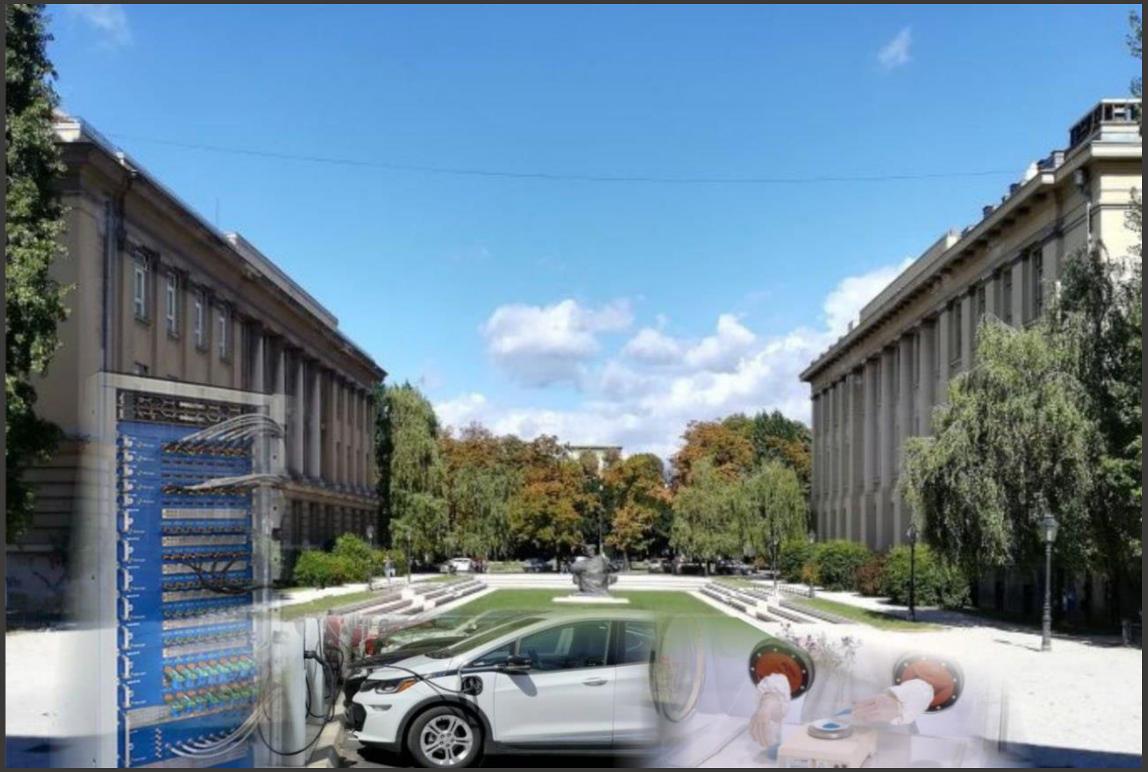
Center for battery technologies

University of Zagreb Faculty of Chemical Engineering and Technology

CBT



- ✓ Research projects
- ✓ Battery testing
- ✓ Single cell manufacture
- ✓ Battery pack assembly
- ✓ Consultancy/Training
- ✓ Workshops organization

Innovative, reliable, and scalable electrochemical energy storage solutions

Can the Development of Batteries Keep Pace with the Increasing Demands of Electric Vehicles and Mobile Devices?

Zoran Mandić, *Faculty of Chemical Engineering and Technology, University of Zagreb*

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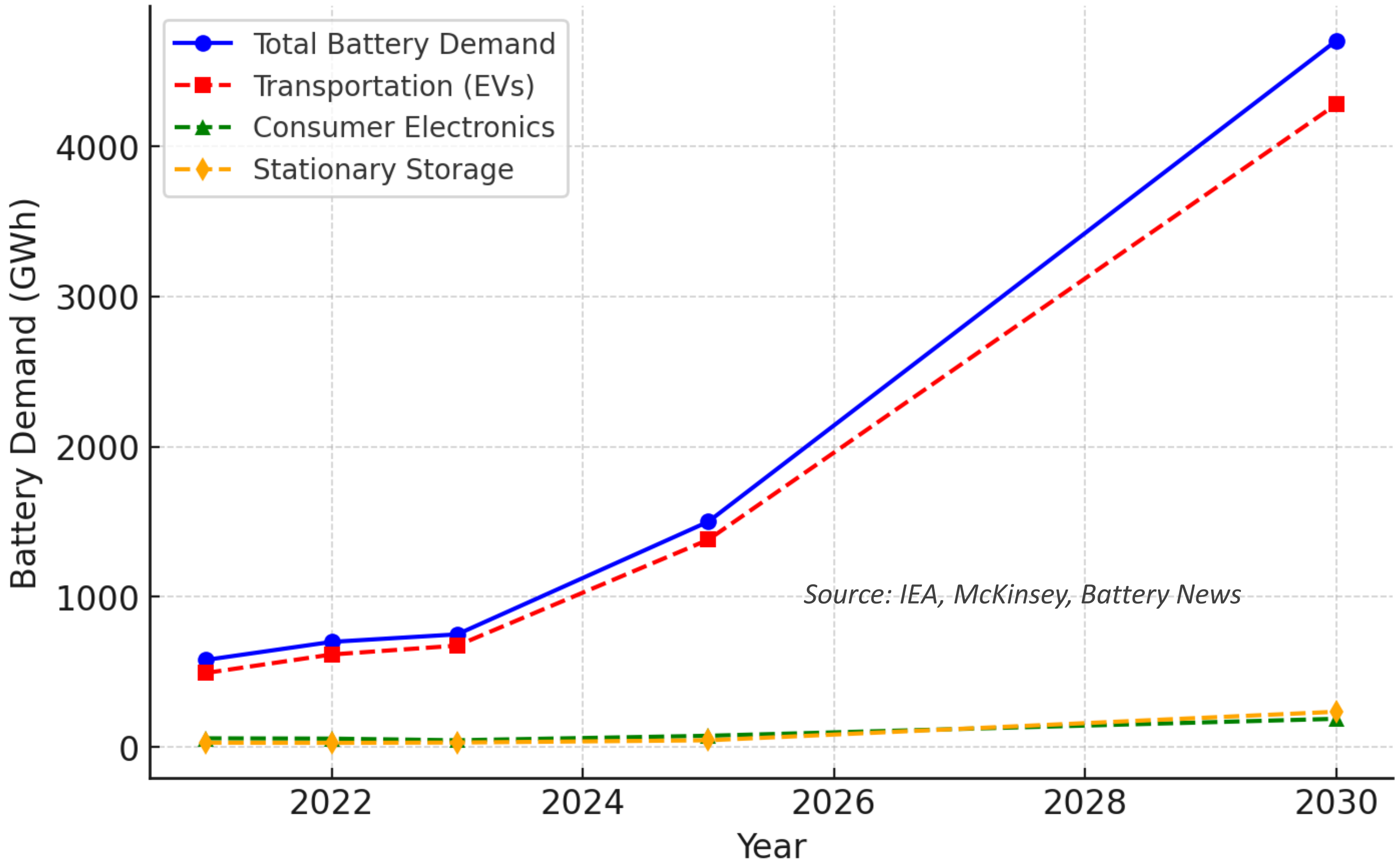
Global Battery Demand (2020-2030)



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Europe battery demand: 250 GWh

Projection: 1500 GWh (2030)

Current gigafactories in Europe:

Germany:
- *Tesla's Gruenheide Plant:* Since 2022, capacity ~ 50 GWh.
- *CATL's Erfurt Plant:* Since2022, capacity ~14 GWh.

Poland:
- *LG Energy Solution's Wroclaw Plant:* Started in 2017, ~ 100 GWh.

France:
- *ACC's Douvrin Plant:* Started 2023, with plans to double its initial capacity of 13 GWh by 2026.

Hungary:
- *Samsung:* Started 2018, with a capacity of 30 GWh.

Sweden:
- *Northvolt:* Commenced production in late 2021, with an installed capacity of 16 GWh.

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Major performances of electric cars

Car performance	Battery parameters	Cell-level processes
Driving distance	Energy density	Charge storage and battery voltage
Acceleration	Power density	Rate of electrochemical reactions
Cycle life	No. of ch./disch. cycles	Reversibility and coulombic efficiency
Charging time	Charge acceptance rate	Charge storage rate

Key performance indicators (EBA)

The European Battery Alliance, through its Strategic Research and Innovation Agenda, has outlined key performance indicators for batteries:

- **Gravimetric Energy Density:** > 400 Wh/kg at the cell level.
- **Volumetric Energy Density:** Surpassing 800 Wh/l
- **Cycle Life:** 3,000 cycles.
- **Charging Rate:** Between 3C and 5C.
- **Cost:** Aiming for €75 per kWh at the pack level.

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Energy consumption	0.2 kWh/km
Minimal energy consumption (ZG-ST)	80 kWh
Reserve capacity	+ 20 %
Capacity deterioration	+ 20 %
Total energy required	120 kWh
Weight (NMC)	> 500 kg
Weight (LFP)	> 600 kg

Li / $FePO_4$ LFP 150 – 180 Wh/kg

Li / $LiNi_xMn_yCozO_2$ NMC 200 – 250 Wh/kg

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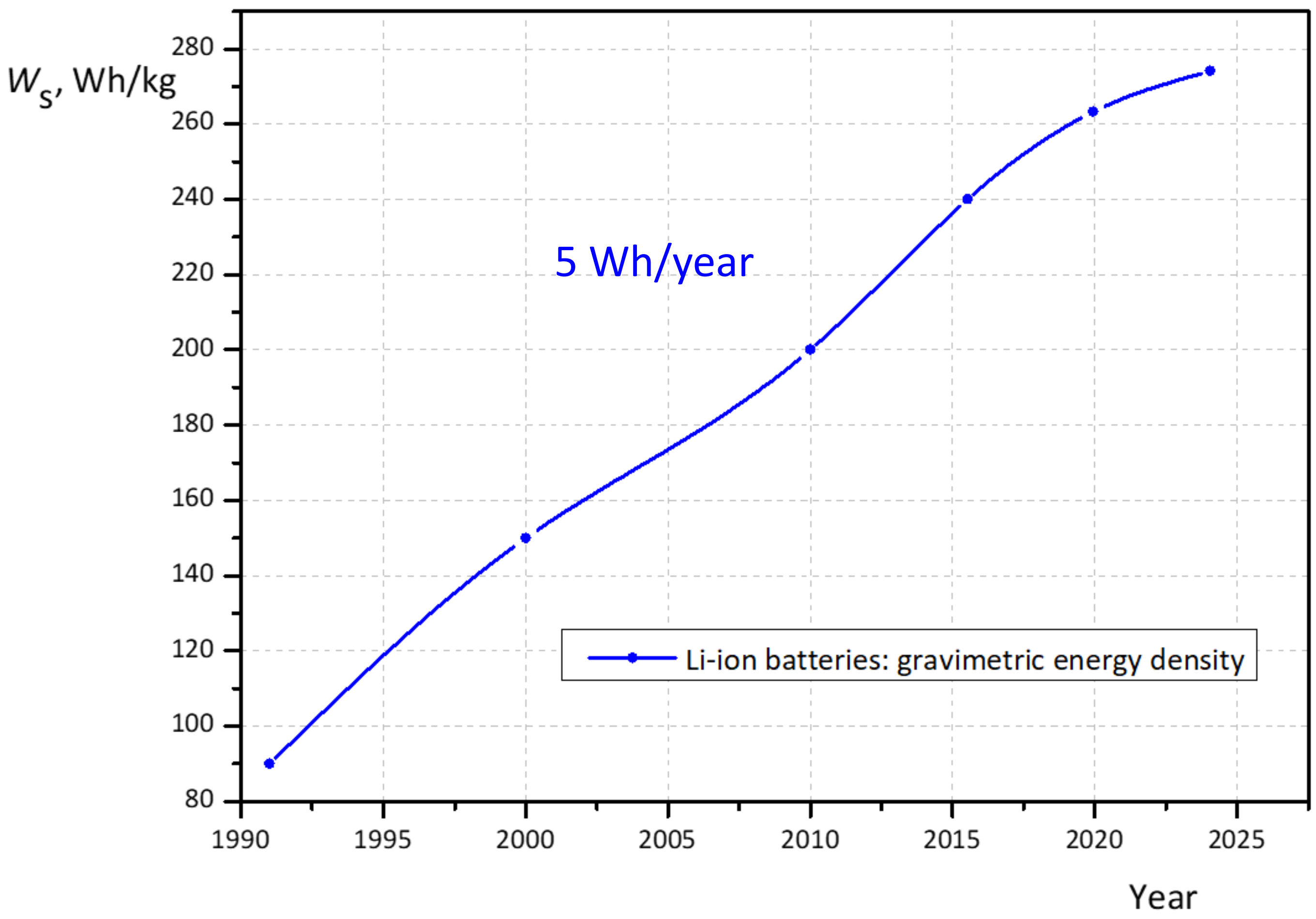

Li / $FePO_4$ LFP

150 – 180 Wh/kg

Li / $LiNi_xMn_yCo_zO_2$ NMC

200 – 250 Wh/kg

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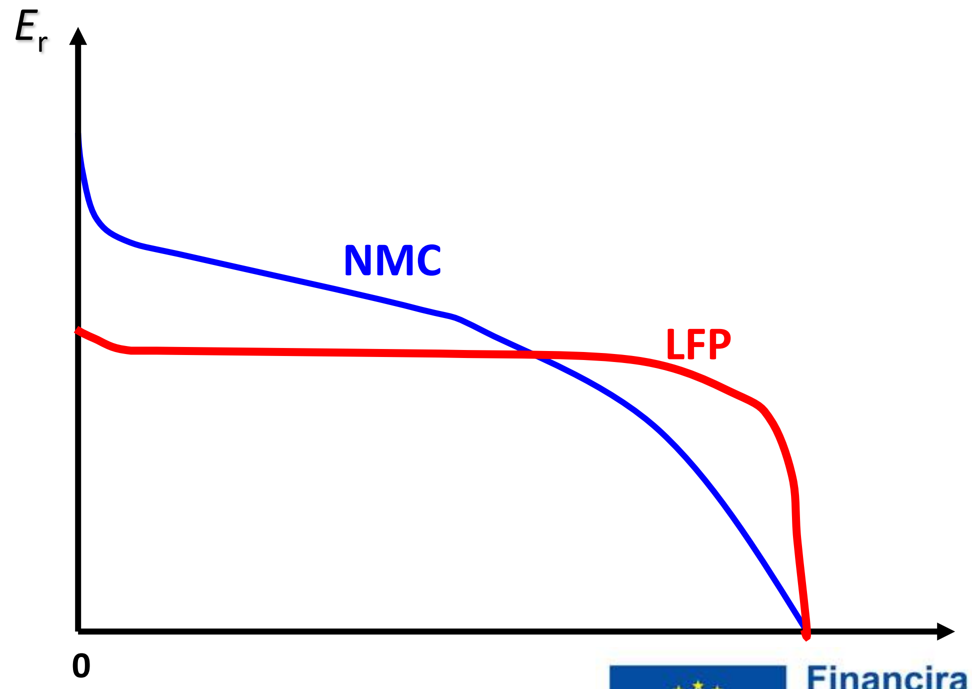
Specific energy

$$W_s = Q_s U \quad [\mathrm{W\,h\,kg^{-1}}]$$

Q_s: [A h kg^{-1}] U: [V]

- Storing as much charge as possible
- Stability and chemical reversibility
- Maximizing working voltage of a battery
- Flatten a voltage profile



Material science and engineering
Electrochemical engineering

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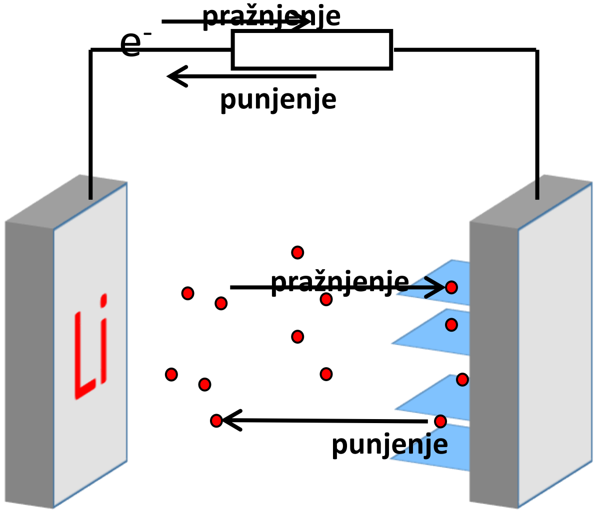
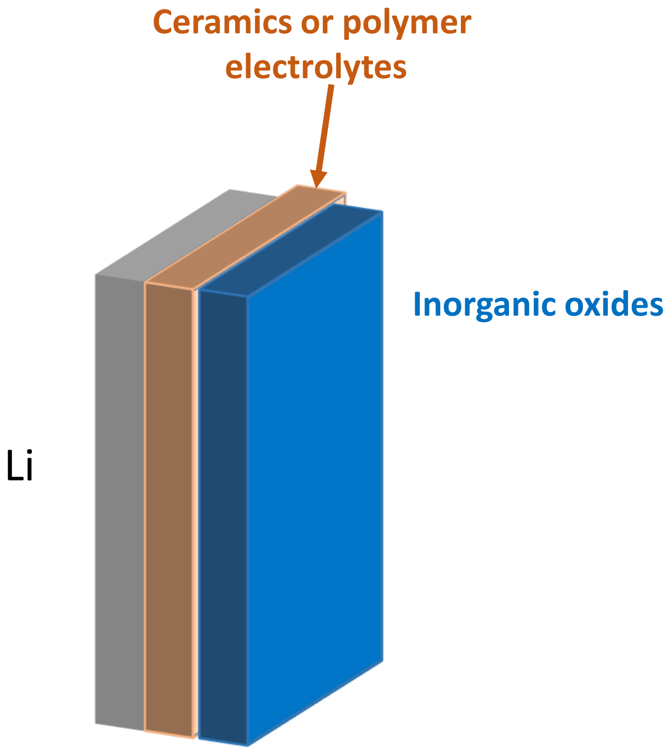
Three most promising directions for developing high energy – high power batteries.

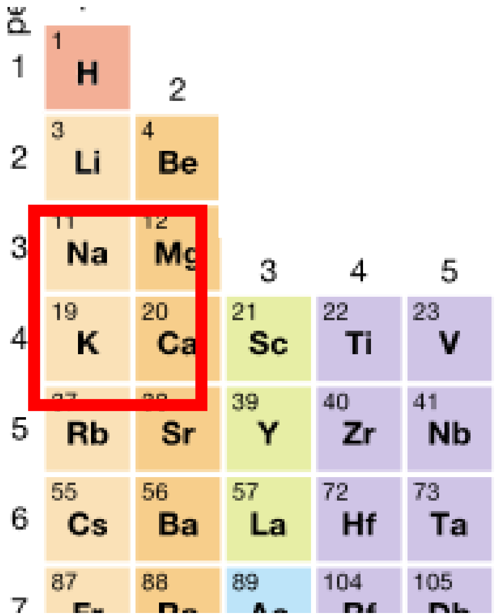
Li – metal



Solid state batteries



Technologies beyond Li-ion



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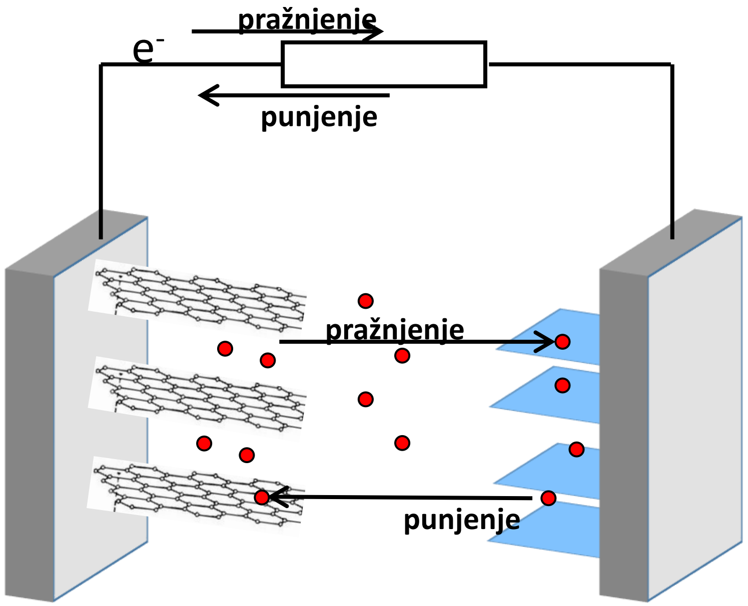
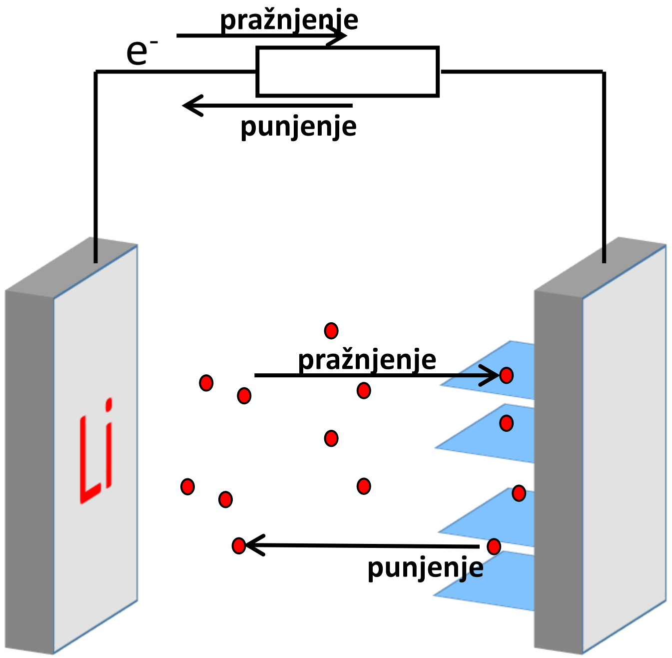
Li-metal batteries

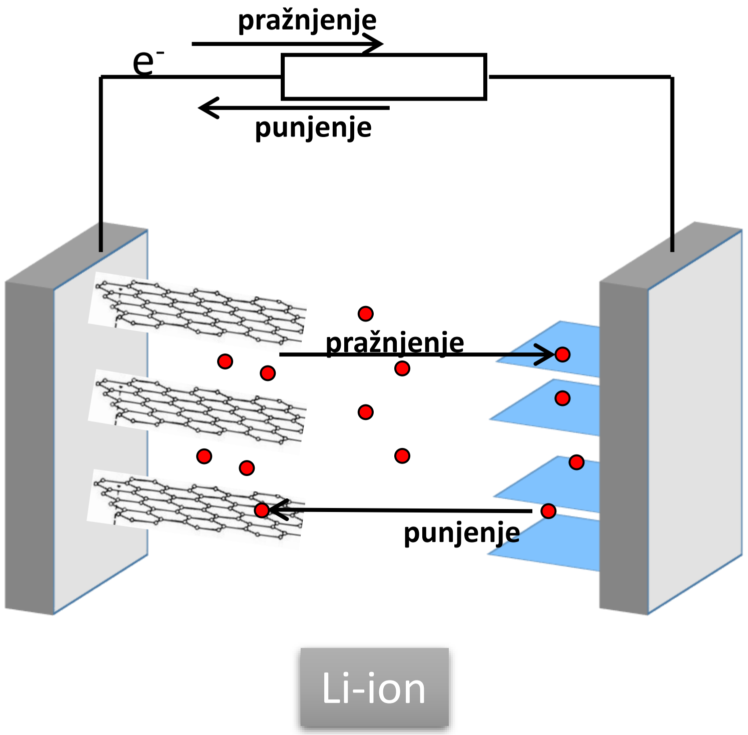


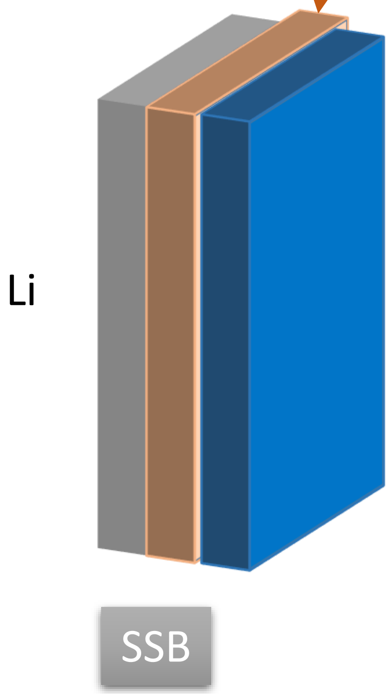
Li-ion



Li-metal

Solid state batteries





Increased battery safety
High Li^+ transport number
Specific energies up to 1000 Wh/kg

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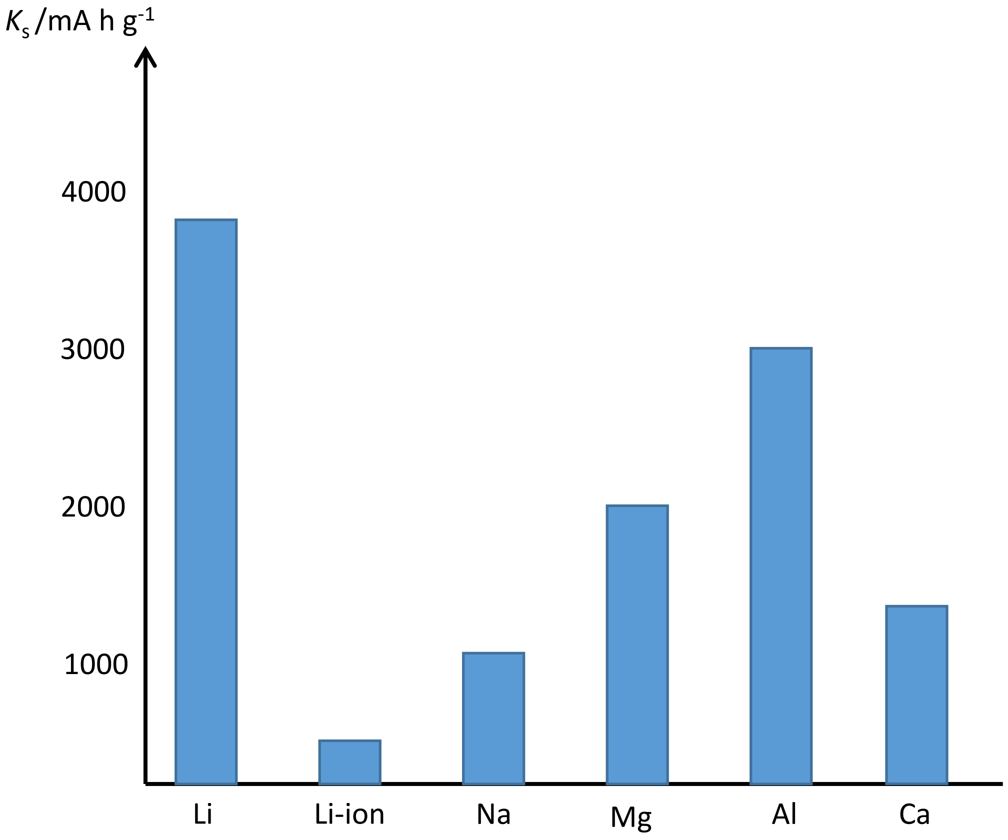
Post-lithium-ion technologies



Ion	E^0 / V	K_s / Ahg^{-1}	r / Å
Li^+	- 3,04	3,86	0,76
Na^+	- 2,71	1,17	1,02
Mg^{2+}	- 2,70	2,21	0,72
Ca^{2+}	-2,84	1,34	1
Al^{3+}	- 1,66	2,98	1,8

Sodium-ion technology mass production: CATL and BYD

Modest specific energy: 150-200 Wh/kg

- 3000 ch./disch. Cycles
- Faster charging rates.

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