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Smart Diaspora 2023

10 - 13 Aprilie 2023, Timișoara

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2023

Next Generation Sustainable Battery Technologies for Smart Mobility and Stationary Applications

Dr. Corina Täubert
Schunk Carbon Technology GmbH
Austria

Agenda

- A Short Presentation: Schunk Carbon Technology GmbH
- The Energy Dilemma
- Battery Technologies: State-of-the-Art Lithium-Ion Batteries
- Environmental Impact of LIBs and the Sustainability Issue
- Sustainable Alternatives to LIBs for the Energy Storage
- Our Solution for a Sustainable Battery Material Supply Made in Europe

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Schunk Carbon Technology GmbH

Austria, Bad Goisern am Hallstättersee

Innovative carbon products for the automotive industry

Application examples

Thermal Management

Thermal management with aluminium graphite components for power electronics and semiconductor backend processing

Charging Infrastructure

Buffering of temperature peaks in Li ion batteries and charging infrastructure with Latent Heat Carbon

Grounding Systems

Contact systems for shaft grounding and for the e drive

Electric Motors

Carbon brushes for various drive motors in the motor vehicle

We are on site for our customers worldwide

Schunk worldwide

29 COUNTRIES **64** LOCATIONS **9.000** EMPLOYEES

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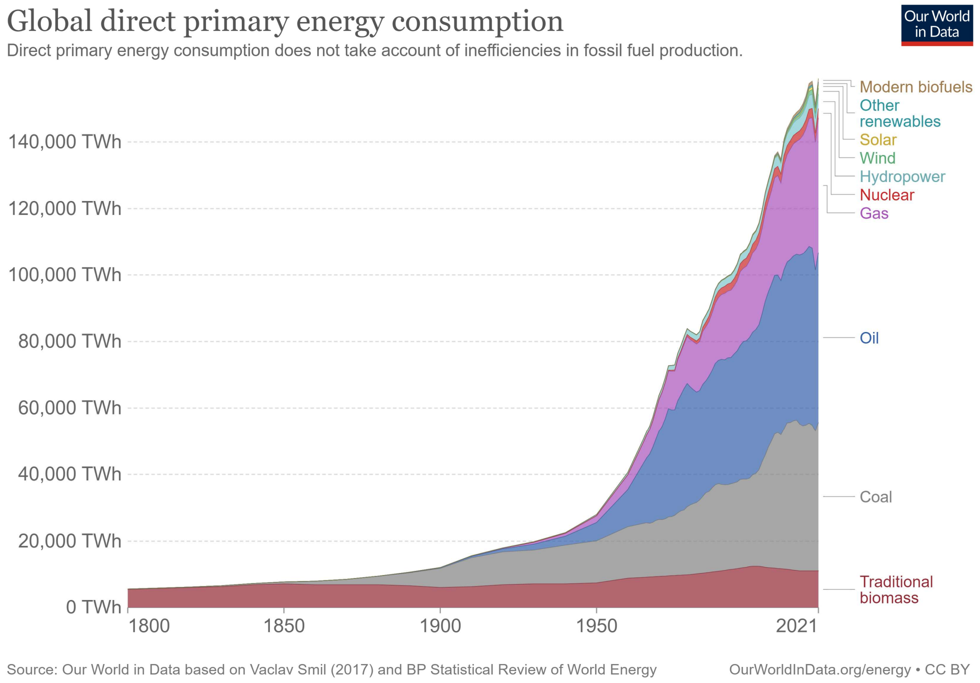
The Energy Dilemma
Human Progress vs. Ecological Disaster

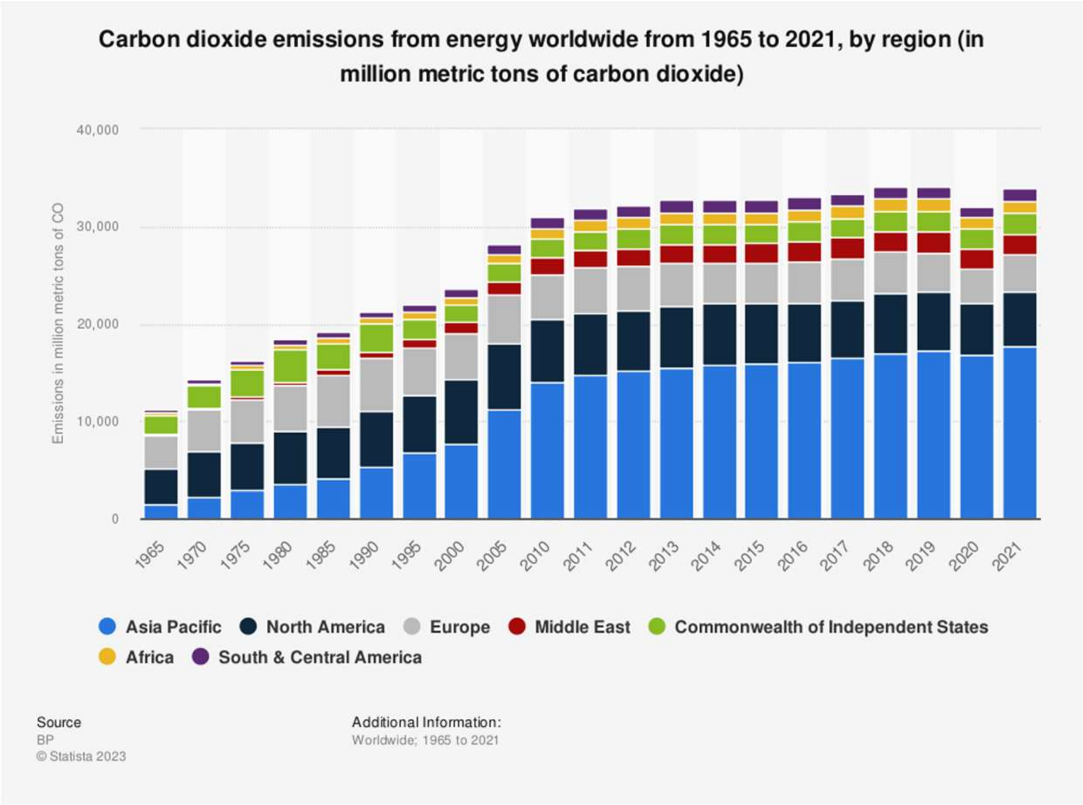
- Energy industry has a significant contribution to the economic growth and development
- Energy and economic development lead to a strong increase in the demand and burning of fossil fuels
- Consequence: release of a massive amount of greenhouse gases (GHG) resulting in global warming
- Strong need for replacing fossil-based with renewables in the global energy systems, and for increasing energy efficiency

https://www.sciencealert.com

https://energycapitalpower.com

Global Energy Consumption and CO_2 Emissions





Smart Cities need sustainable & efficient energy systems and e-mobility!

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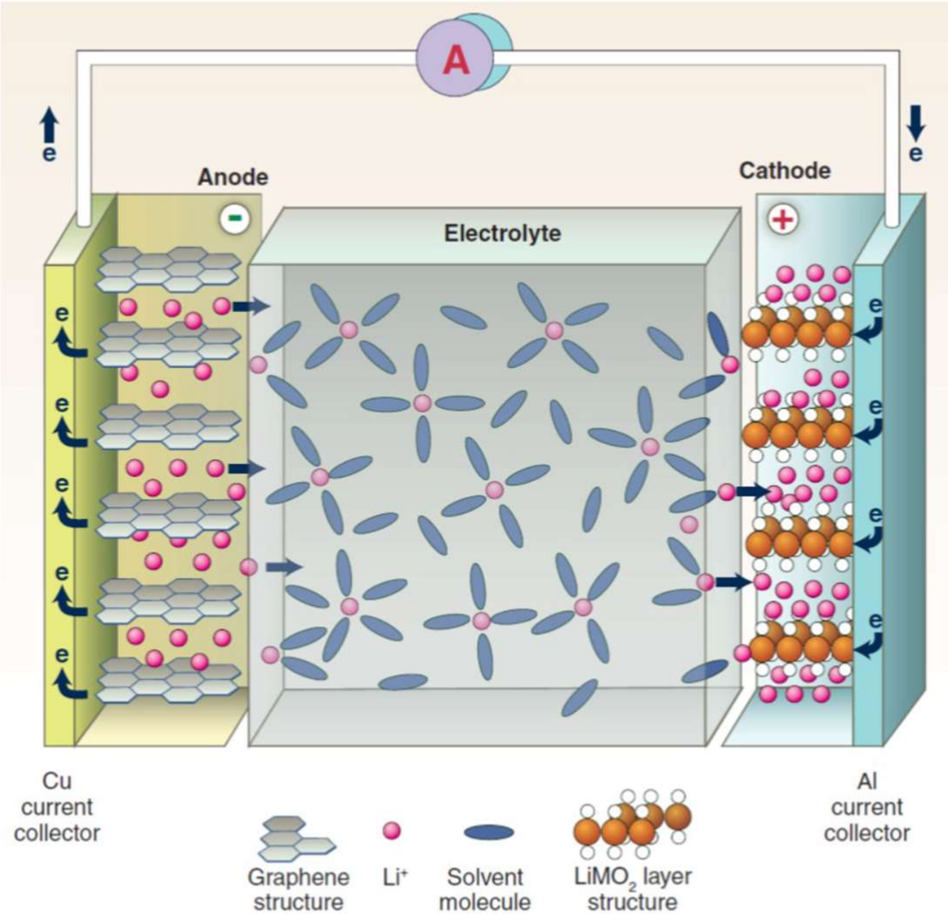
Efficient Storage Systems for a Decarbonised Energy System

https://knowhow.distrelec.com/de/

- Both **renewable energy** and **e-mobility** rely strongly on **efficient energy storage** devices
- **Batteries** are the **key enabling energy storage devices** for the transition to a sustainable decarbonised energy system

- **Lithium Ion Batteries (LIBs)** are considered the **most promising** and relevant technologies, due to their **high energy density** and cycling stability, as well as **design flexibility**
- LIBs already dominate the markets for portable devices, and became the technology of choice for almost all xEV
- The **global market** for **LIBs** in xEV and stationary applications is considered to be **huge**

Lithium-Ion Working Principle



J. Wandt, PhD Thesis TU München, 2017

- **Anode**: mostly **graphite**; $Li_4Ti_5O_{12}$ (LTO)
- **Cathode**: **vast material variety**; $LiMO_2$ or $LiMPO_4$ (M = **Co**, Ni, Mn, Fe, Al, etc.), $LiMn_2O_4$ spinel
- **Electrolyte**: $LiPF_6$ in organic carbonates as solvents (e.g., EC, DMC, EMC)
- **Separator**: microporous polymer membrane, ceramic composite membrane
- **Flexibility of cell designs** – pouch, prismatic and cylindrical (different sizes)

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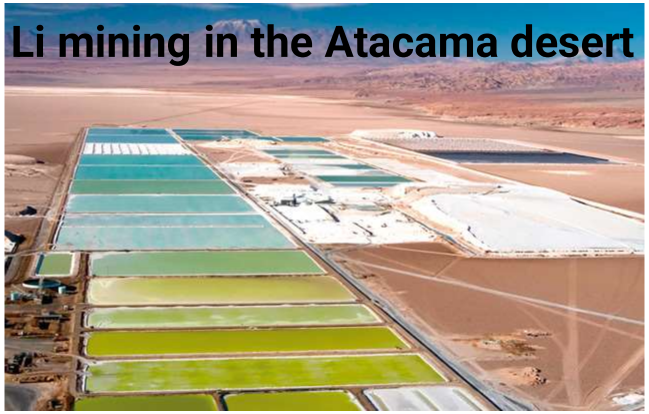
Lithium-Ion Disadvantages, Environmental Impact and Sustainability Issues



https://www.france24.com

https://www.wired.com

- The use of expensive and critical raw materials: Li, graphite, Co, Ni → high supply risk and costs
- Li extraction process consumes vast amounts of water → significant impact on other activities
- > 70 % of the world's Co is produced in the Democratic Republic of Congo (DRC)
- Use of graphite – critical raw material, energy-intensive process (synthetic graphite)
- Safety issues – liquid electrolyte, low stability at high temperatures

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Next Generation Battery Technologies
Trends: Higher Energy, Lower Costs & Sustainability

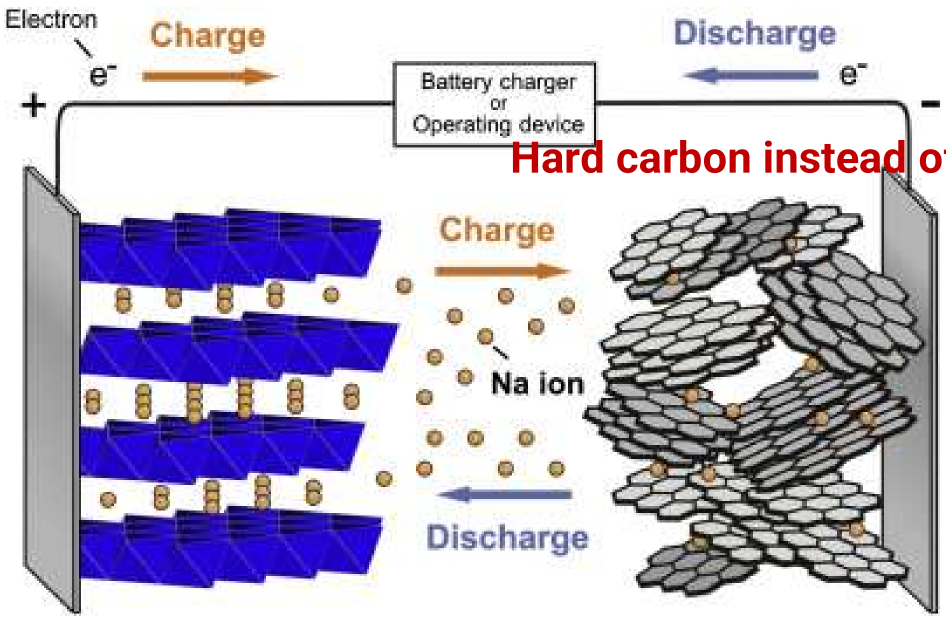
Advanced LIBs

- Less Co, graphite: Ni-rich cathode materials (NCM811), Si-based anodes; high voltage cathode materials
- Structured electrodes, optimized cell components (electrolytes, current collectors)
- Environmentally friendly processes for materials synthesis, electrode and cell manufacturing

Post LIBs

- **Sodium-Ion:** highest technological maturity level of all post LIBs; Na ions instead of Li
- **All-Solid-State Batteries:** increased safety – solid instead of liquid electrolyte; less mature, issues with large-scale production
- **Li-Sulphur:** low cost, abundant materials, high gravimetric but low volumetric energy density; low cycling stability, capacity fading

Sodium Ion Batteries as a Sustainable Drop-In Technology



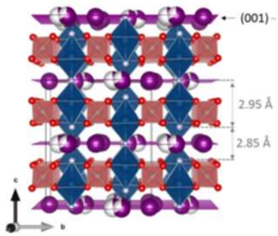
Hard carbon instead of graphite

A. Kanwade et al., RSC Adv., 2022, 12, 23284

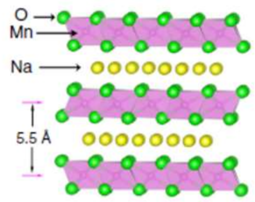
Al instead of Cu current collector

Co- and Ni-free cathode materials

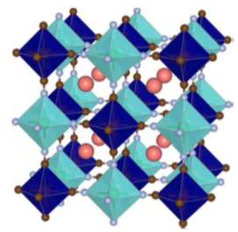
- **Similarities to LIBs:** working principle, material types
- **Abundant and cheap materials:** Na, Fe, Mn, Al, hard carbons instead of critical raw materials (Li, Co, graphite)
- **Drop-In technology:** manufacturing is compatible with LIBs production equipment & processes; gigafactories are fully adaptable to SIBs production



NVPF



$NaMO_2$



PBA

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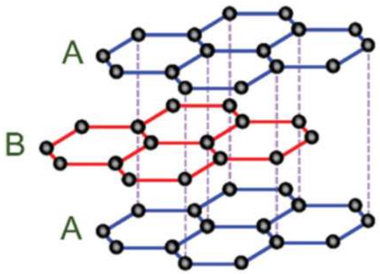
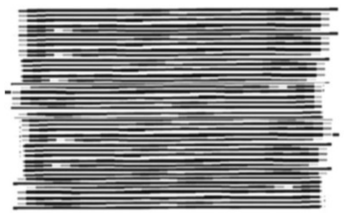
Sustainable Hard Carbons as Anode Materials for SIBs

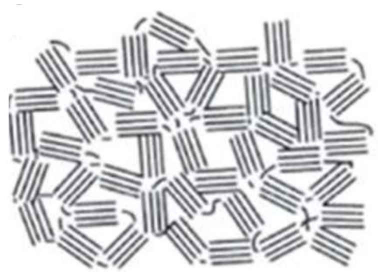
- Non-graphitizable hard carbons are the most promising anode materials for SIBs
- Main trend: hard carbons made of bio-based, sustainable precursors, e.g., coconut shells, wood, sugars, cellulose, lignin, chitosan, banana/pomelo/apple peels, rice husks, corn cob, argan/peanut shells
- Synthesis at T < 1600 °C → significant energy savings in the manufacturing processes; graphite needs 3000 °C!



Graphite unit cell

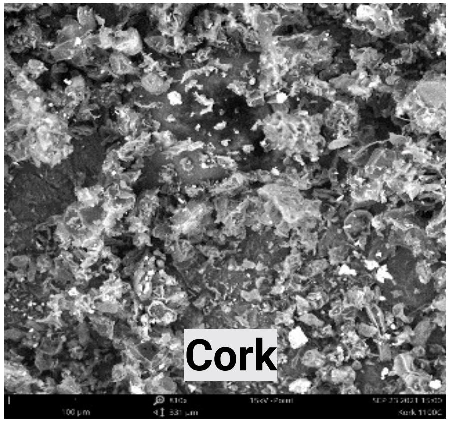

Graphite

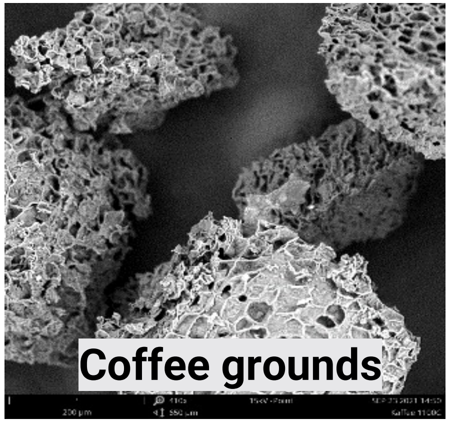

Graphitisable Soft Carbon

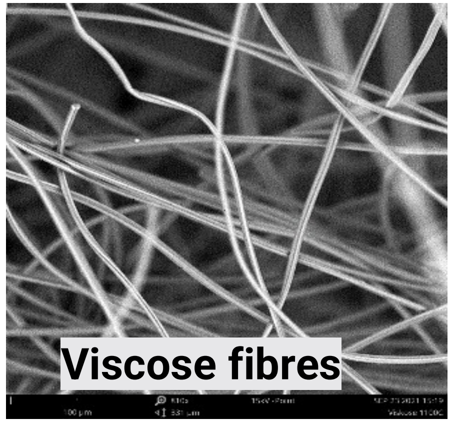

Non-graphitisable Hard Carbon

Bio-Based Precursors for Hard Carbons

- **Advantages bio- and biowaste-precursors:** cheaper, more abundant and environmentally benign
- **Disadvantages:** uneven distribution around the world, seasonal variation, inorganic impurities, low carbon yield
- **Screening of several promising bio-based precursors:** cellulose, viscose fibres, cork, coffee grounds, lignin – within the framework of a **R&D project in Austria; criteria:** availability, low costs, high carbon content, less impurities







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Key Take-Aways

- Batteries are the key enabling energy storage devices for a decarbonised energy system
- LIBs are currently the most relevant battery technologies
- Among all post LIBs, SIBs have a great potential to improve the overall sustainability
- Hard carbons made of bio-based precursors are crucial for a sustainable battery material production
- Materials and batteries made in Europe will significantly contribute to the development of a whole battery value chain in Europe

And the Future Belongs to SIBs ☺: First Small City EVs Equipped with SIBs

Sehol **E10X**, JAC Motors

https://news.italy24.press/business/429660.html

25 kWh battery pack (HiNa Battery, China), 252 km range (NEDC cycle)

EV3, Jiangling Motor Electric Vehicle (JMEV)

https://cnevpost.com/2022/12/22/farasis-energy-sodium-ion-battery-ev-model-available-2023/

Mulțumesc și drum bun în era orașelor inteligente!