

Elettrochimica e energetica dei materiali

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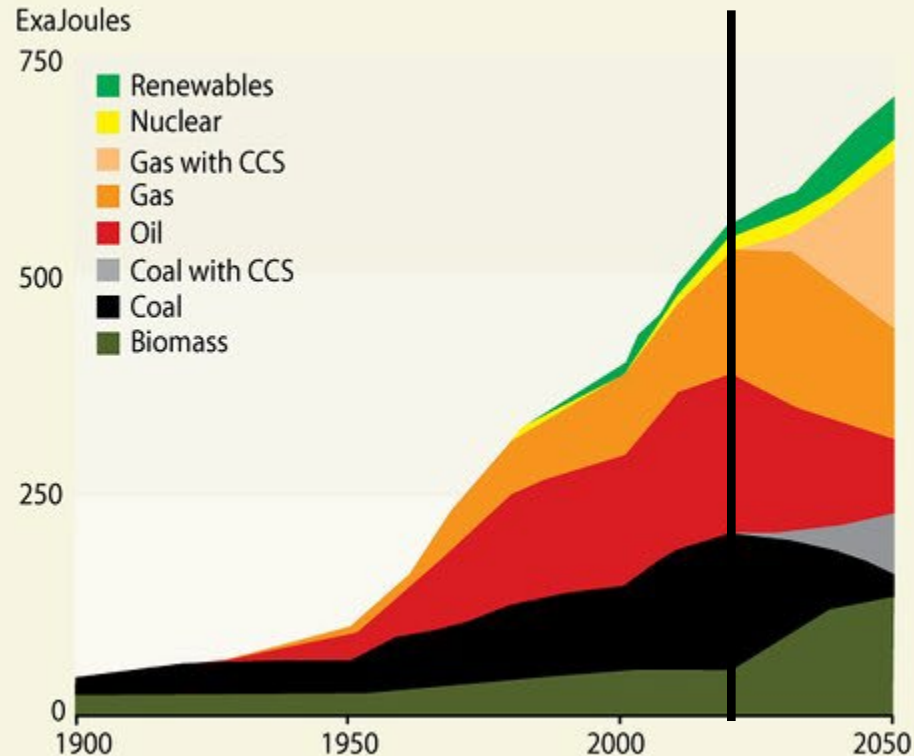
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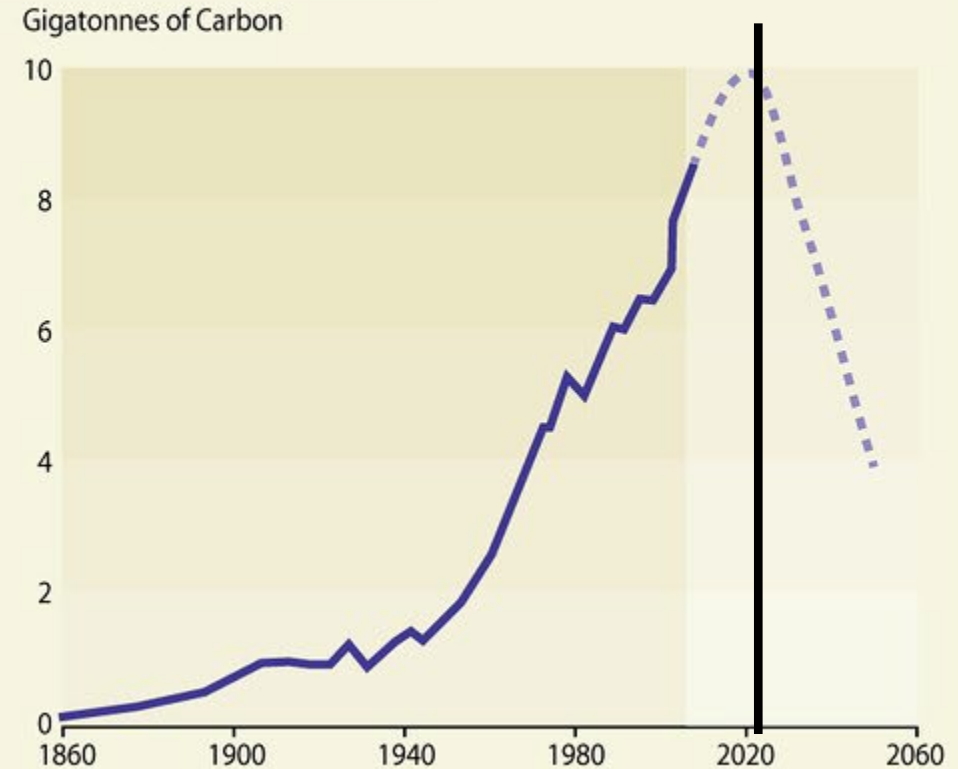
Via Cozzi 55 Milano

The energy issue

Global primary energy consumption

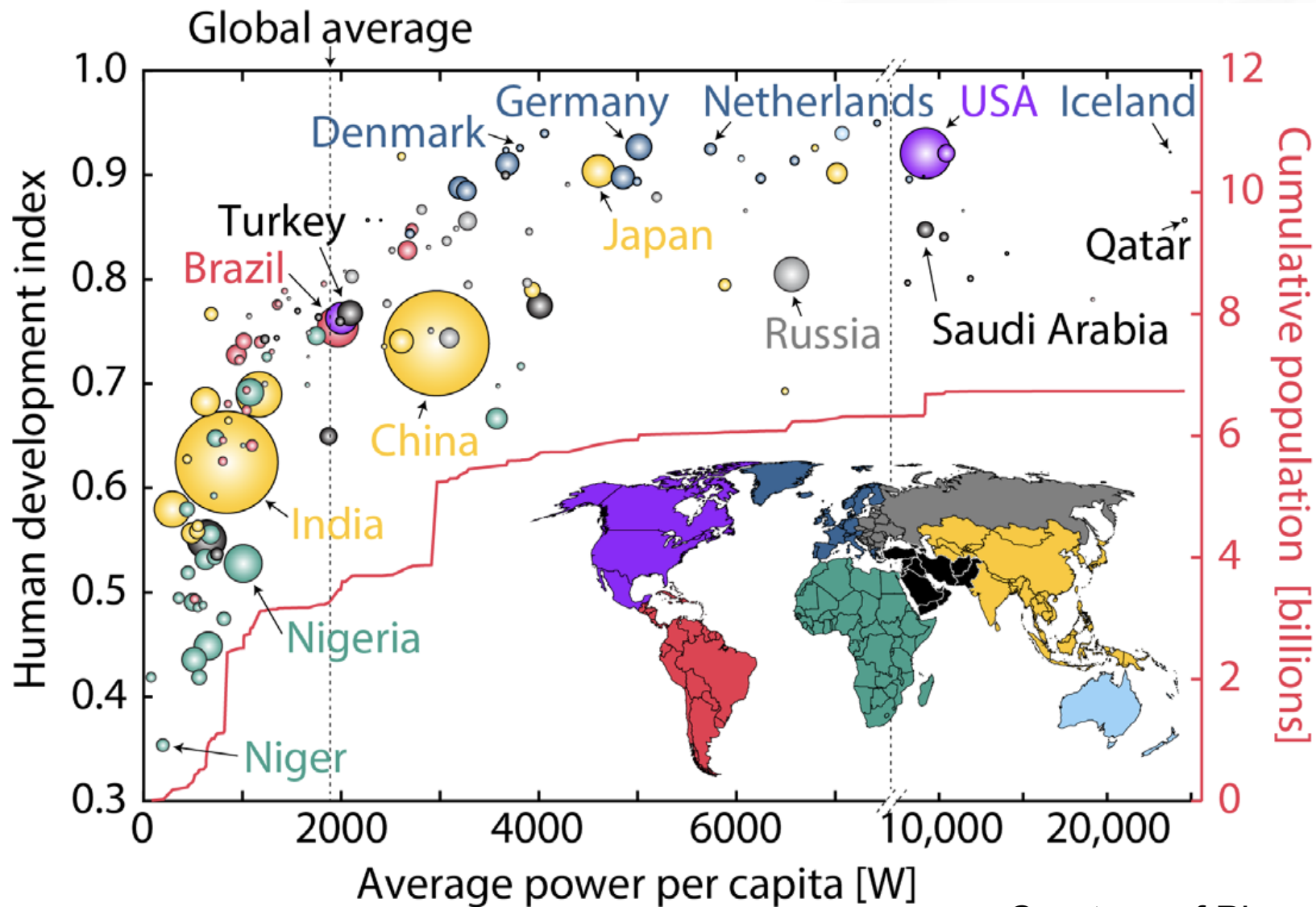


Global CO₂ emission



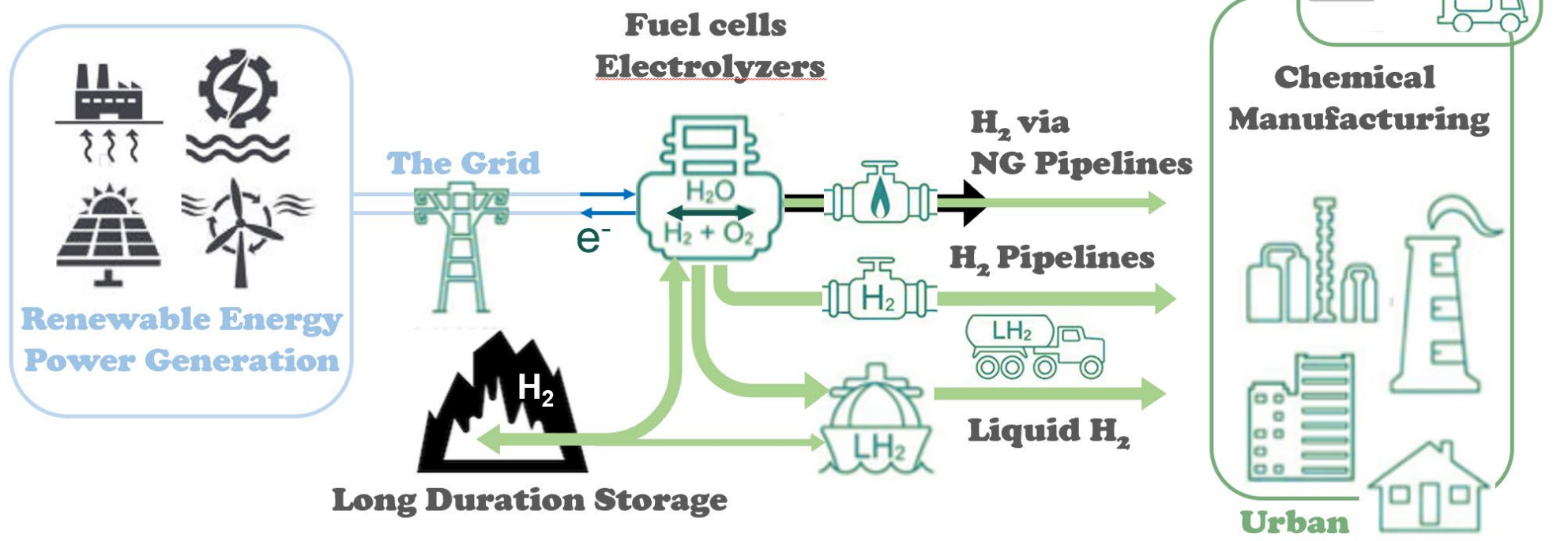
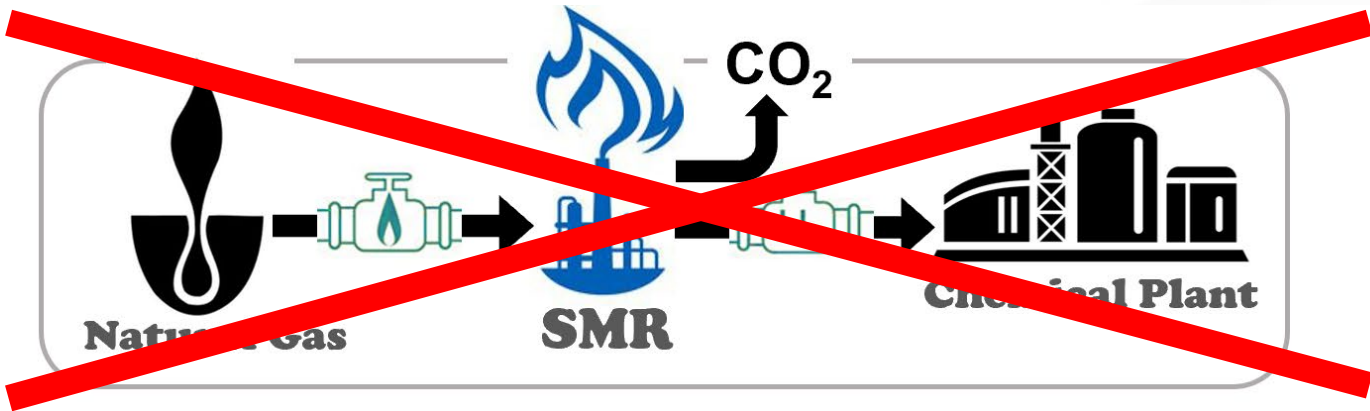
1 ExaJoule = 10^{18} Joule \longrightarrow 100 ExaJoule = 278 Petawatt/hour
 Peta = 10^{15}

The human development index

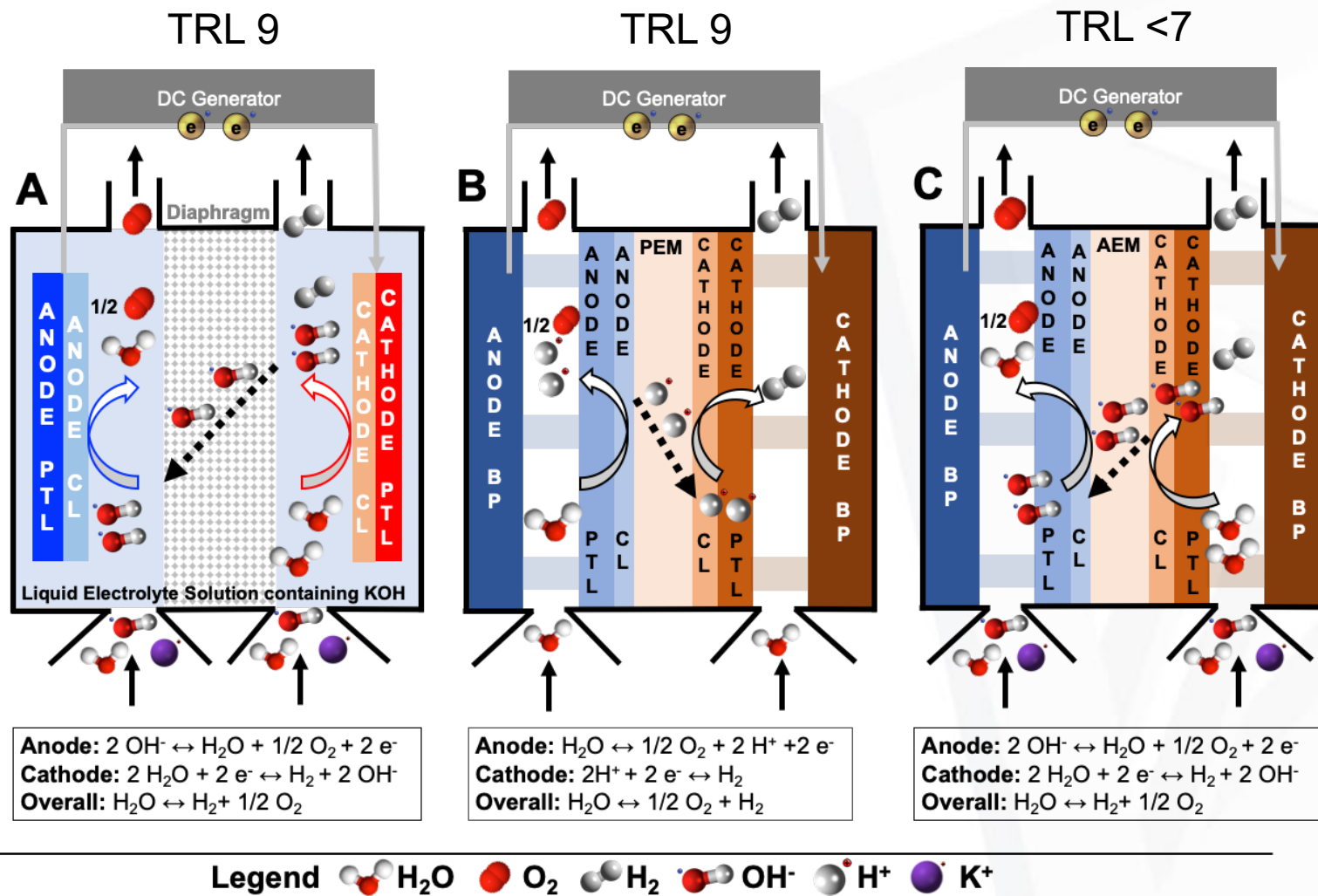


Courtesy of Plamen Atanassov

Green hydrogen chain



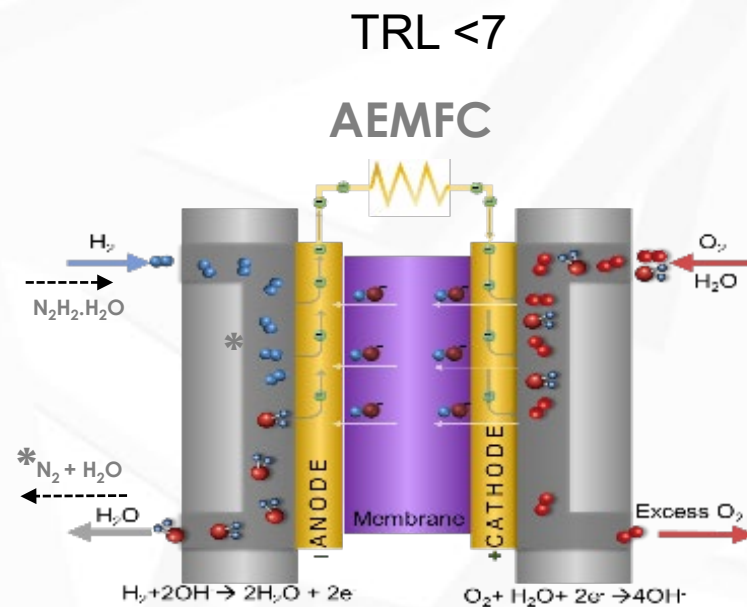
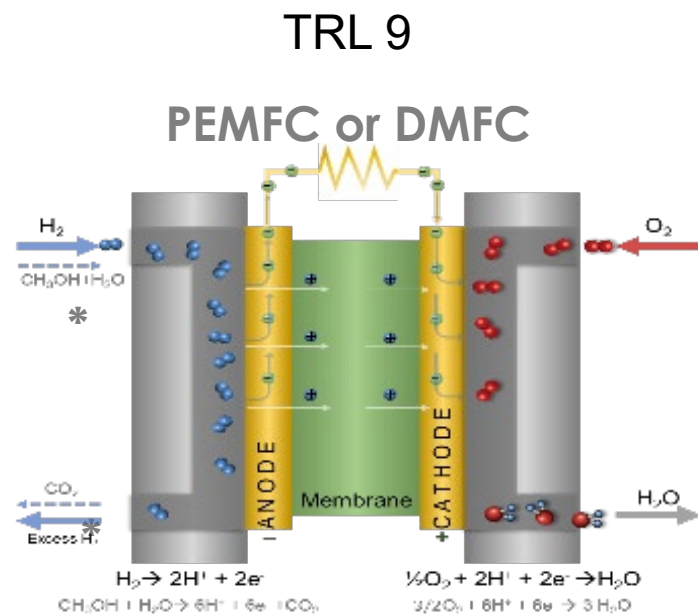
Water electrolyzers: state of the art



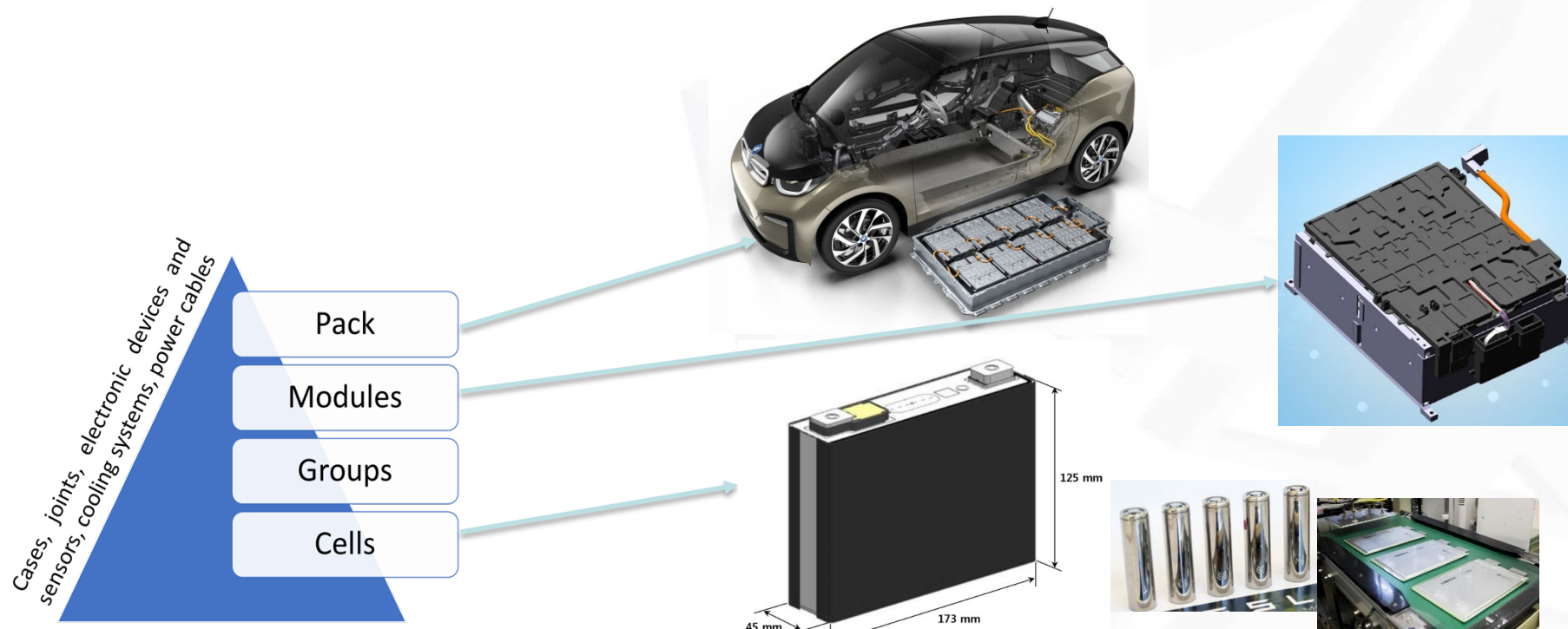
- A) Alkaline electrolyzer
- B) PEM electrolyzer (PEMEL)
- C) AEM electrolyzer (AEMEL)

PTL: porous transport layer
 CL: catalyst layer
 BP: bipolar plates

Fuel cells: state of the art



Lithium-ion batteries (LIBs): the automotive sector



TYPE OF CELLS

Cylindrical



Prismatic

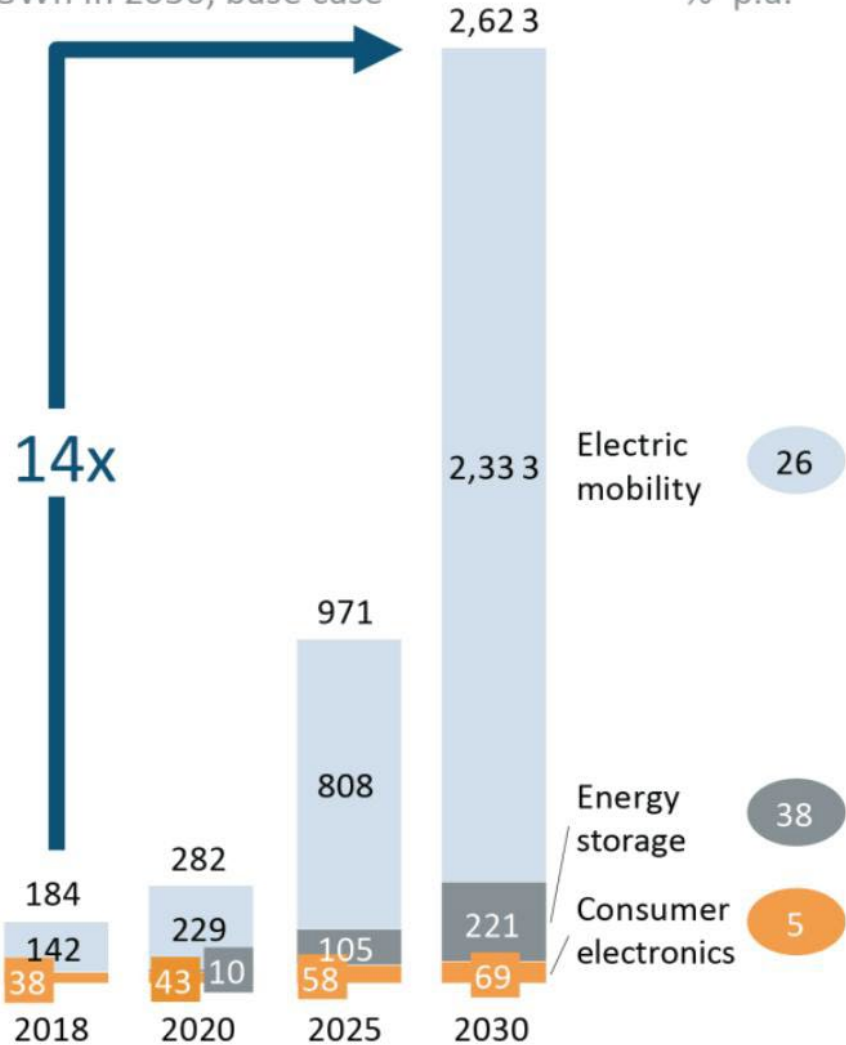


Pouch

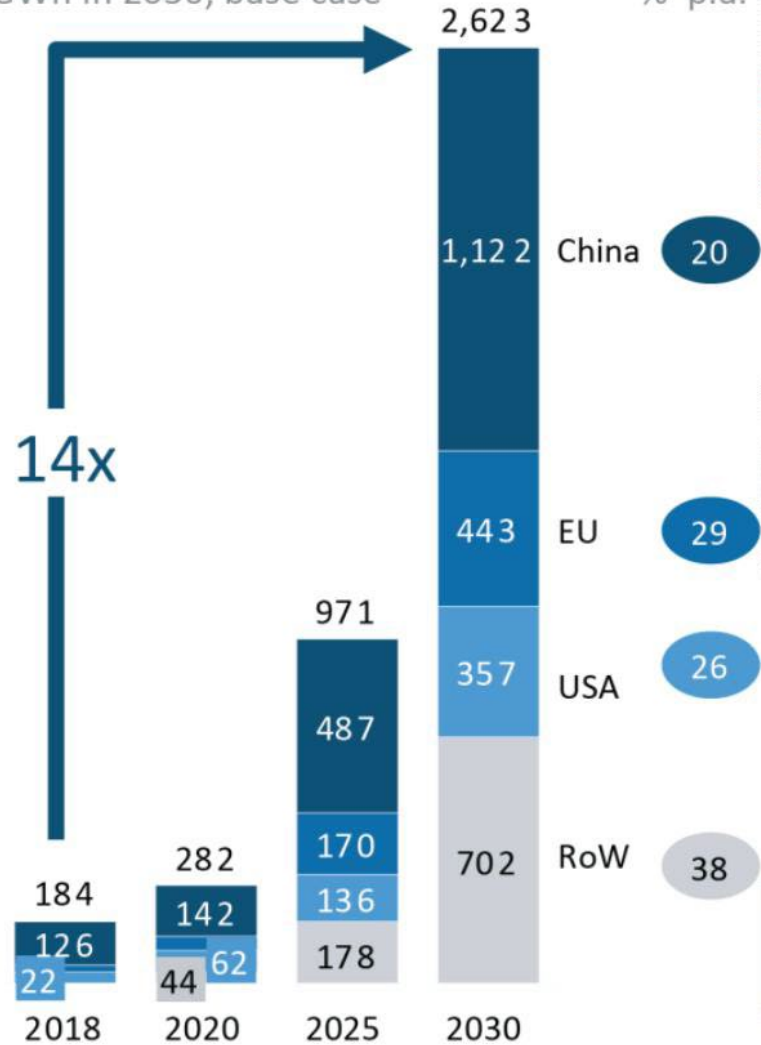


Lithium-ion batteries (LIBs): overall market development

Global battery demand by application
GWh in 2030, base case



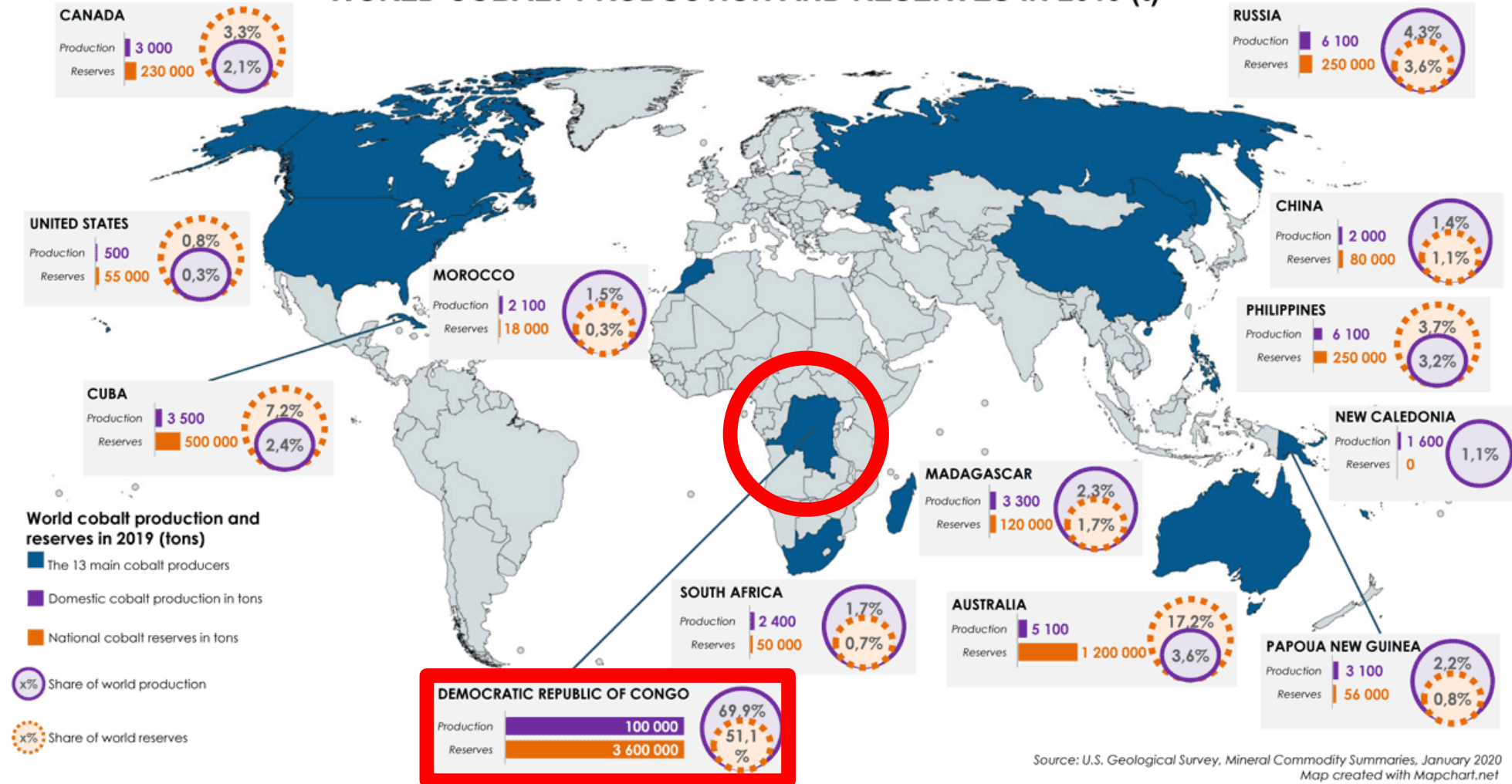
Global battery demand by region
GWh in 2030, base case



Source: EU SRIA 2020

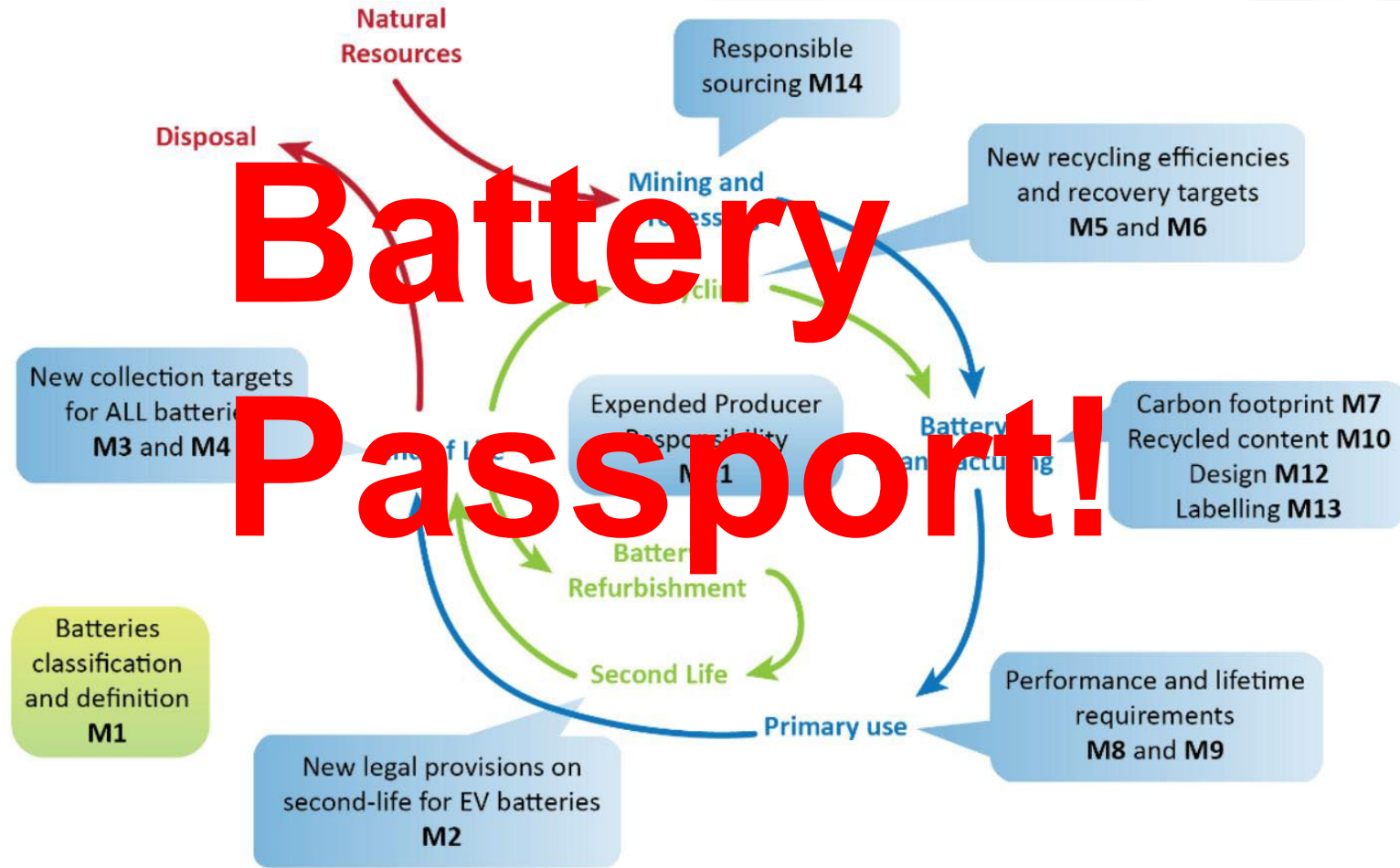
Lithium-ion batteries (LIBs): the case of cobalt

WORLD COBALT PRODUCTION AND RESERVES IN 2019 (t)



Source: U.S. Geological Survey, Mineral Commodity Summaries, January 2020
Map created with Mapchart.net

Lithium-ion batteries (LIBs): the batteries cycle



Fuel cells and electrolyzers

Piercarlo Mustarelli

- Synthesis, fabrication and characterization of membranes (ion conducting) for fuel cells and electrolyzers

Batteries

- Anodes for lithium, sodium and other beyond-lithium batteries
- Cathodes for lithium, sodium and other beyond-lithium batteries
- Electrolytes for lithium, sodium and other beyond-lithium batteries
- Cell testing

Riccardo Ruffo,
Piercarlo Mustarelli
Chiara Ferrara

EBLab (6 PhD student, 0.75M euro funding)

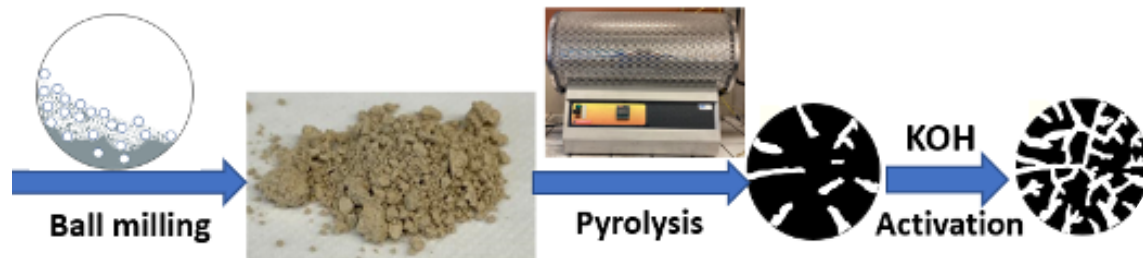
Catalizzatori per celle a combustibile ed elettrolizzatori

- Biomasse o Plastica di rifiuto



- Produzione di carbone attivato

E altri rifiuti...



- Funzionalizzazione del catalizzatore



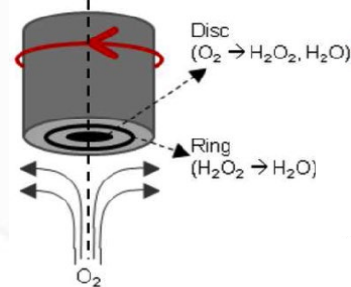
Pirolisi



CARATTERIZZAZIONE
SUPERFICIE CHIMICA
SUPERFICIE MORFOLOGIA

- T (600-1100°C)
- Gas (N₂, H₂, NH₃)

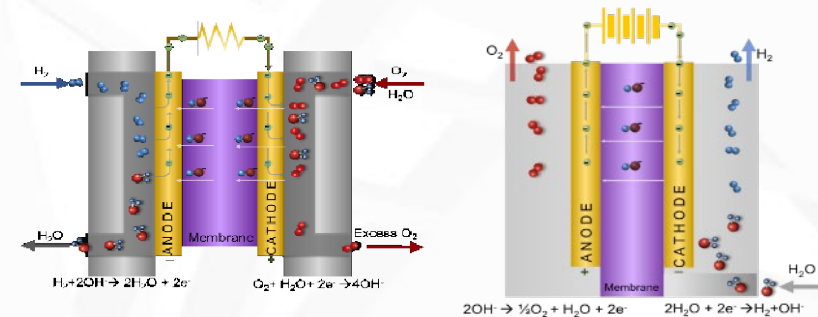
Elettrodo a disco ed anello rotante



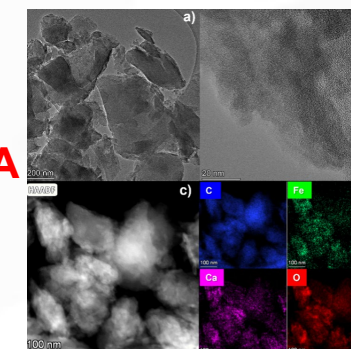
Integrazione Elettrodi



Cella a combustibile ed elettrolizzatori



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Lithium Ion Battery Recycling

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Thesis in a nutshell

- Characterization of the spent lithium-ion batteries (chasing the origin of the performance fading)
- Development of methods for the degradation of the spent cathode materials (e.g.: use of organic acids, deep eutectic solvents, low temperature pyrolysis...)
- Development of methods for the recovery of critical raw materials from the products of cathode degradations (e.g.: Li, Co, Ni, Mn...)