CLIMATE-FRIENDLY BATTERIES FOR TOMORROW'S MOBILITY

GSV Forum “Stromspeicher – essentiell für die Energiewende”
23rd February 2023

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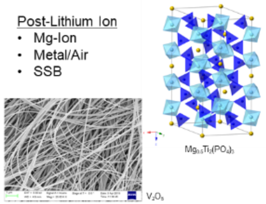
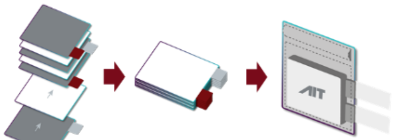
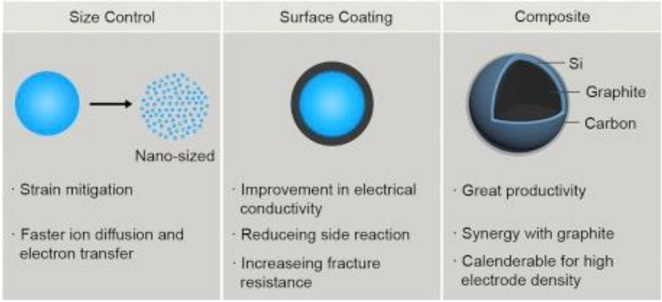
BATTERY TECHNOLOGIES (@AIT)

Materials Anodes, Cathodes	Electrode and Cell Fabrication	Performance and Safety Tests → Up to Module Level	Batterie SoX-Diagnostics Ageing-Modelling	Post-mortem Analyses
Lithium Ion • Cathodes: HE-NMC • Anodes: Sn-alloys, Si/C composites Post-Lithium Ion • Mg-Ion • Metal/Air • SSB	RPL, Dry room • Electrode to pouch Cell max. 10 Ah	Accredited tests • Electrical, environment, and safety tests	Analytical methods & real-time diagnostics • *In situ* XRD-cell • Multiplex integration in GC/MS • Vibration-based tests	Characterization • Physical, chemical and electrochemical methods • *In situ* and *operando* measurements

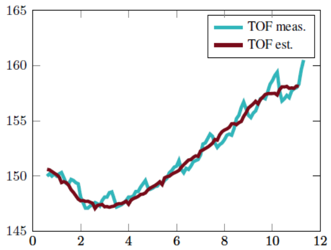


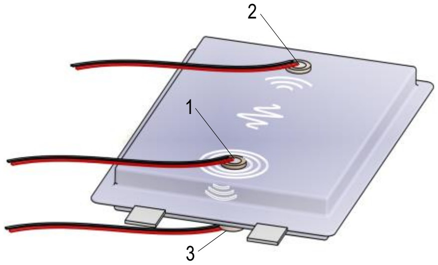


Complete research chain from materials to semi-industrial production battery cells

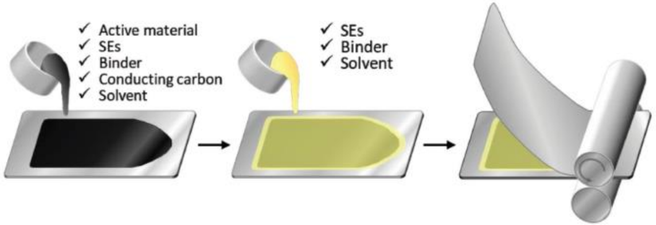


Development of LIB **material coatings** and **interface stabilization**





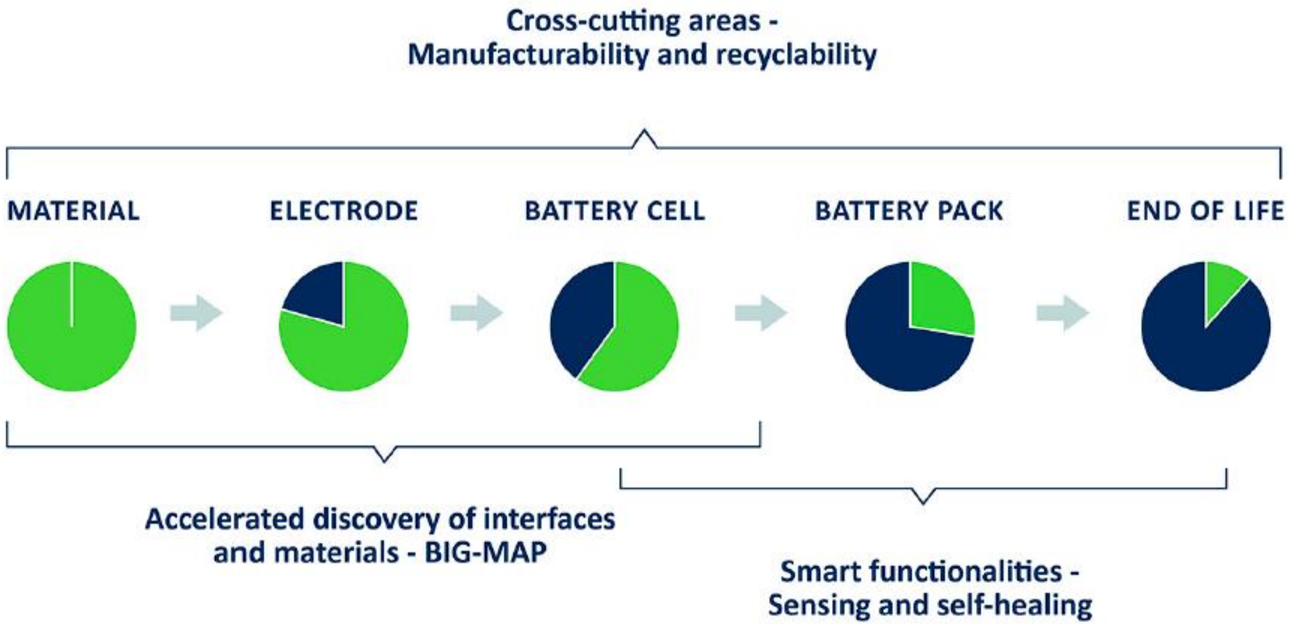
Advanced characterization tools, e.g. ultrasonic time-of-flight based state-of-charge estimator



Solid-state battery processing:

- electrolyte processing on hybrid-polymer electrolytes with ceramics
- Scaling laboratory processes towards industrially relevant cells

DECREASE IN TOTAL CAPACITY AS INACTIVE MATERIAL IS ADDED



https://battery2030.eu/digitalAssets/860/c_860904-l_1-k_roadmap-27-march.pdf

FROM CONCEPT TO CELL PRODUCTION

Schematic of the Overall Battery R&D Process from Conception to Production

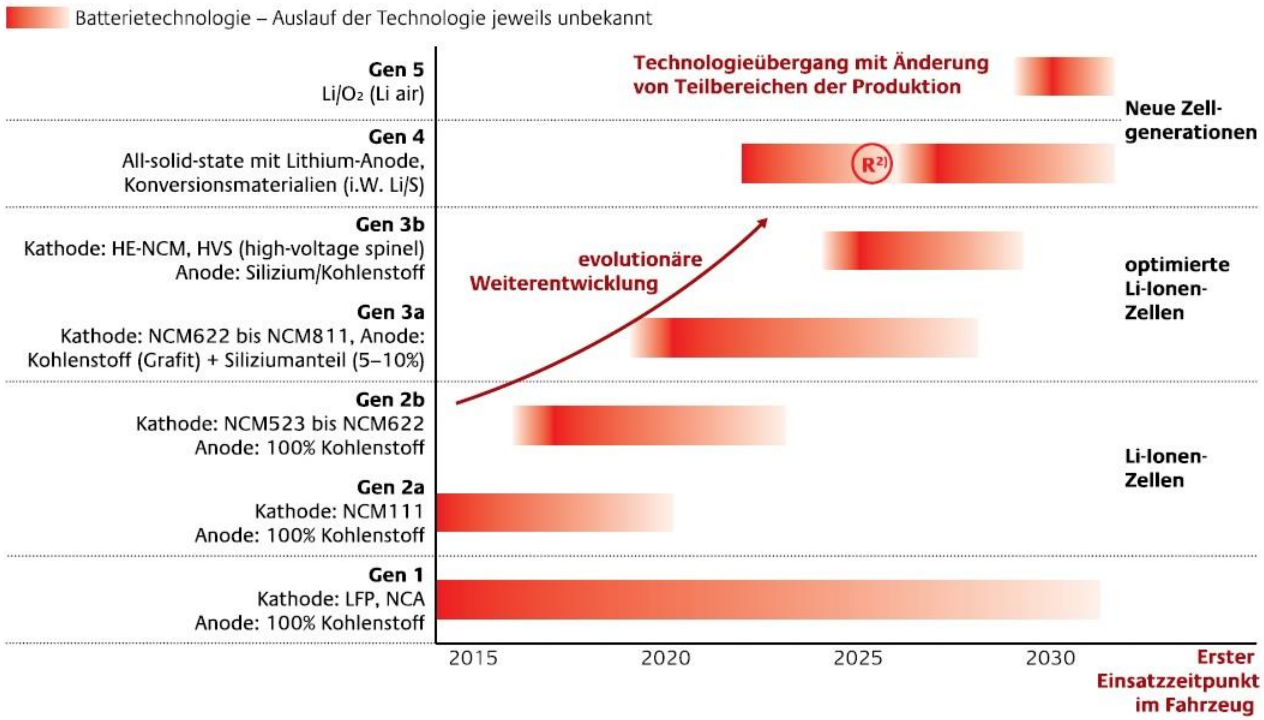
Concept Generation → **Production**

Concept Validation	Research	Applied Research	Development	Advanced Development
An idea in a creative mind Limited exploratory laboratory experiments Establish repeatability of performance Is there a market?	Scale-up experiments Characterize fundamental properties of concept, chem. composition, structure, etc. Evaluate size of commercial opportunity	Lab/prototype cells Initial map of performance, rate, cycling, temperature, etc. Scale-up of material preparation Preliminary market scope	Confirm research results Establish initial product format Develop unit assembly operations Make, test, and characterize 5 to 10 cell lots of 100 cells each Construct business plan	Design initial cell product Design and construct unit operations Scale-up prototype cell fabrication Run 3 to 5 sizable pilot line-factory trials Finalize business plan Market development

	Concept Validation	Research	Applied Research	Development	Advanced Development
Timing	One to three years	One to three years	Three to four years	Three to five years	Two to four years
Staffing	One	Two to four	Four to ten	Eight to sixteen	Twelve to thirty
Materials Batch	Grams	10 to 50 g	100 g to 1 kg	1 kg to 10 kg	10 kg to 100 kg

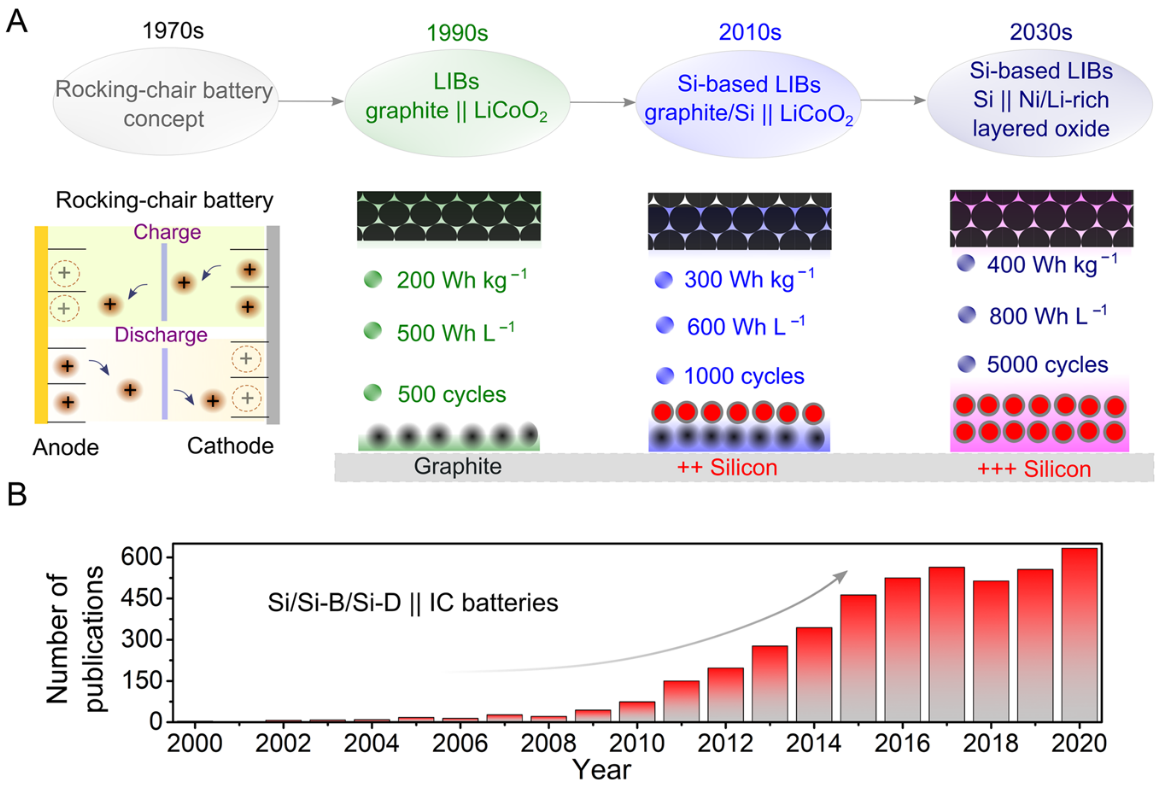
10-19!!!

OVERVIEW - ROADMAP



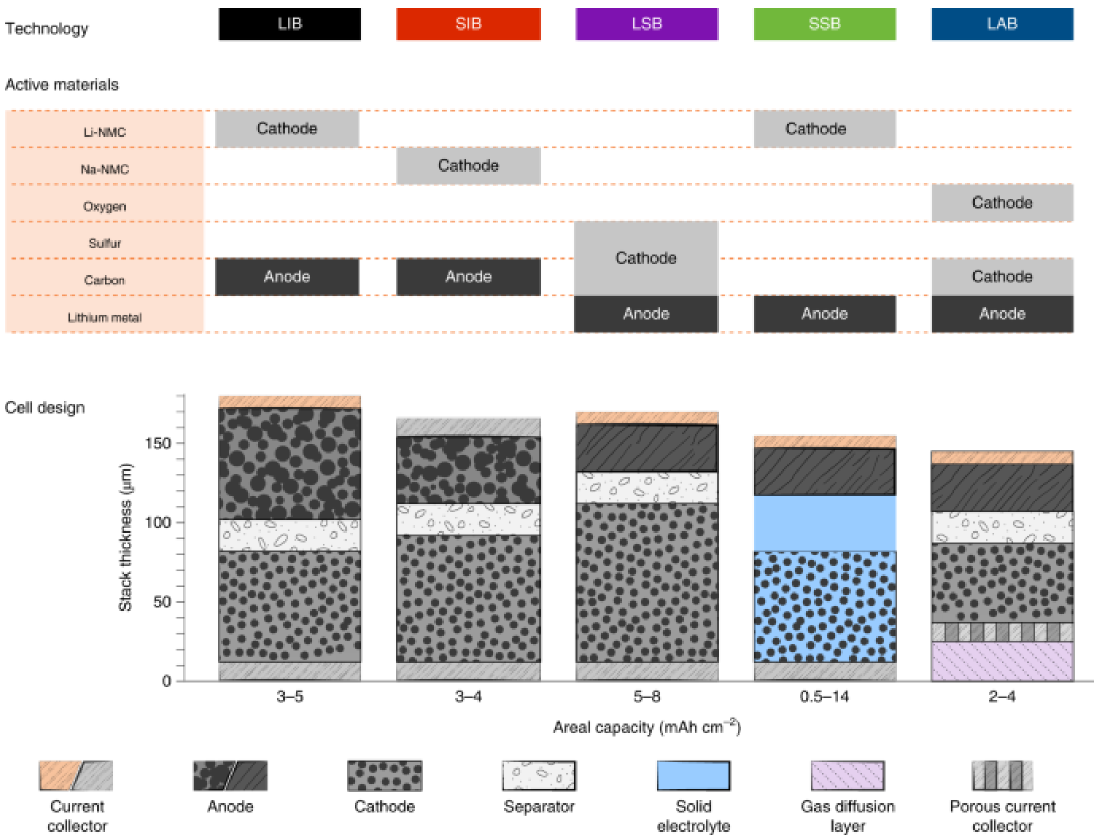
Nationale Platform Elektromobilität: Roadmap integrierte Zell- und Batterieproduktion Deutschland, Jan 2016

PERFORMANCE OF LIBS SINCE DEVELOPMENT



Nature Communications **volume 12**, Article number: 5459 (2021)

POST-LI TECHNOLOGIES & CELL DESIGN



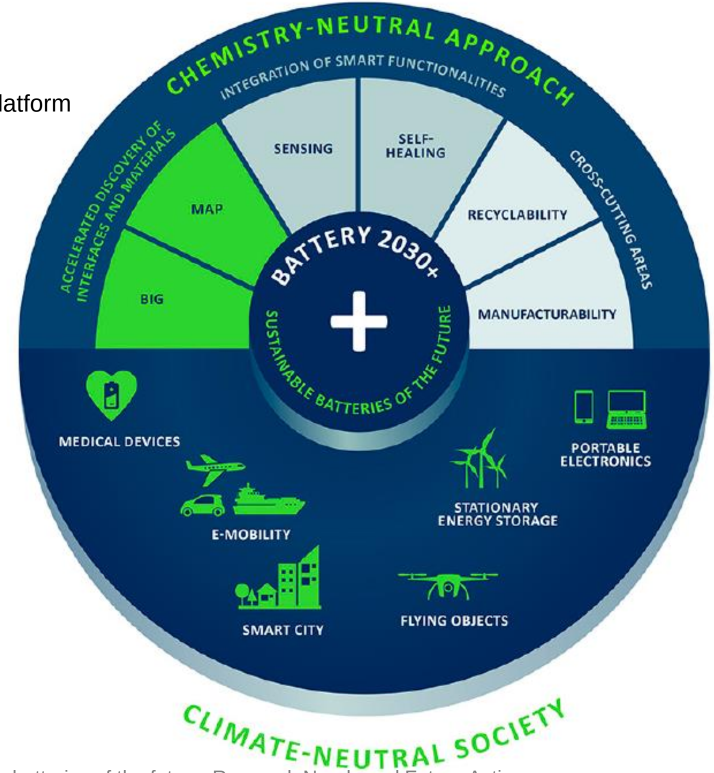
WHAT IS THE FUTURE?

To enhance the lifetime and safety of batteries

Materials **A**cceleration **P**latform

Battery **I**nterface **G**enome

Essential to secure new sustainable materials with high energy and/or power performance and that exhibit high stability towards unwanted degradation reactions. Special attention must be paid to the complex reactions taking place at the many material interfaces within batteries

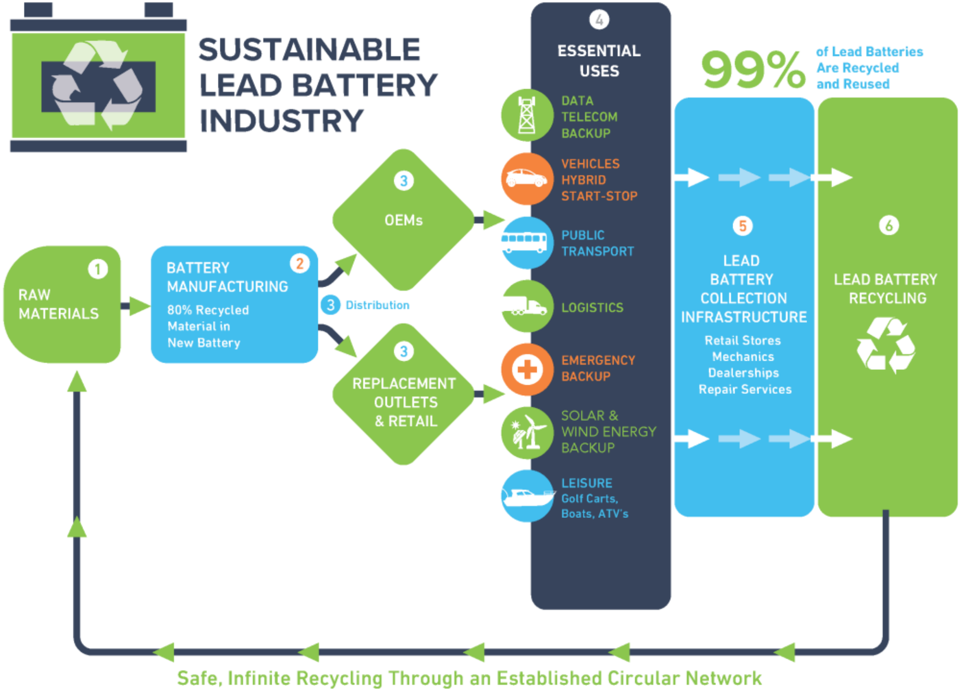


Can the new materials be upscaled in a sustainable way?
Can we recycle the new cell concepts suggested?

Battery 2030, Inventing the sustainable batteries of the future, Research Needs and Future Actions

RECYCLING AND 2ND LIFE

» *Potential circular economy model for lithium batteries.*



Essentialenergyeveryday.eu, 2019

Vpsolar.com, 2019

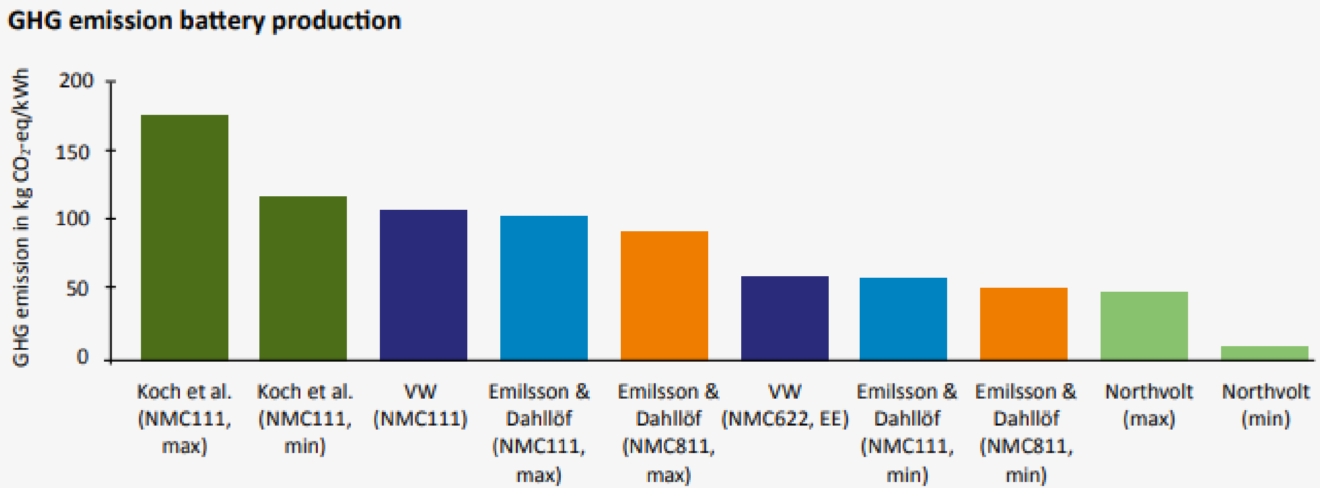
Research pilot line in a nutshell…

R&D on **energy storage** technologies:

From **cell manufacturing** and prototyping,
through **material & component screening**,
simulation to **cell testing.**

Pouch cell production facilities for
small series up to **10 Ah/cell**
in Austria‘s only dry room

ENERGY CONSUMPTION OF CELL PRODUCTION



Energy consumption of cell production based on NMC cathode materials

Source: VDI/VDE, study 2021

Depends on many factors

- Factory scale
- Region and climate
- Cell size and format

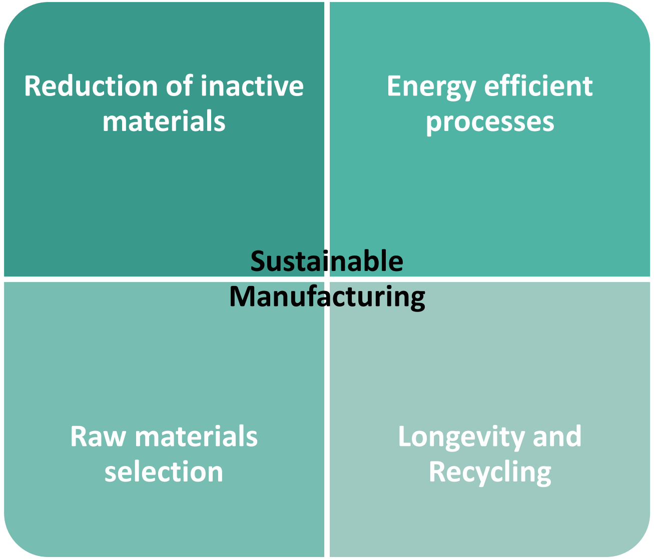
HOW TO ACHIEVE GREEN CELL PRODUCTION?

Reduction of **inactive materials**
- Increased energy density

Energy efficient processes
- Solvent free or reduced processing
- Dry room environment reduction

Raw materials
- CRM-free cell chemistries

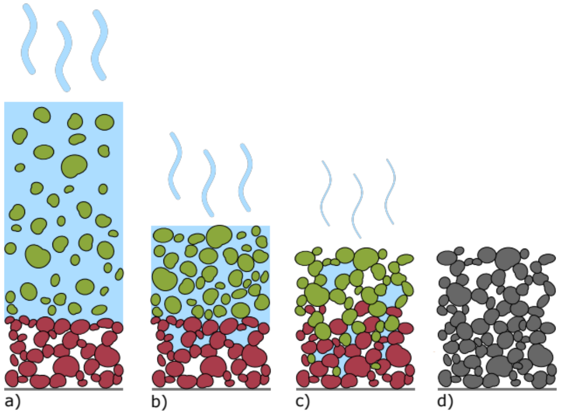
Longevity and Recycling
- Smart Cells and Cell Design



REDUCTION OF INACTIVE MATERIALS

Challenges of **thick electrodes**

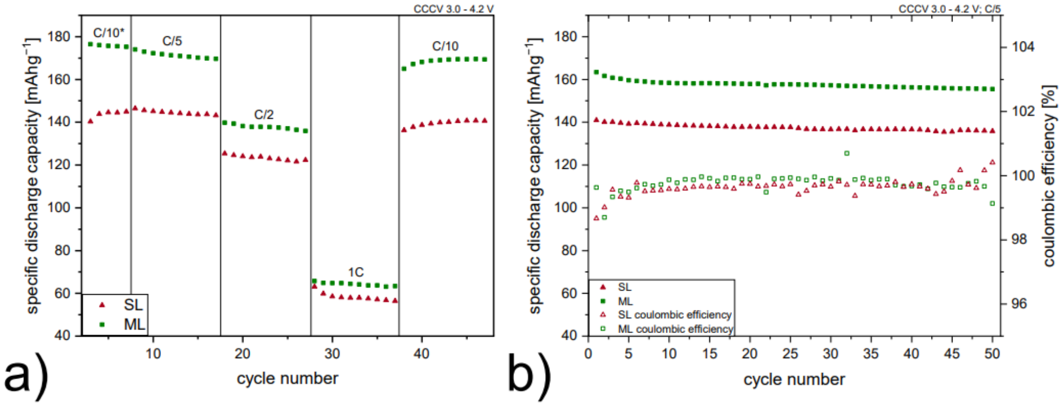
- Delamination
- Binder migration
- Residual solvents
- High resistance
- Poor electrochemical performance



Multilayer approach

Variation of:

Active materials
Porosities
Binder content
etc. …

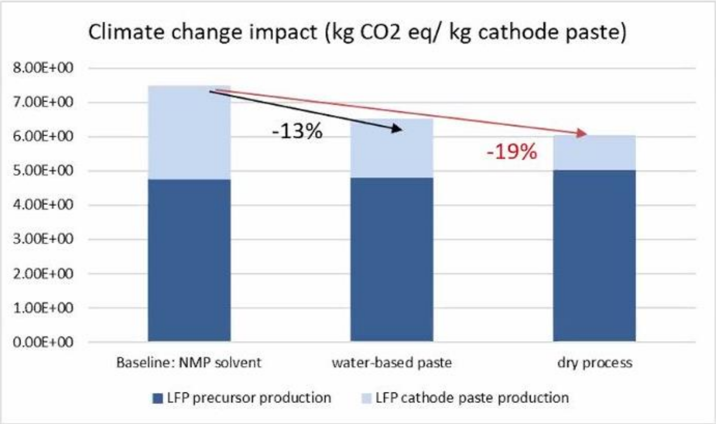


Neidhart et al., Nanomaterials 2022, 12/3, 317.

IMPACT OF ENERGY OPTIMISED PROCESSES

Potential energy and cost reduction from sustainable Li-ion cell production.

Conventional production process	Proposed new process/concept	Potential energy reduction	Potential cost reduction
NMP-based slurry preparation	Solvent-reduced H_2O based slurries	0.4%	4-6%
Conventional electrode thicknesses	Thick electrodes with high areal capacity > 4 $mAhcm^{-2}$	25-30%	20-25%
Electrode coating with following drying unit and compacting	Single-unit approach of drying and compacting electrodes	2%	4%
Mechanical electrode cutting	Laser-cutting of electrodes	3-4%	2-3%
Dry room for slitting, stacking, electrolyte filling production steps	Energy-efficient drying unit and direct transfer to electrolyte filler	15-20%	10-12%
Electrolyte filling in several steps and under vacuum	One-step filling with less electrolyte amount	0.2%	5-10%
Conventional formation and ageing	Improved energy and time efficient formation and ageing procedures	1-2%	8-10%
Conventional scrap rate of 5%	Reduced scrap rates of maximum 1%	n.a.	1-3%



Source: EMPA, Green Batteries Conference 2021.

INNOVATION NEEDS

- Green manufacturing
- Advanced equipment
- Increasing yield
- Implementation of generation 4 into production
- New processes for cell production
- New alternative materials for CRM replacement

LET Employees

AUSTRIAN INSTITUTE OF TECHNOLOGY
TOMORROW TODAY

THANK YOU!

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