Storage: the state of the technology

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Acknowledgements

Ångström Advanced Battery Centre
Over the last century electricity has developed from being a scientific curiosity to one of the major energy carriers in our society. Why?
Electrical storage

- Metal-Air Batteries
- Flow Batteries (ZnBr, VRB, P)
- NaS Battery
- Lead-Acid Batteries
- Ni-Cd
- Other Adv. Batteries
- High Energy Super Capacitors
- Long Duration Fly Wheels

- Hydro and pumped hydro

- High Power Fly Wheels
- High Power Supercaps

- Rotating storage

- Energy Management
- Bridging Power
- Power Quality & UPS

- Discharge Time at Rated Power
- Hours
- Minutes
- Seconds

- 1kW, 10kW, 100kW, 1MW, 10MW, 100MW, 1GW

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Power and Energy

Specific Energy [Wh/kg]
Specific Power [W/kg]

Capacitors
Electrochemical Capacitors
Batteries
Fuel Cells

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The Coming Energy Market
Where are the batteries today – after two centuries?

Alessandro Volta, 1799
(Cu/Zn)

1839 Fuel cell
1859 Pb-acid
1899 Ni-Cd (Swedish)
1973 Li-metal
1975 Ni-MH
1979 Li-polymer (Armand)

1990: Li-ion (Sony)
Different types of storage

Energy density
Safety
Life time, Cost
Power efficiency

Safety
Power/Energy density
Life time, Cost

Life time, Cost
Up scalability
Power/Energy density
Safety
The lithium-ion battery in portable electronics
Vehicles
Energy Diversification for future automobiles

Primary Energy

- Crude Oil
- NG
- Coal
- Bio
- Hydro
- Nuclear
- Solar / Wind
- Tide / Geo thermal

Liquid Fuel

Gas Fuel

Hydrogen

Hydrogen

Electricity

Plug-in HVs

From Toyota

ICE Vehicle

ICEHV

FC-HV

EV

From Toyota

The Coming Energy Market
The electrical vehicle

National goals…

• Germany 1.000.000 EVs 2020
• USA 1.000.000 EVs 2015
• France 2.000.000 EVs 2020
• Denmark 600.000 EVs 2025

Will this happen?
The EV battery

- Energy content: 30kWh
- Weight: 200 kg
- Cathode material: 70 kg
- Anode material: 35 kg

One EV battery corresponds to 10 000 mobile phone batteries!
Challenges for the future EV battery market

• Safety
• Cost
• Environmental impact
• Availability of raw materials
• Transport of new batteries
Cathode materials for Li-ion batteries

Cathode active materials for Li-ion & Pol batteries, in Tons, 2000-2010

World wide battery market

The grid
The Grid

Energy production = Energy consumption
Renewable energy sources

How to increase the utilisation of the renewable energy sources?
New battery concepts
Nano silicon

Si based Li-ion batteries soon on the market

Staggering capacity gains

1200 mAh/g
LiFeSO$_4$F

Synthesis

Electrochemistry
- charge/discharge

Electrolyte
- ion transfer

Structural changes
- diffraction

Surface chemistry
- x-rays

Cathode material: LiFeSO$_4$F
Minimising carbon dioxide footprint

Ceramic process → Solvothermal process → Hydrothermal process → Ionothermal process → Bio-mineralization process

Lower temperatures → Economy of atoms

Bulk → Nano

700°C Solid state reaction → 120°C Solution reactions → 180°C → 200°C → 60°C


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The Coming Energy Market
The Lithium-air battery
A new generation of “green” Li-ion batteries

Dilithium dirhodizonate

Chemical/thermal Recycling of used batteries

Users

Packaging and shipping

Fabrication

Elaboration of the electrochemically active materials via “Green Chemistry”

Li-ion batteries the next 20 to 30 years

- Energy density: 250 Wh/kg, 800 Wh/l
- "Greener" technology
- Future energy density targets
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Micro batteries

Same foot-print area (base):

2D – thin film
Short Li transport path
↑ high rate capability (power)

2D – thick film
Large amount of active material
high capacity (energy density)
Why moving from 2D to 3D battery design?

Same foot-print area (base):

3D – thin film

Short Li transport path AND Large amount of active material

→ No need to compromise between energy density and power density

E. Perre PhD. Thesis 2010 with joint degree from Université Paul Sabatier and Uppsala University
3D-microbatteries
Current collector of copper

Current collector of copper deposited with Sb
Thank You!