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BASE
Batteries Sweden

Vad händer på svensk (och internationell) batterifront?

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Ångström Advanced Battery Centre
Uppsala Universitet

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ÅABC - who are we?

Ångström Advanced Battery Centre @ Uppsala University

Ca. 90-100 people

3 Professors (Edström, Brandell, Berg) – in core group
6 Assoc. Prof.
1 Assist. Prof.
12 Researchers (permanent)

2 research engineers
ca. 25 post-docs
>40 PhD students
X guests, interns, master students…

BATTERY 2030+

Coordinator

BASE Batteries Sweden

Coordinator

Swedish Electromobility Centre

Thematic leader
Energy Storage

erc

Knut och Alice Wallenbergs Stiftelse

VINNOVA

STandUP for ENERGY

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Battery components

- Anodes
- Cathodes
- Liquid electrolytes
- Solid electrolytes
- Separators
- Binders
- Self-healing components
- Interfaces

- Our research

Method-oriented development

- Structural characterization
- Surface characterization
- Online-characterization
- New sensors
- Electroanalytical techniques
- Modelling

Battery concepts

- Li-ion
  - *Safety*
  - *Ageing*
  - *Sustainability*
- Solid-state
  - Ceramic
  - Polymer
- Na-based batteries
- Organic batteries
- Other metals: Zn, Ca, Mg, K…
- Li-S
- Li-O_2

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Trendspaning

1. Mycket snabbt ökande tillverkningsvolymer av batterier - ställer nya krav.
2. En konsolidering av aktörer, men också nytillväxt
3. En fortsatt evolutionär utveckling av Li-jonbatterierna – material & design
4. Vertikal integration längs värdekedjan
5. Forskningsintresse för mindre traditionella aspekter av värdekedjan
6. Förhoppningar om revolutionära språng – nya cellkemier
7. En framtida diversifiering av batterikemier

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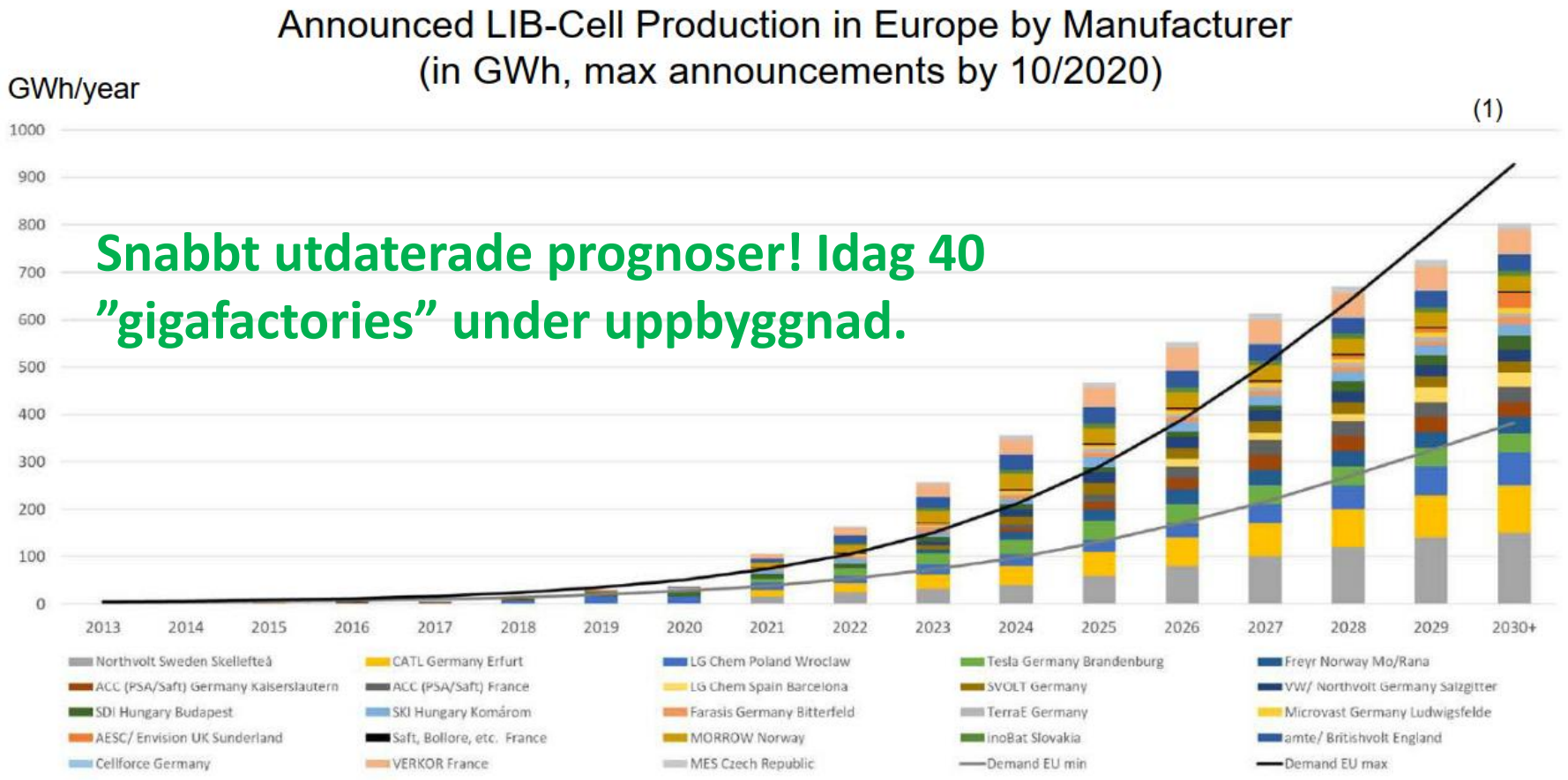
The growth of the battery sector



Snabbt utdaterade prognoser! Idag 40 ”gigafactories” under uppbyggnad.

Strong correlation with the growth of the EV sector

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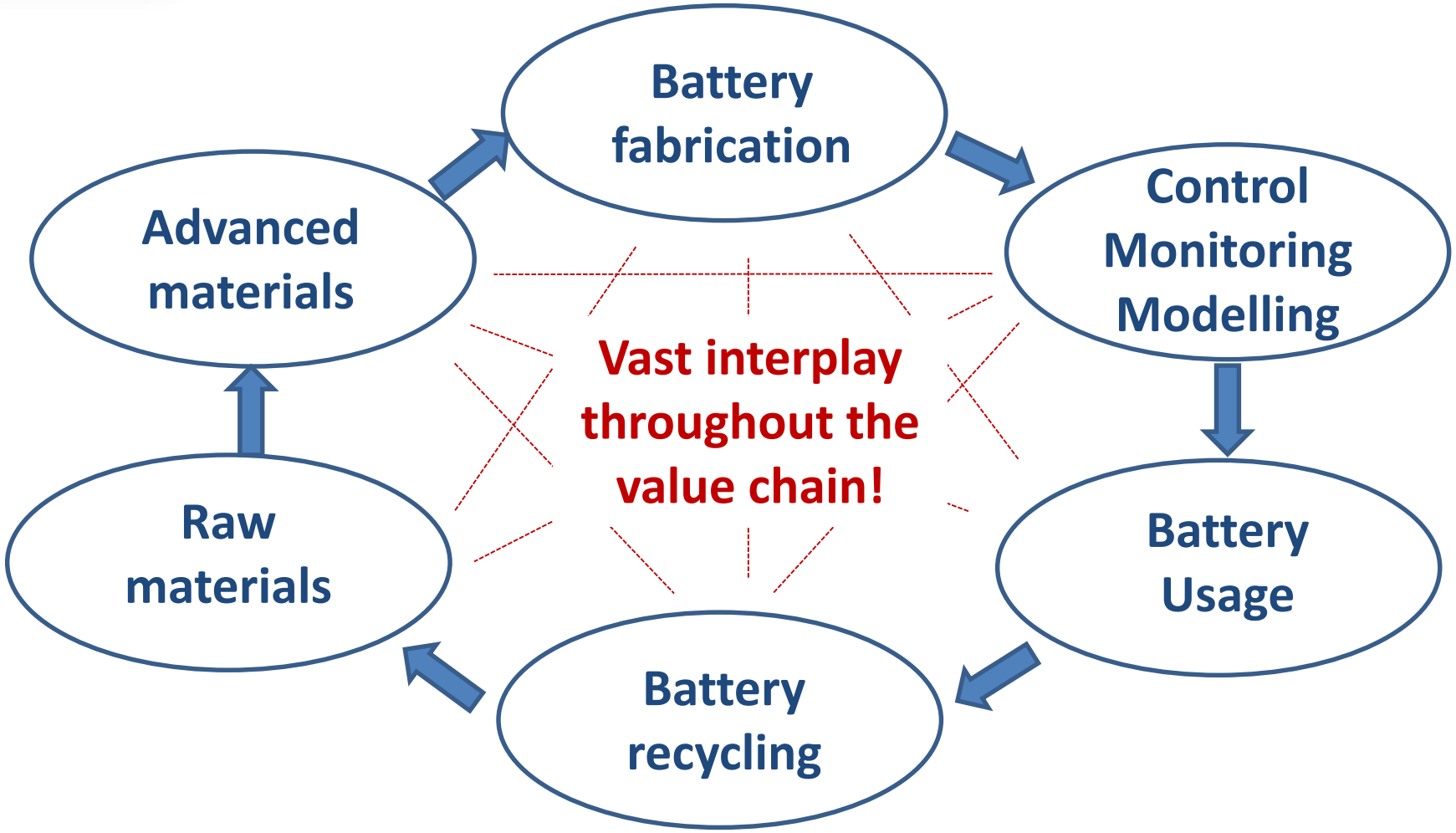
Research along the battery value chain



Research and education needed throughout the entire value chain.

ÅABC is particularly strong in the ”center”

ÅABC

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Batteries Sweden BASE

The Swedish landscape

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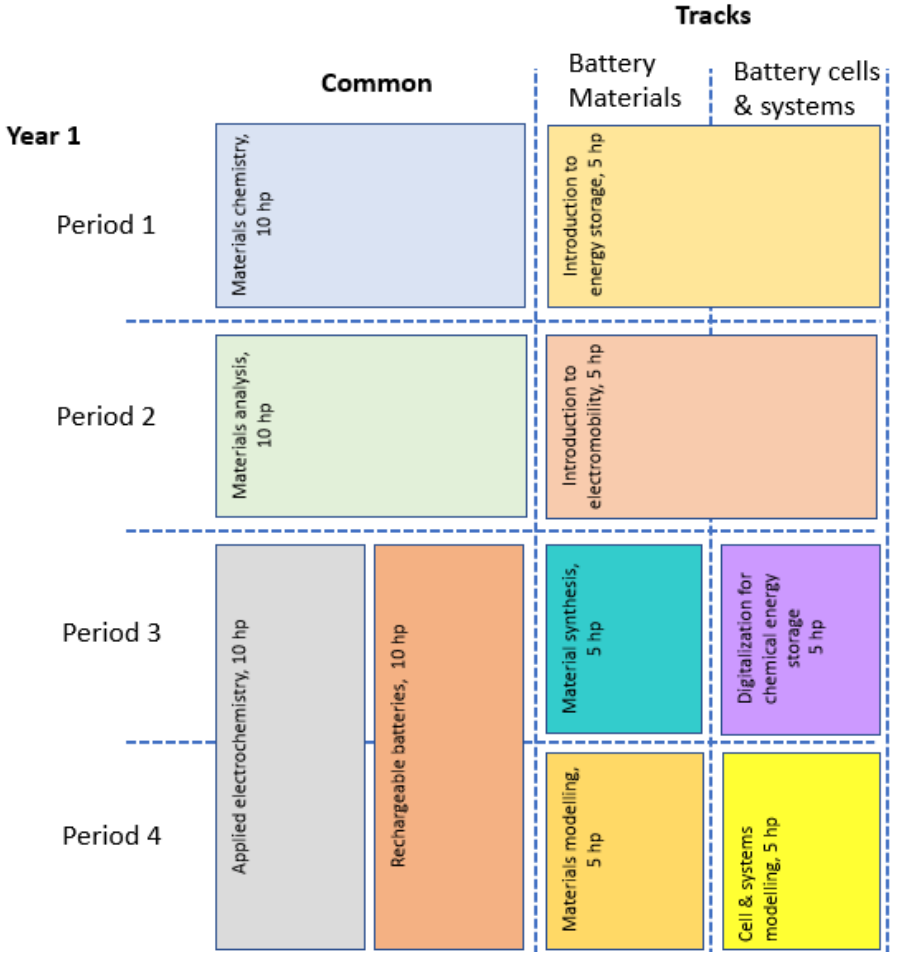
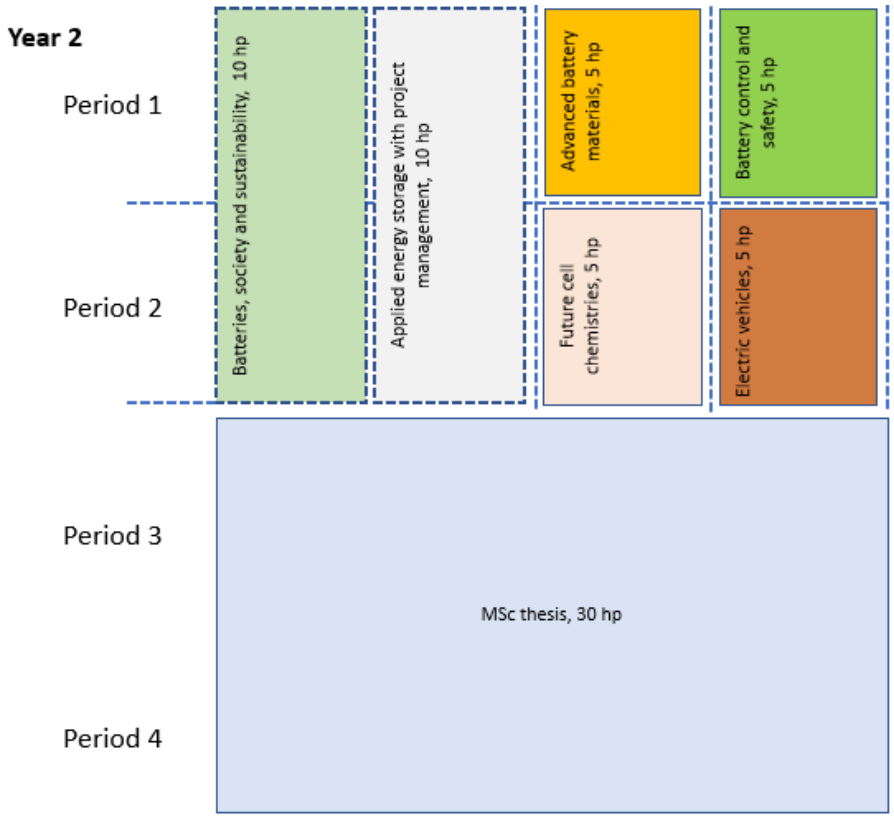
Educational needs
– a new master programme in battery technology





Start: Autumn 2022 30 students

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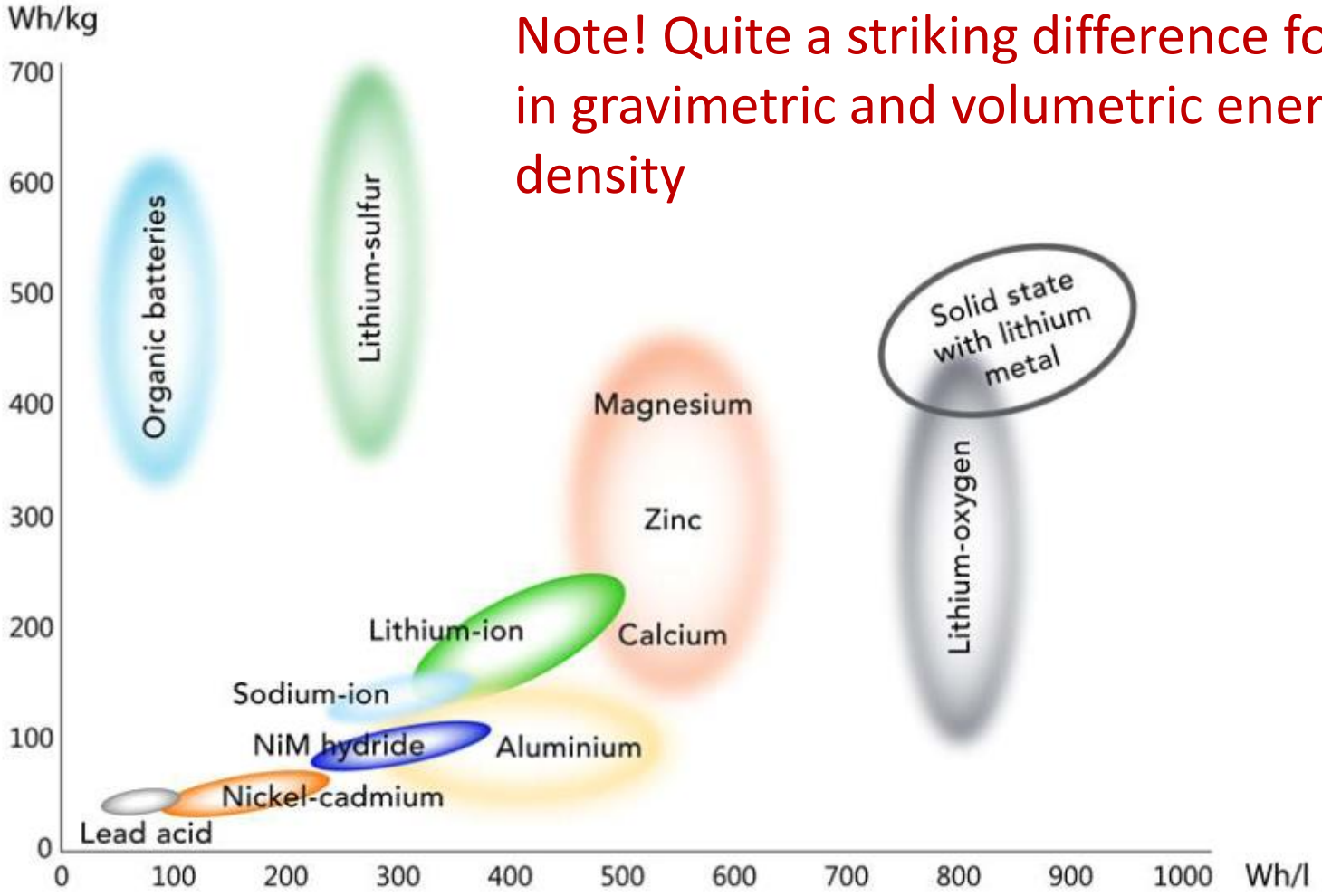
New chemistries – the battery revolution



Note! Quite a striking difference for some in gravimetric and volumetric energy density

Energy density not the *only* relevant parameter!

- Cyclability
- Efficiency
- Safety
- Cost
- Sustainability
- Power
- Charging time
- Etc…

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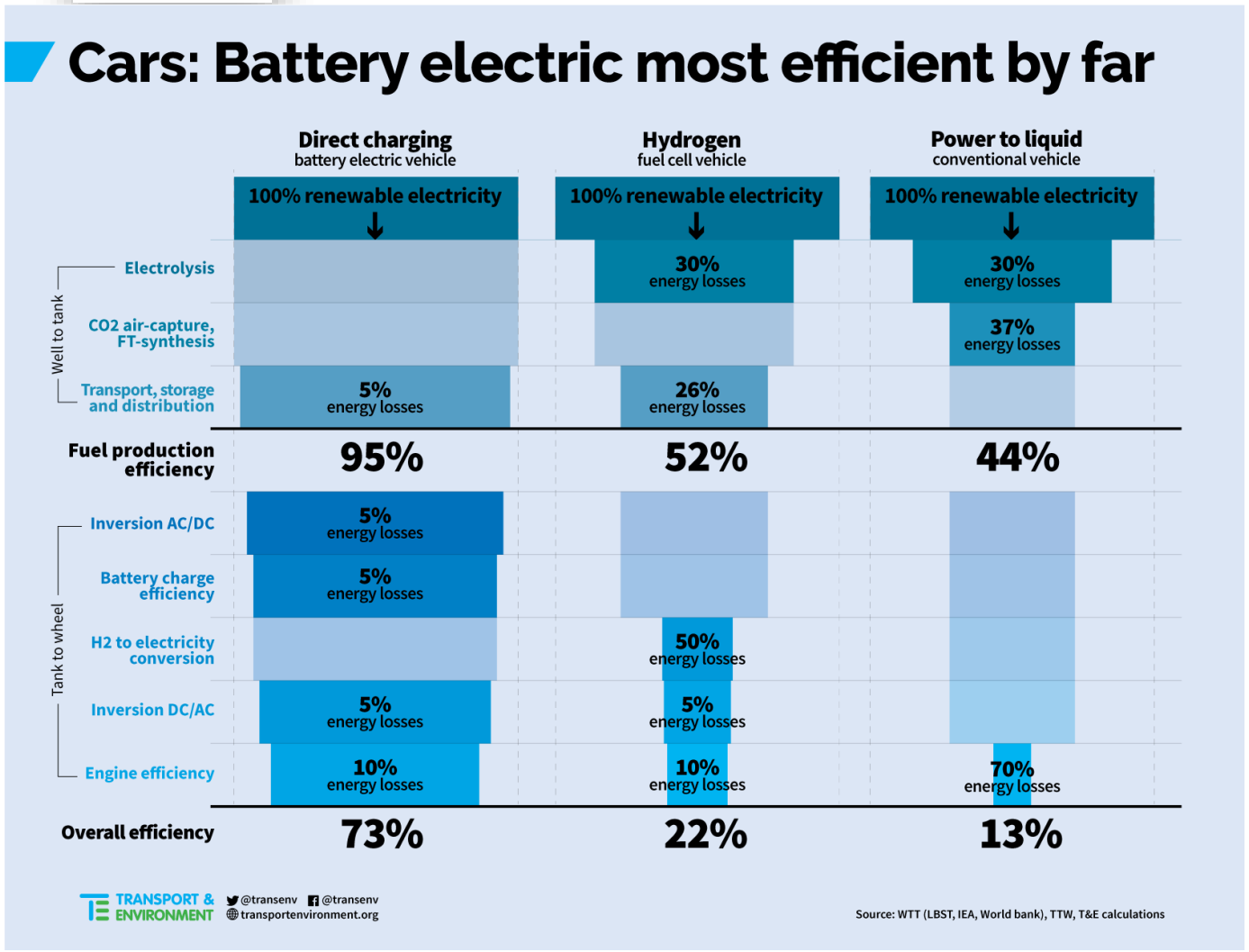
Other storage technologies

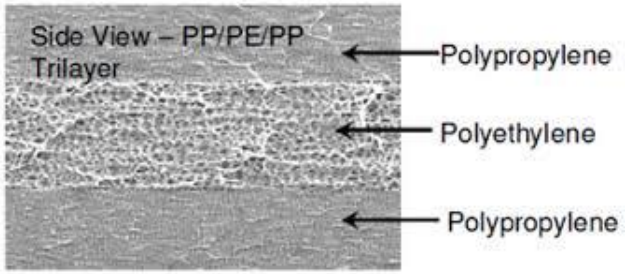


Less costly alternatives are interesting (stationary)

Higher energy and/or power density is useful (transportation)

More scalable solutions are required (grid)

What's in a Li-ion Battery?

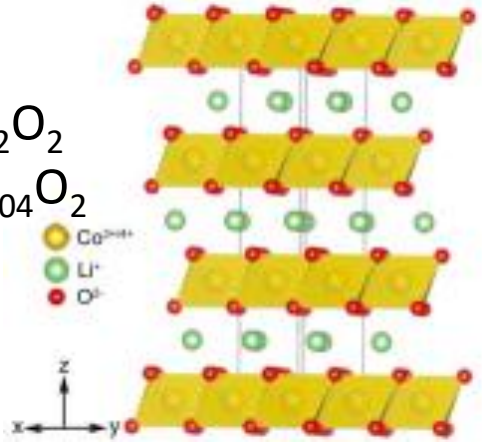


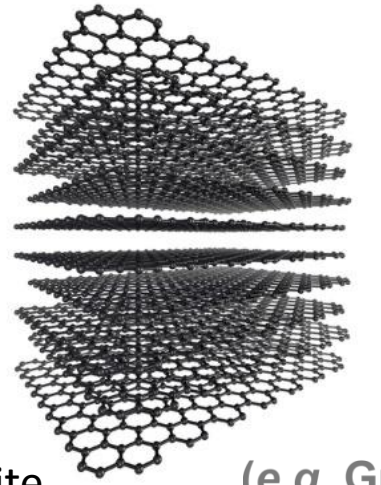
Layered oxides

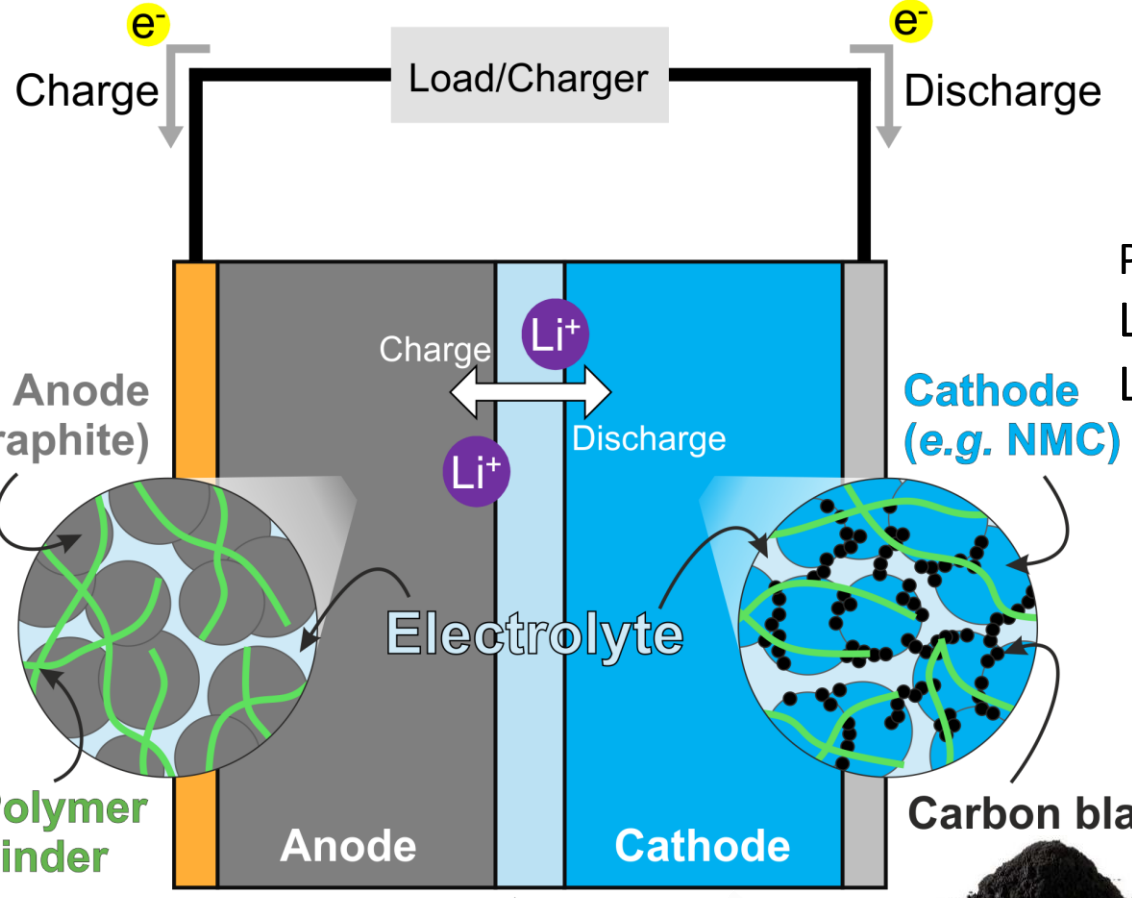
$LiCoO_2$

$LiNi_{0.6}Mn_{0.2}Co_{0.2}O_2$

$LiNi_{0.84}Co_{0.12}Al_{0.04}O_2$



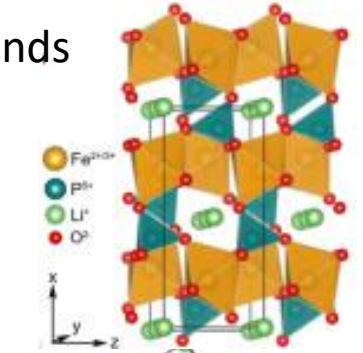




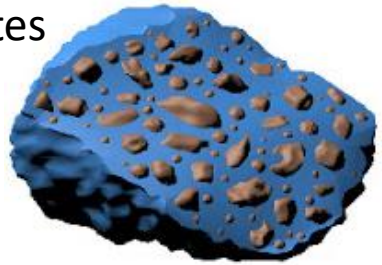
Polyanionic compounds

$LiFePO_4$

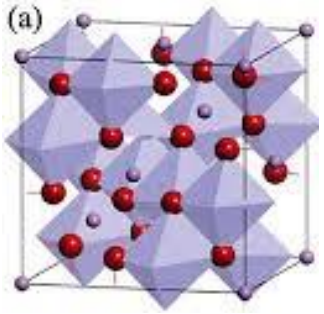
Li_2FeSiO_4

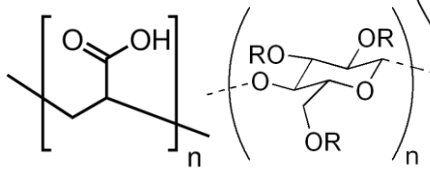


Silicon-graphite composites



$Li_4Ti_5O_{12}$

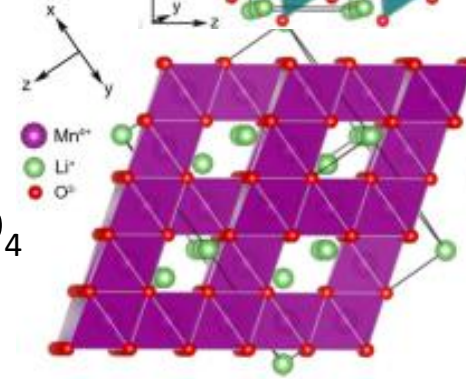


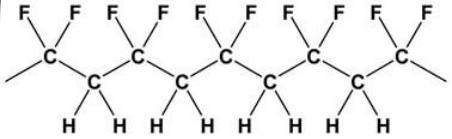


Spinel oxides

$LiMn_2O_4$

$LiNi_{0.5}Mn_{1.5}O_4$





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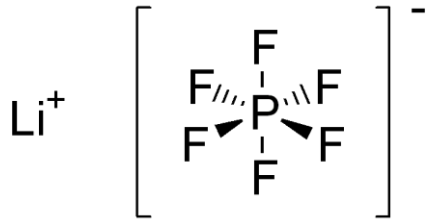
What's in a Li-ion Battery? The electrolyte…

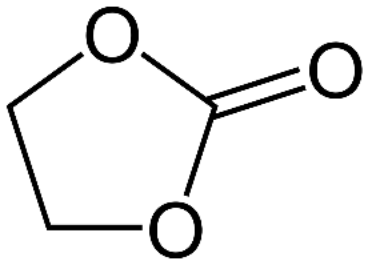
Electrolyte

Salt

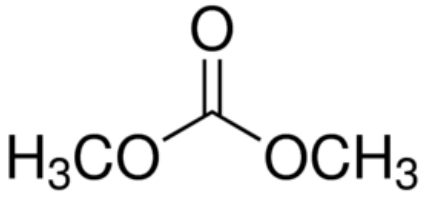


Lithium hexafluorophosphate

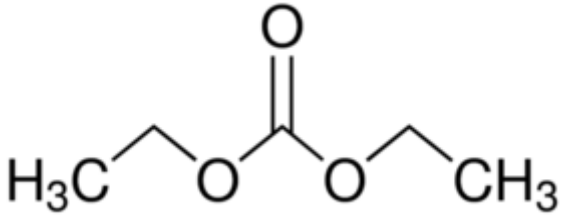
Organic solvents



Ethylene carbonate

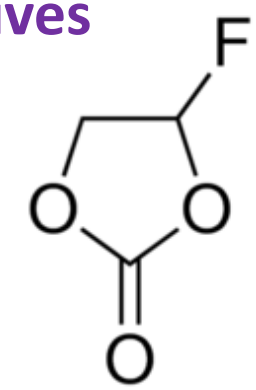


Dimethyl carbonate



Diethyl carbonate

Additives



Fluoroethylene carbonate

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Availability of Materials

Critical Raw Materials (supply risk vs. economic importance)

Raw Material	Critical Stage	Main Producers	Import Reliance (EU)	End of Life Recycling Rate
Cobalt	Extraction	Congo DR (59 %) China (7 %)	86 %	22 %
Bauxite (for Al)	Extraction	Australia (28 %) Greece (12 %)	87 %	0 %
Lithium	Processing	Chile (78 %) United States (8 %)	100 %	0 %
Natural Graphite	Extraction	China (47 %) Brazil (12 %)	98 %	3 %

Ethical considerations when sourcing materials:

- from areas of conflict,
- from mines which exploit workers (child labour)

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A few words on graphene…

1. A useful active material?

Facile stitching of graphene oxide nanosheets with ethylenediamine as three dimensional anode material for lithium-ion battery

Mahshid Ershadi [a, b], Mehran Javanbakht [a, b, *], Sayed Ahmad Mozaffari [b, c], Daniel Brandell [d], Ming-Tao Lee [d], Beniamin Zahiri [e]

- **Large surface area is problematic – side-reactions**
- **Poor cyclability**
- **Not excellent volumetric capacity**

2. A surface protective agent?!

Promising results on existing LiB materials: LNMO cathodes, Si anodes
Processing needs development. Cost?

3. A combined structural stabilizer and electronically conductive matrix!

Clearly competative for Li-S, organic batteries, etc. Market?

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Thank you!