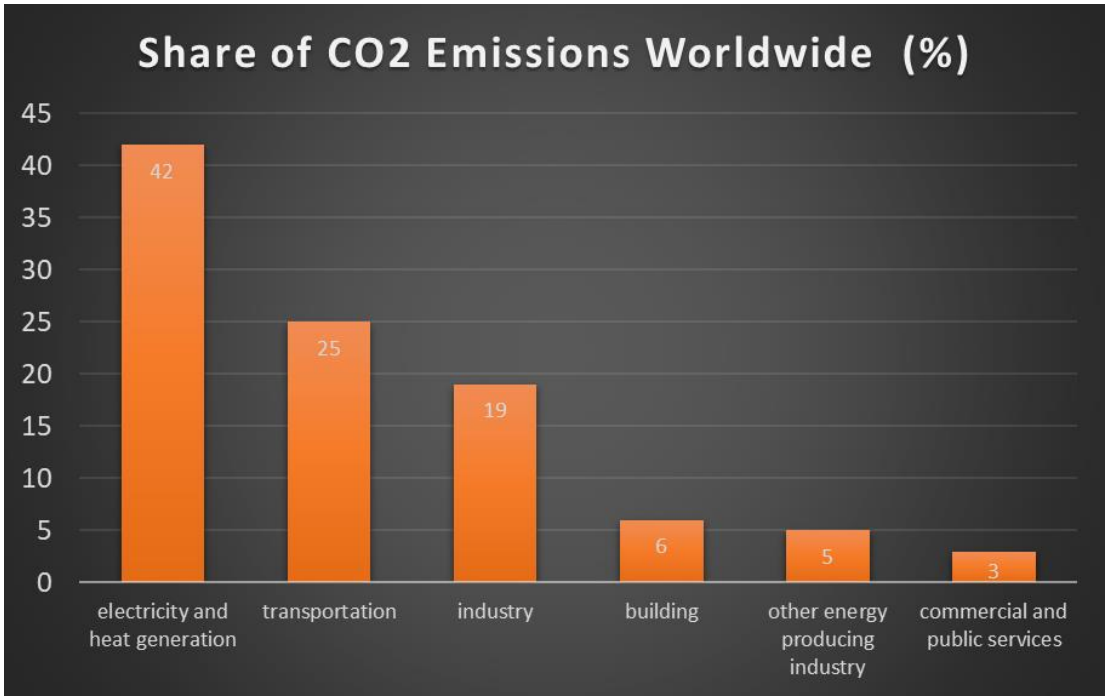
Festkörperbatterien

HIU – Tag der offenen Tür
Ulm, 18.09.2021

KIT Karlsruhe Institute of Technology
ulm university universität ulm
ZSW
DLR

Problem:

Fossile Brennstoffe: Kohle, Erdöl, Erdgas, Benzin werden benötigt
zur Produktion von Elektrizität und als Treibstoff für unsere Fahrzeuge
→ aber tragen zur **Luftverschmutzung** bei

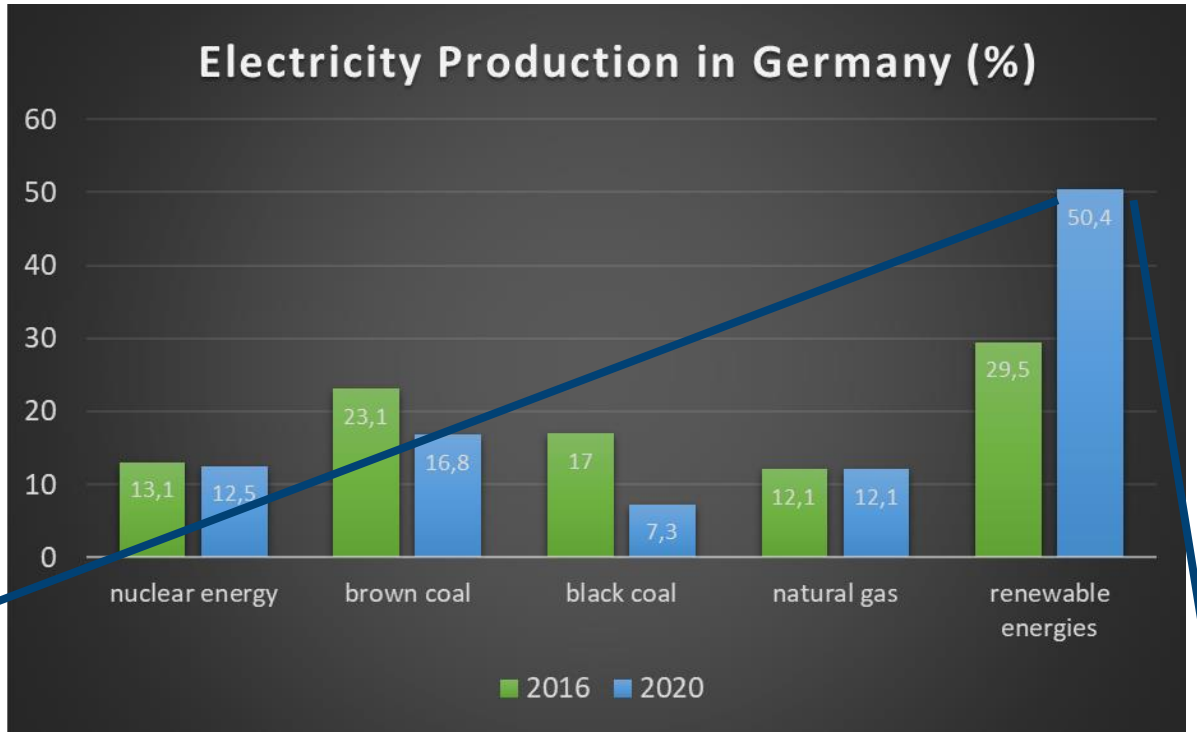


Stand: 2018

http://www.energie-investment.org/windkraftanlage-kaufen.html
https://www.proprofs.com/quiz-school/story.php?title=fossil-fuels-ones-that-harm
http://de.statista.com/statistik/daten/studie/167957/umfrage/verteilung-der-coemissionen-weltweit-nach-bereich/

Lösung:

Erneuerbare Energien und Elektromobilität:

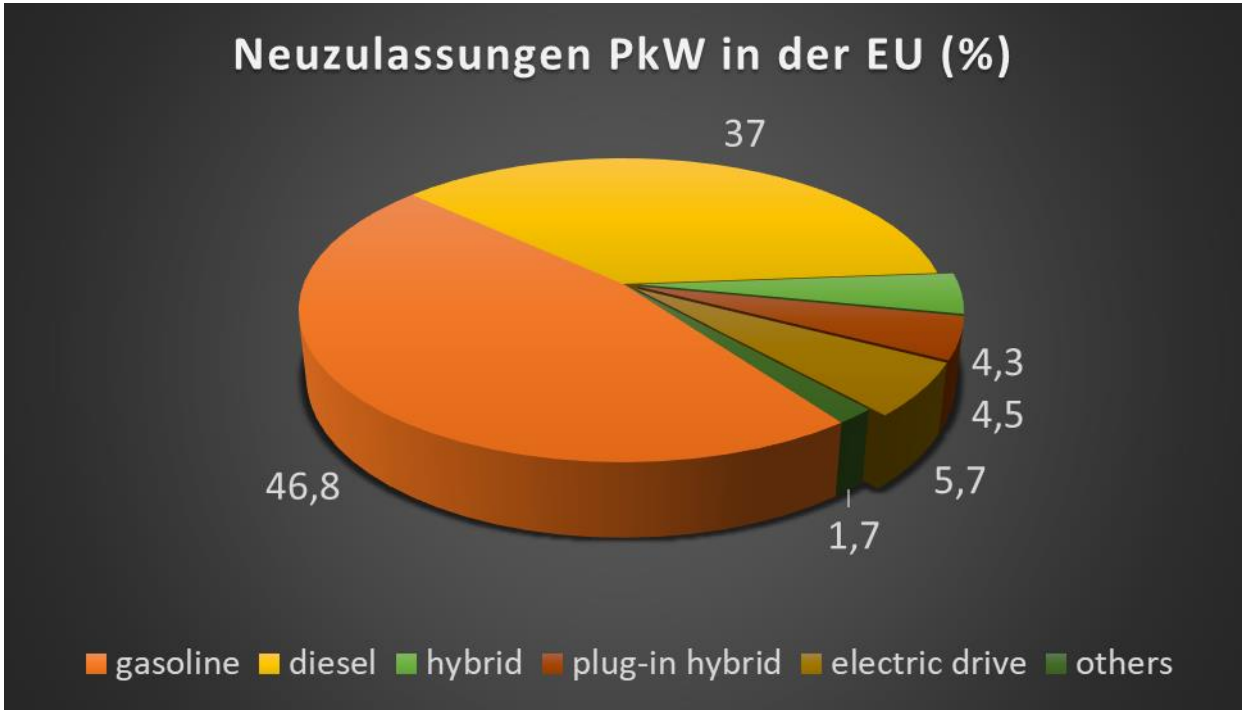


27% Windenergie 10.4% Photovoltaik 9.3% Biomasse 3.7% Wasserkraftwerke

http://www.bbc.com/capital/story/20140422-would-you-work-here
http://www.truecar.com/blog/2015/03/27/electric-cars-for-earth-month-spotlight-on-electric-vehicles-for-2015/
https://1-stromvergleich.com/stromreport/strommix

Lösung:

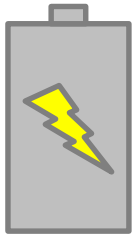
Erneuerbare Energien und Elektromobilität:



Stand: 2020

→ ***Zukunft:*** *Anteil an Elektroautos wird weiter steigen …*

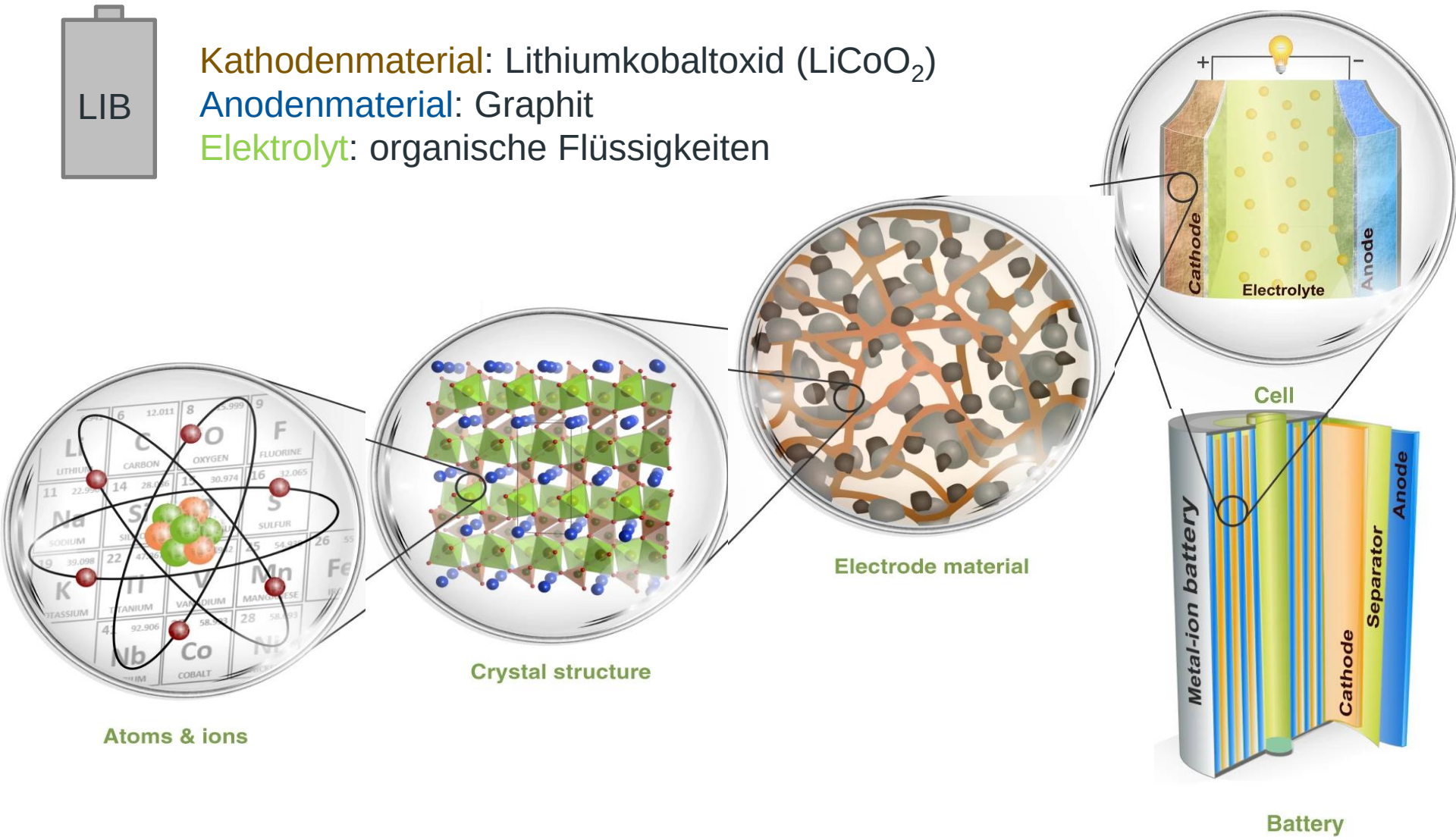
Bedingung: Nur realisierbar wenn die Energie in **Batterien** gespeichert werden kann



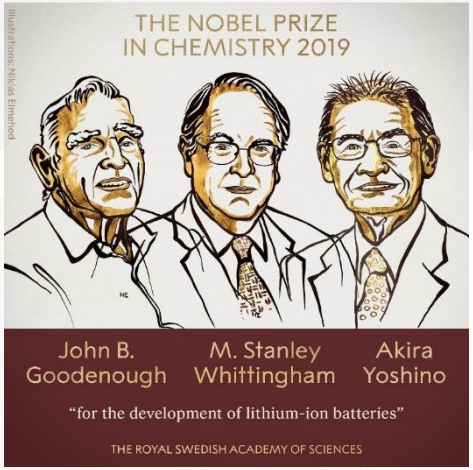
https://de.statista.com/statistik/daten/studie/1001972/umfrage/verteilung-derantriebsarten-bei-den-pkw-zulassungen-in-europa/,

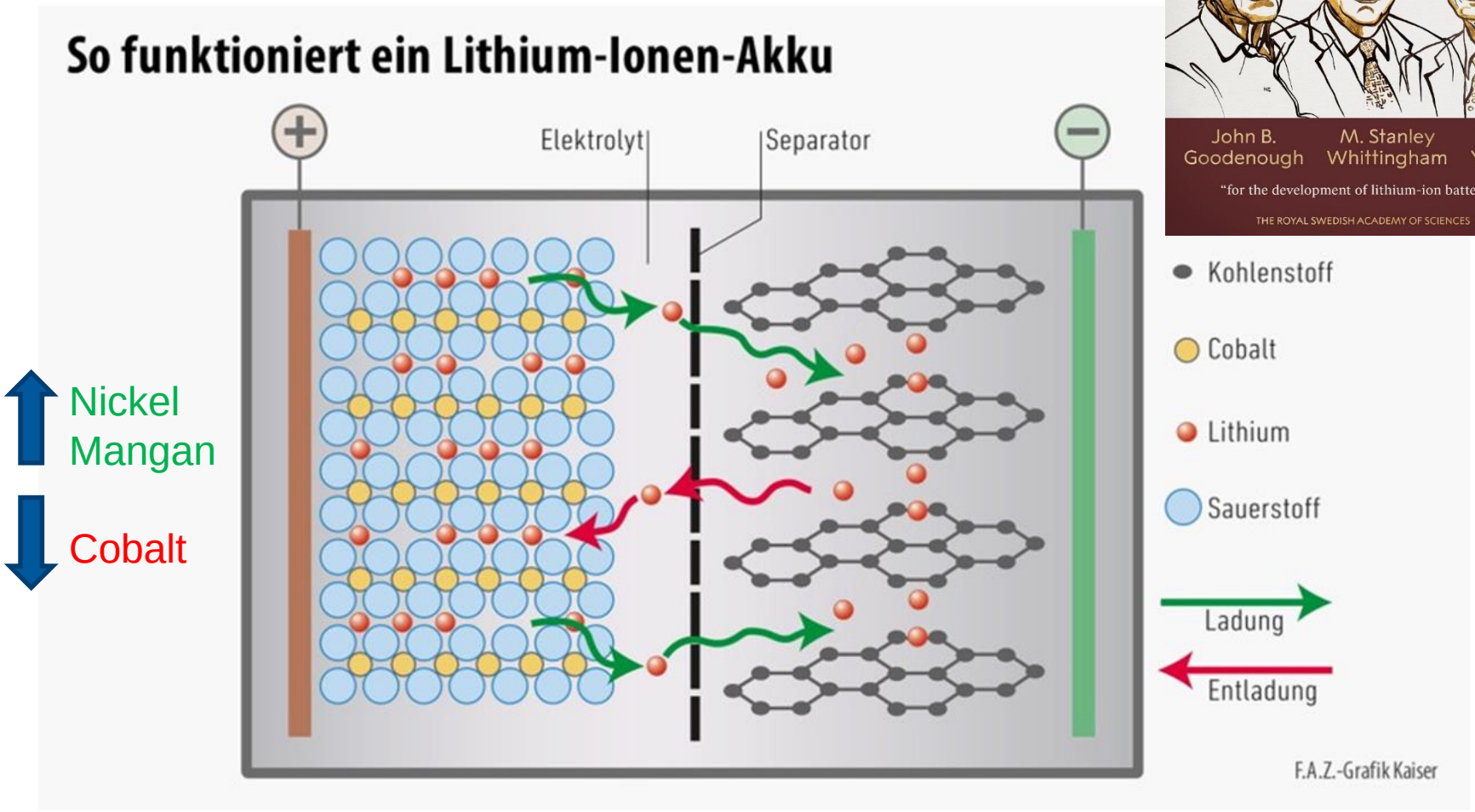
LIB

Kathodenmaterial: Lithiumkobaltoxid ($LiCoO_2$)
Anodenmaterial: Graphit
Elektrolyt: organische Flüssigkeiten



https://www.nature.com/articles/s41467-020-18736-7/figures/1



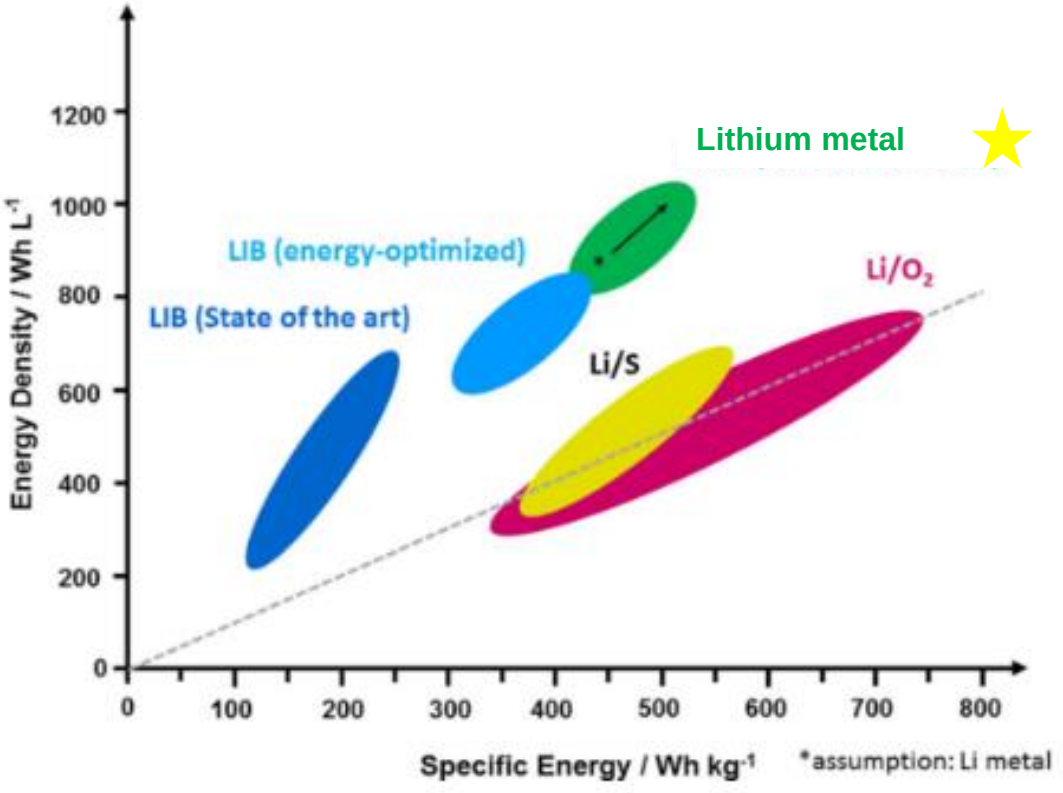


Kathode $LiCoO_2$ Graphit **Anode**

https://www.faz.net/aktuell/wissen/probleme-und-potentiale-der-lithium-ionen-technik-14030759/beim-aufladen-wandern-14039354.html

Next-Generation Batteries:

Lithium-Ionen-Batterien: erreichen bald ihr Limit
→ Kann hohen Energispeicherbedarf nicht bewältigen



Lithium-Ionen-Batterien

Lithium-Metal-Batterien
Festkörperbatterien

Lithium-Schwefel Li/S

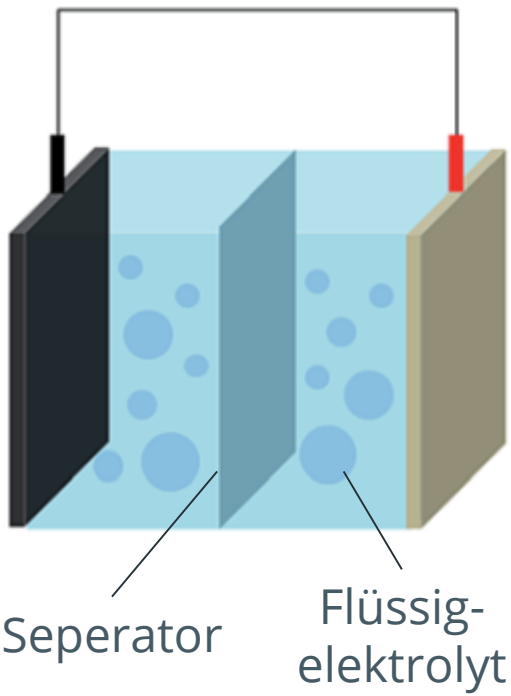
Lithium-Luft Li/O_2

Post-Lithium Batterien
- Natrium
- Magnesium

Was sind Festkörperbatterien?

- Einfach gesagt: das Flüssigelektrolyt wird durch ein Festelektrolyt ersetzt.

Lithium-Ionen-Batterie



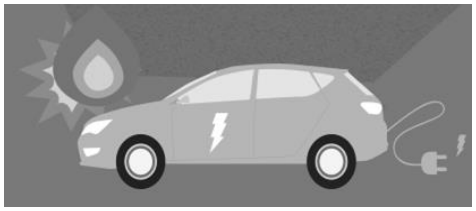
Festkörperbatterie

Lian et al., J. Mater. Chem. A, 2019, 7,20540

Wieso zur Festkörperbatterie wechseln?

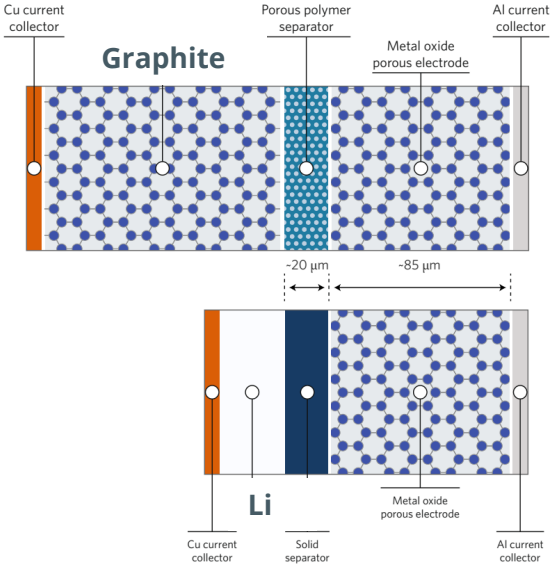
Sicherheit

- Keine leichtflüchtigen und brennbaren Flüssigkeiten
- Kein Auslaufen

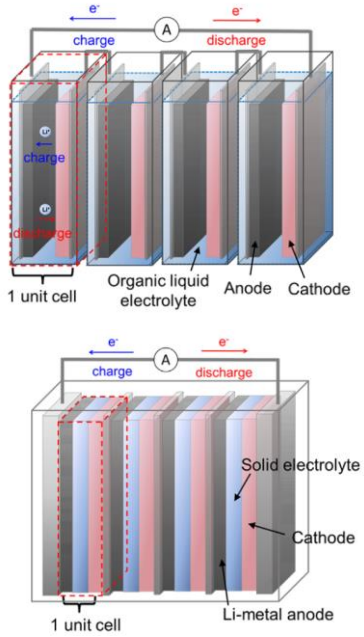


Energiedichte

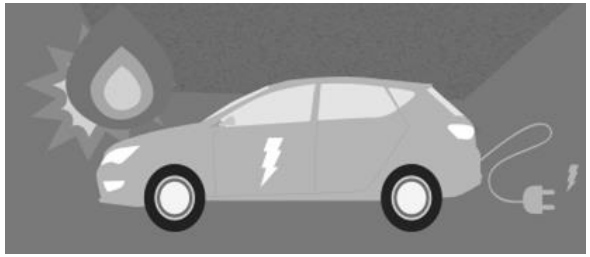
- Li Metall Anode



- Bipolare Elektroden



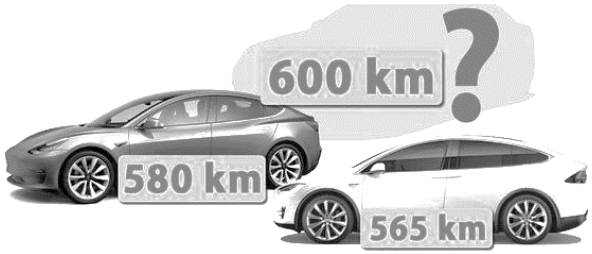
Albertus et al., Nature Energy 3 (2018) 16-21
Y. Gambe et al, Scientific Reports, 5 (2015) 8869



Festelektrolyt

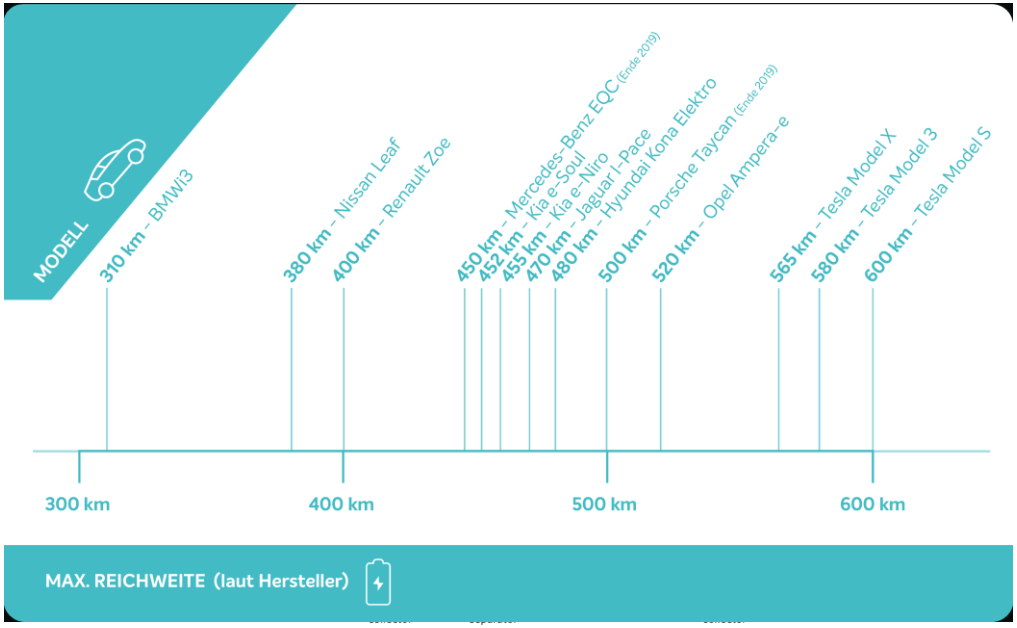
Sicherheit

- Mechanische Stabilität → Flexibler, kein Auslaufen
- Electrochemische Stabilität → höhere Spannungen
- Thermische Stabilität → höherer Temperaturbereich



Lithium Metall
increases energy density
& specific energy

Reichweite



Specific Energy[1]

100-200 Wh/kg → 400-500 Wh/kg

Energy Density

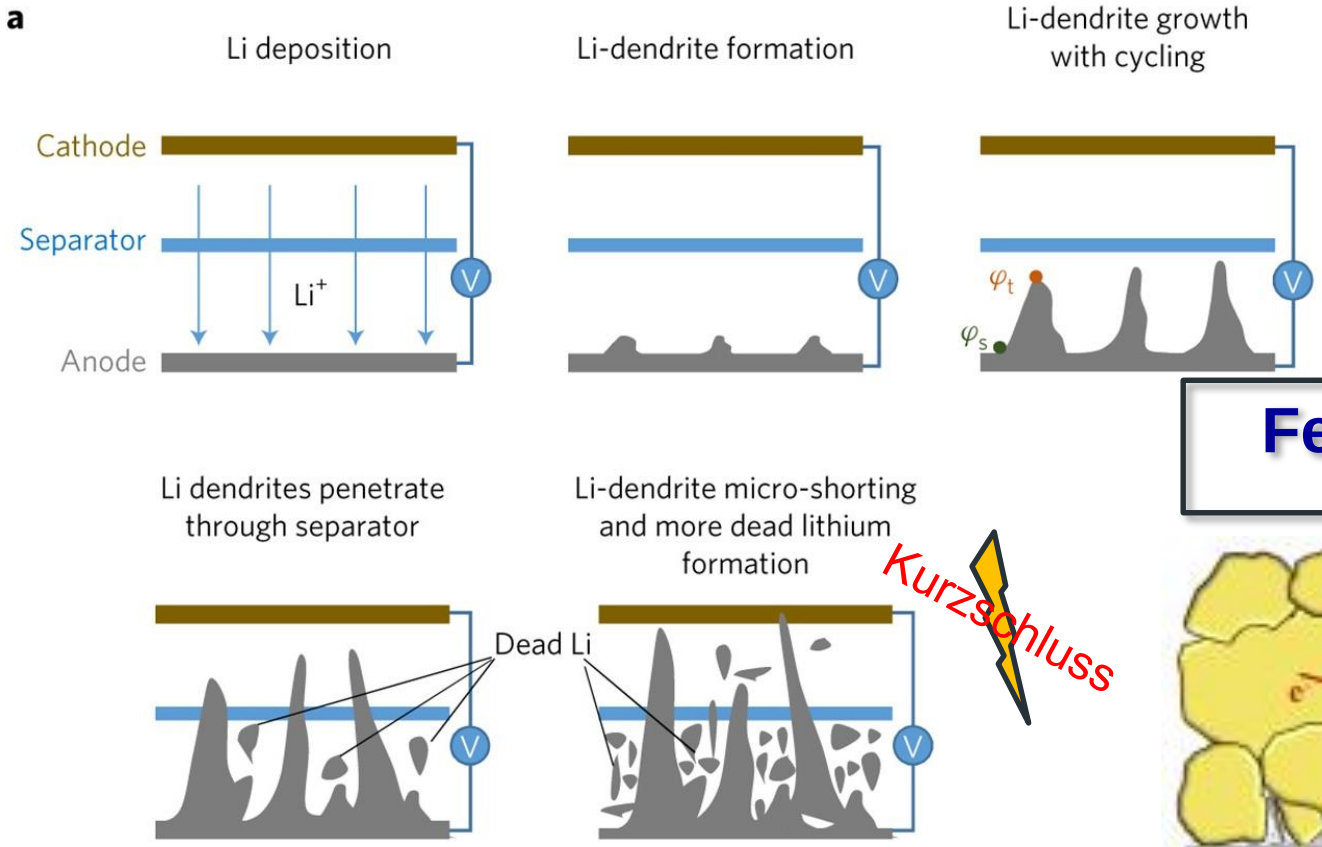
200-300 Wh/L → 1200 Wh/L

+30% mehr Reichweite

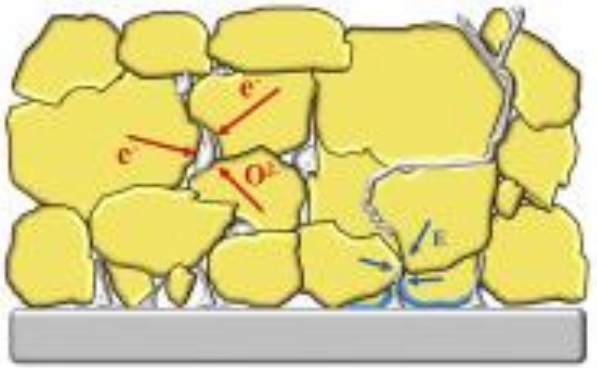
1. Hu, Q., "The renaissance of lithium metal: SolidEnergy's role in the future of lithium batteries", Sponsor Feature.
2. https://de.statista.com/

Lithium Metall in Flüssigelektrolyten
ist problematsich → Dendritenwachstum

Lithium Metall
increases energy density
& specific energy



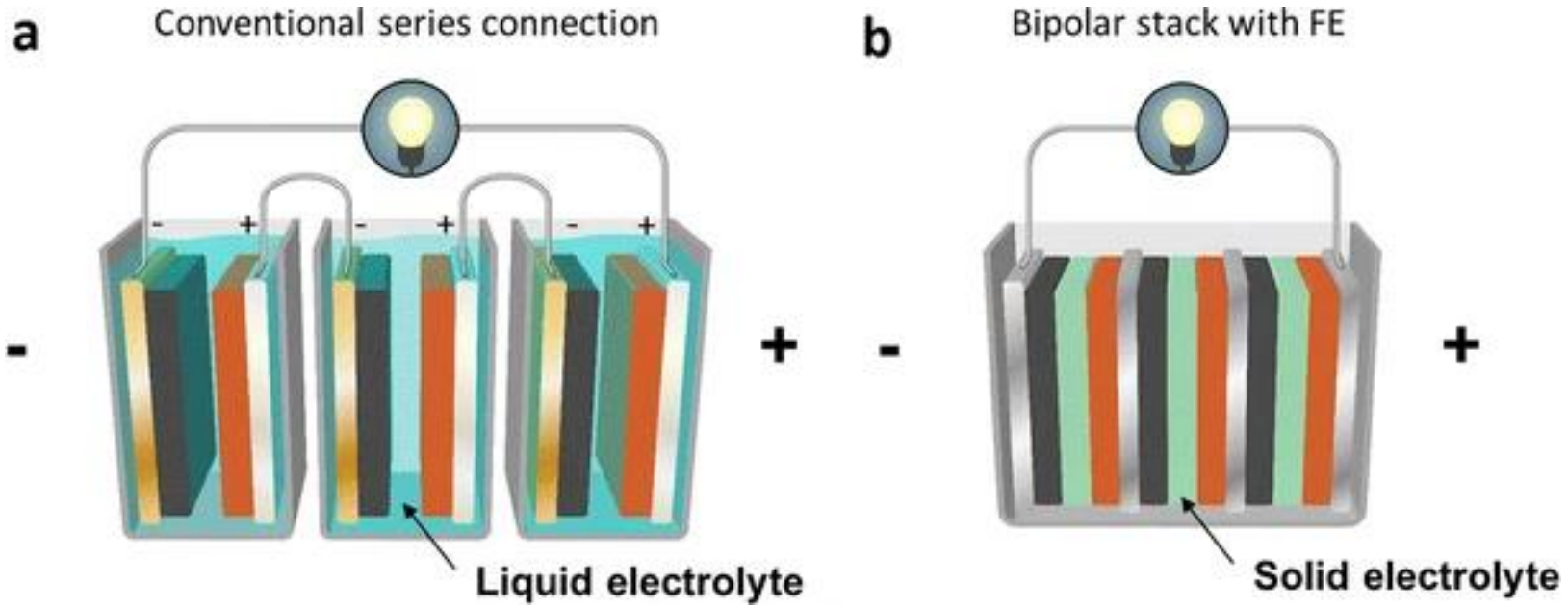
Festelektrolyt



https://www.nature.com/articles/nenergy201783?proof=t https://www.sciencedirect.com/science/article/pii/S2590238520301284

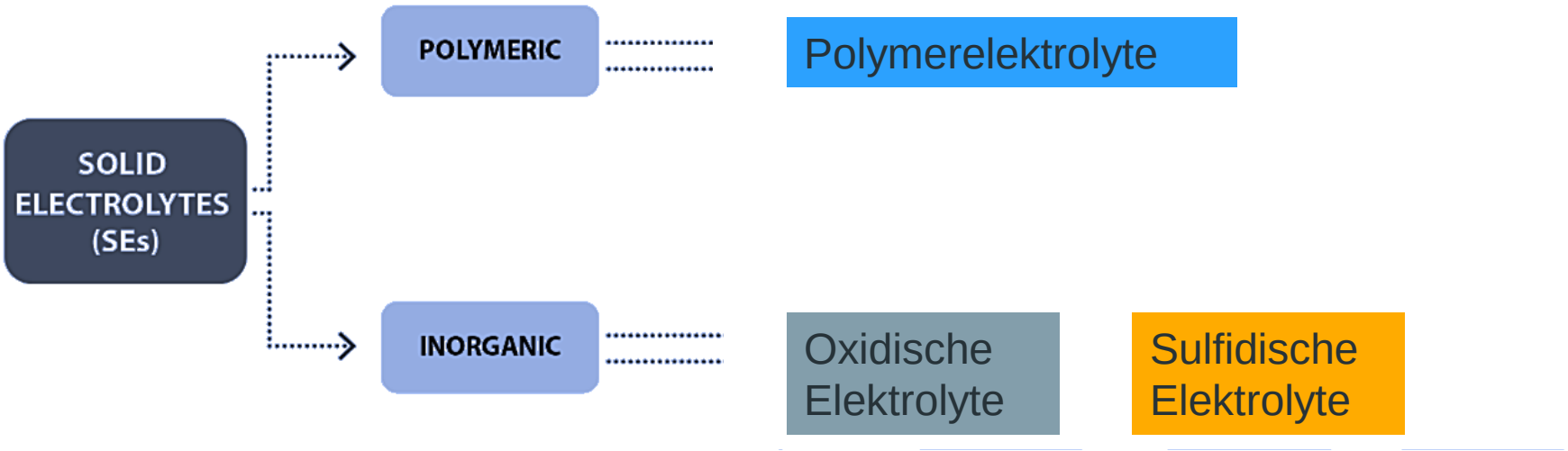
Bipolar Stack

↓ PACKAGING



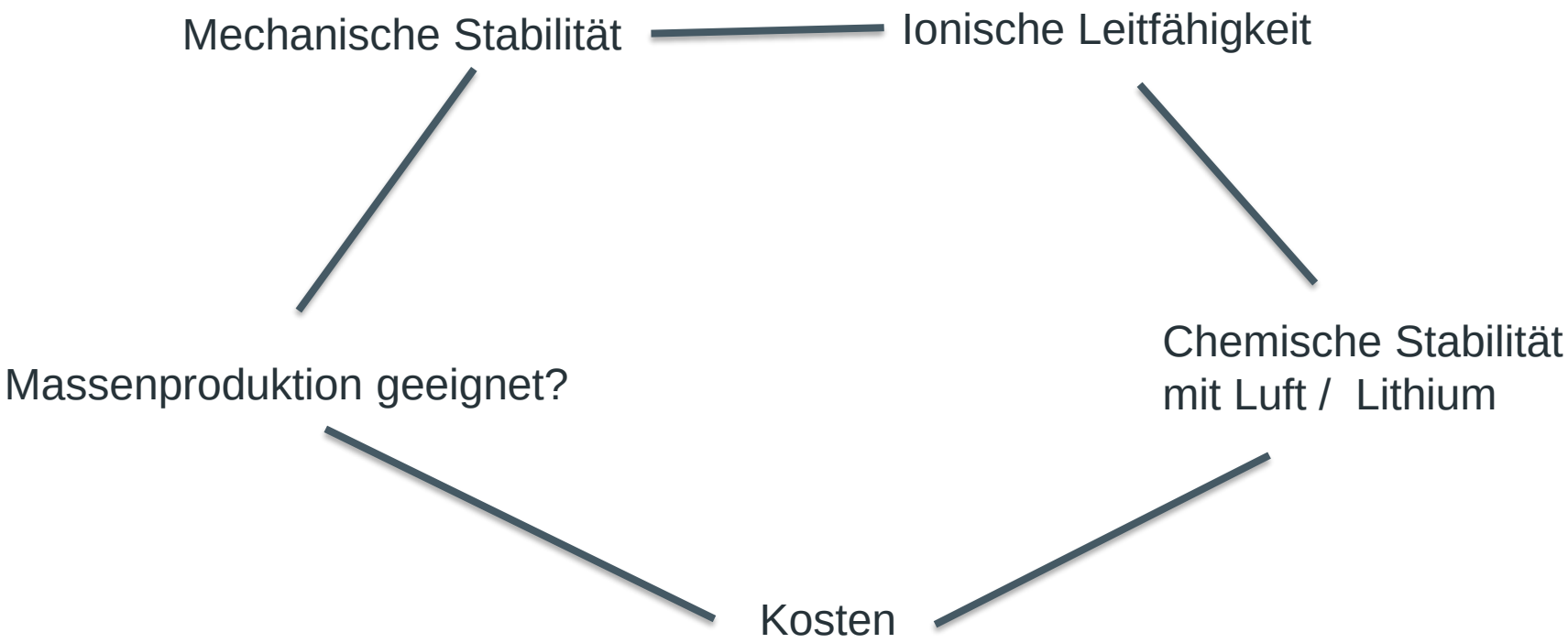
https://link.springer.com/article/10.1007/s10008-017-3610-7/figures/12

Typen von Festelektrolyten[1]



Varzi *et al.*, *J. Mater. Chem. A.*, **4**, 17251-17259 (2016).

Polymerelektrolyte | Oxidische Elektrolyte | Sulfidische Elektrolyte



https://www.frontiersin.org/files/Articles/573826/fenrg-08-00202-HTML/image_m/fenrg-08-00202-g001.jpg

Polymerelektrolyt

Bolloré bluecar

Seit 2012 Serienproduktion

Reichweite: 250 km durch eine 300 kg schwere Lithium-Metall-Polymer-Batterie

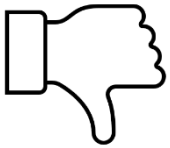
Ladezeit der Batterie: Angabe des Herstellers: 6 h

https://www.bollore.com/en/activites-et-participations-2/stockage-delectricite-et-systemes/blue-applications/

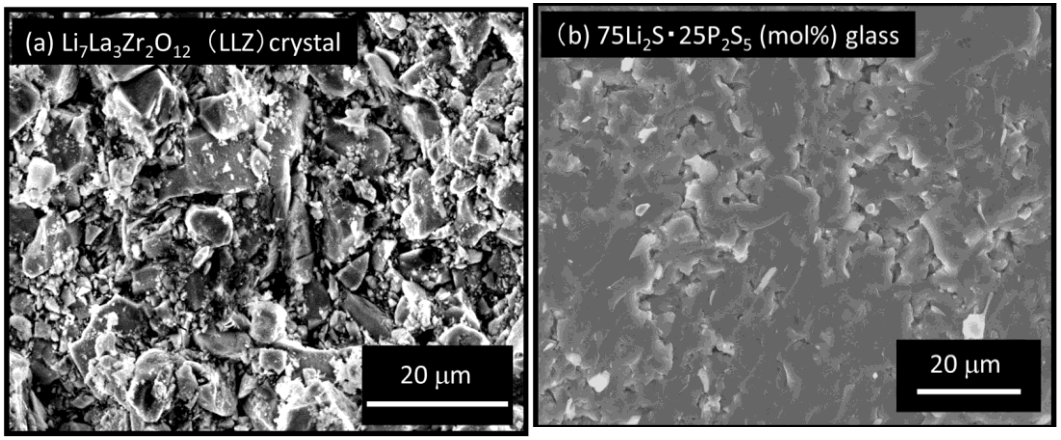
Anorganische Elektrolyte

Oxide vs Sulfide

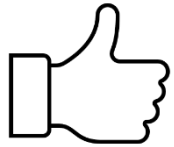
Sintervorgang notwendig



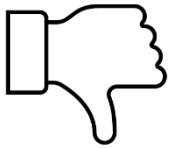
Stabil an Luft



Duktile Materialien

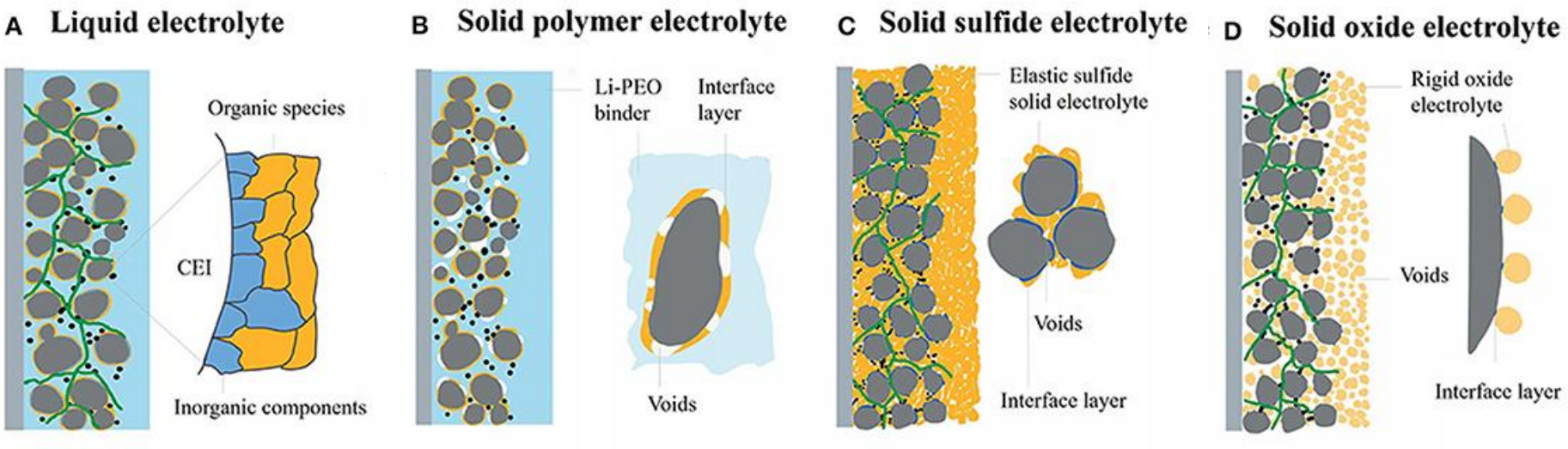


Zersetzt sich an Luft / Feuchtigkeit



https://www.sciencedirect.com/science/article/pii/S1359028613000867

Kontaktierung



Sulfide sehr viel versprechend

https://www.frontiersin.org/articles/10.3389/fchem.2018.00616/full

Toyota stellt Protoype mit Festkörperbatterie vor

https://www.youtube.com/watch?v=cfSSHYOrQNI

https://insideclimatenews.org/news/19032021/solid-state-batteries-electric-vehicles-automakers/

THANKS FOR LISTENING.