Batterie per autoveicoli elettrici: stato dell'arte e l'Europa cosa fa?

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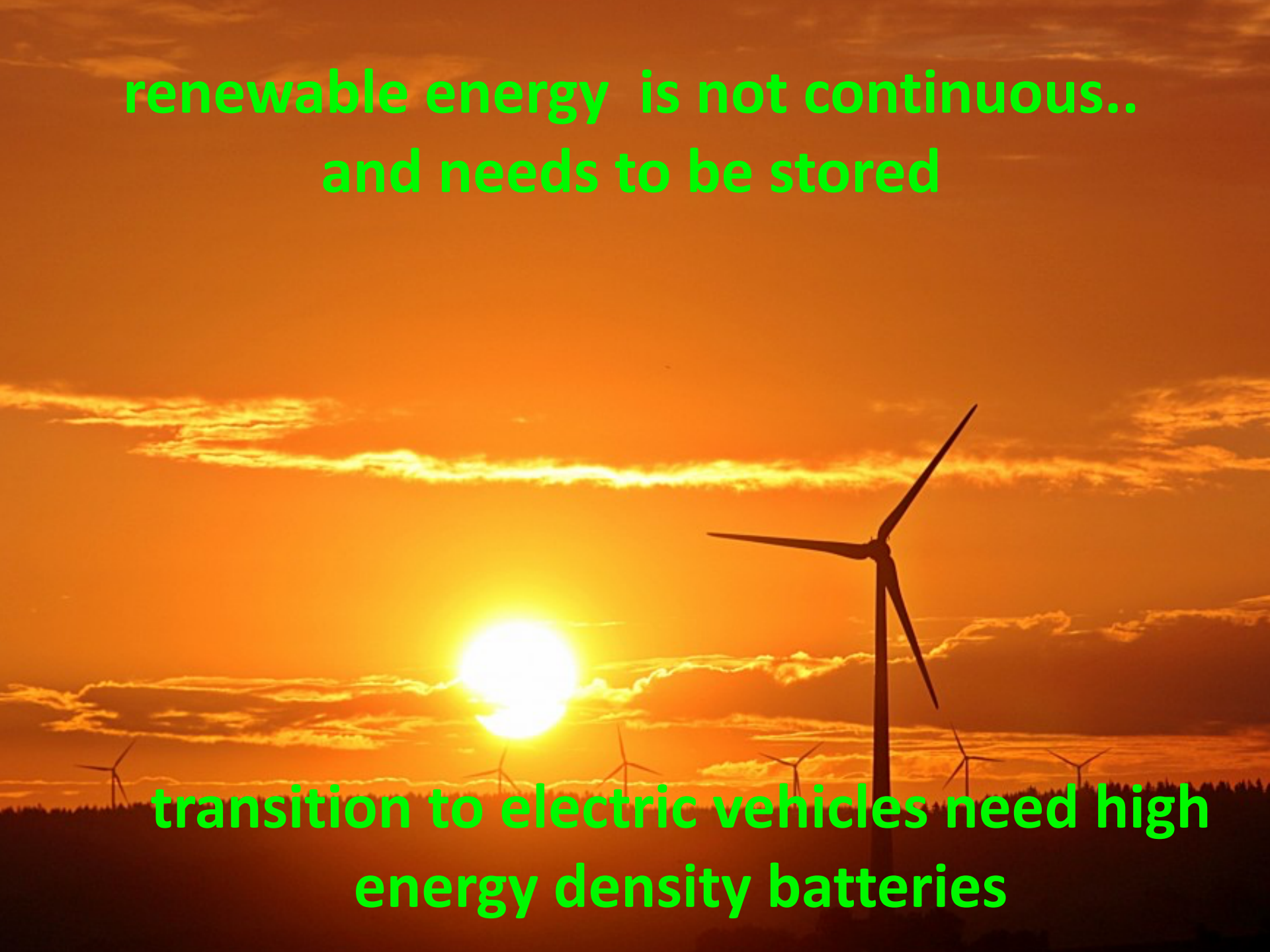

renewable energy is not continuous..
and needs to be stored
transition to electric vehicles need high
energy density batteries

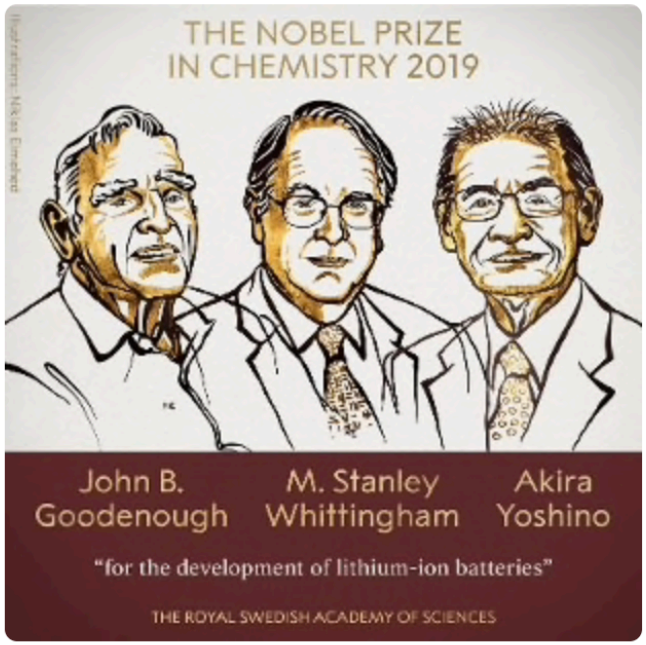
2019 Very important year for batteries

L'annuncio a Stoccolma

Premio Nobel per la Chimica a Goodenough, Whittingham e Yoshino

Gli scienziati premiati "per lo sviluppo di batterie agli ioni di litio" che hanno rivoluzionato le nostre vite e sono in tutti i cellulari, laptop e veicoli elettrici

Condividi 8 Tweet



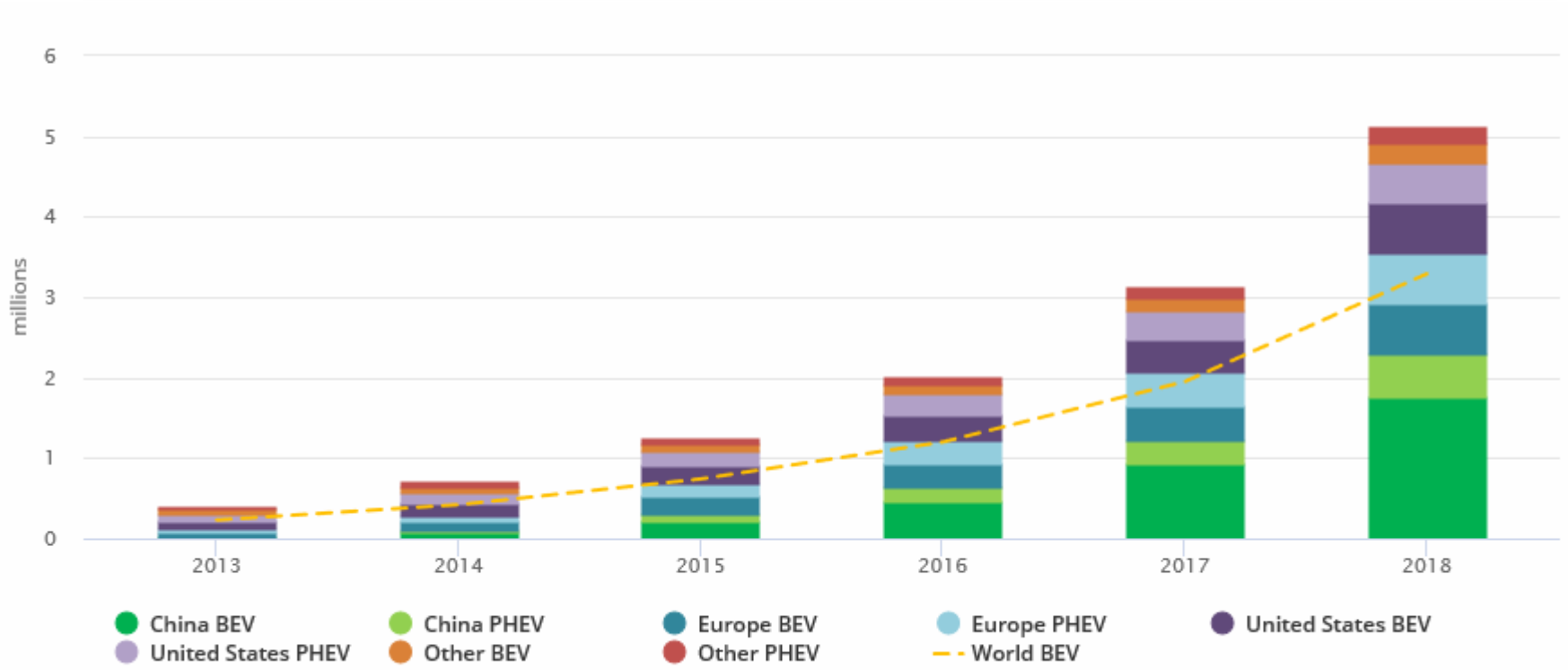
09 ottobre 2019

Il premio Nobel per la Chimica è stato assegnato a John B. Goodenough, M. Stanley Whittingham e Akira Yoshino "per lo sviluppo di batterie agli ioni di litio" che hanno rivoluzionato le nostre vite e sono in tutti i cellulari, laptop e veicoli elettrici.

I tre premiati hanno così aperto la strada a fonti di energia diverse dai combustibili fossili.

Goodenough, 97 anni, è nato in Germania, a Jena, nel 1922 e dal 1952 ha lavorato negli Stati Uniti, nell'Università di Chicago e poi in quella del Texas ad Austin. Whittingham, 78 anni, è nato in Gran Bretagna e dopo aver

EVs increase in last 5 years



- Electric passenger cars passing 5 million in 2018, +63% from 2017
- 45% of electric cars are in China – a total of 2.3 million – compared to 39% in 2017.
- Europe accounted for 24% of the global fleet, and the United States 22%.

Source IEA 2019 report

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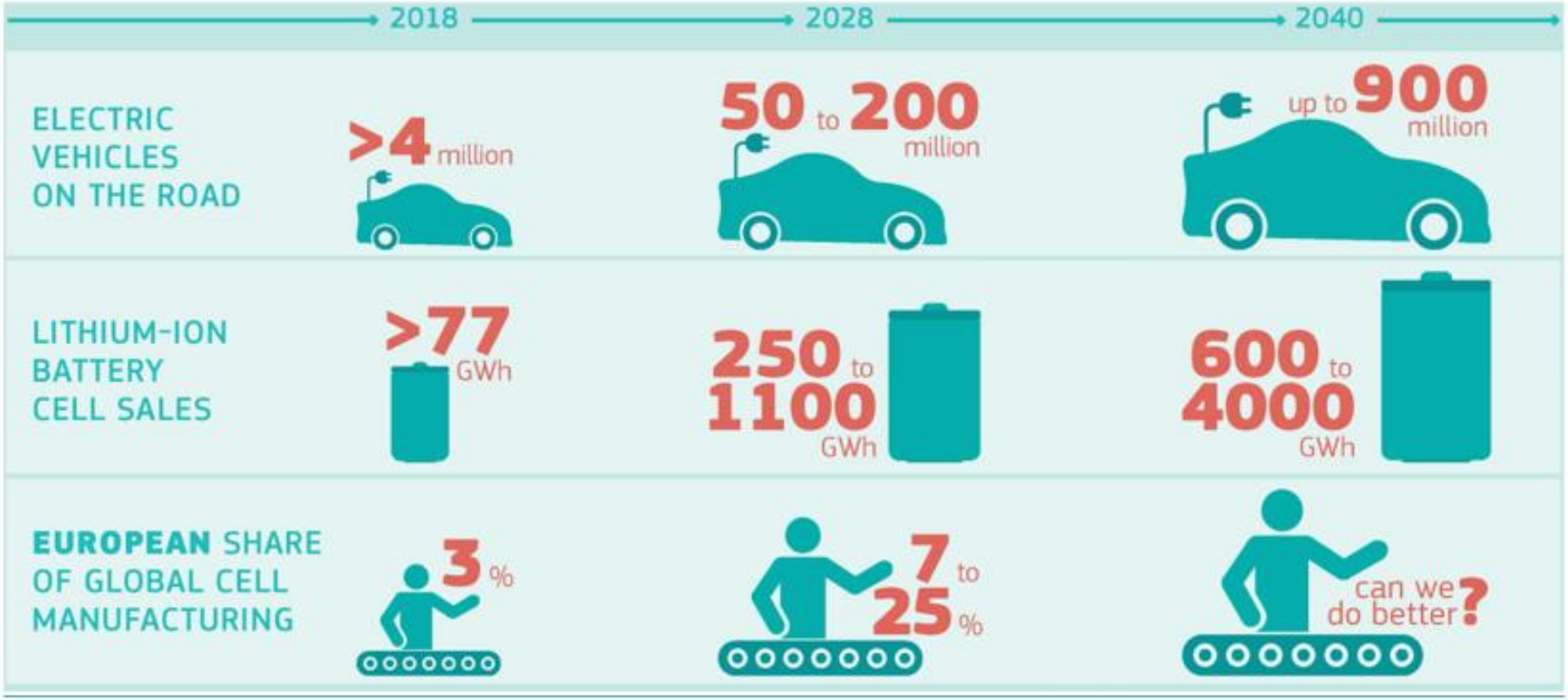
Aumento di EVs richiede una forte produzione di batterie



Global supply and demand of Li-ion batteries and the European share in manufacturing. Source: JRC

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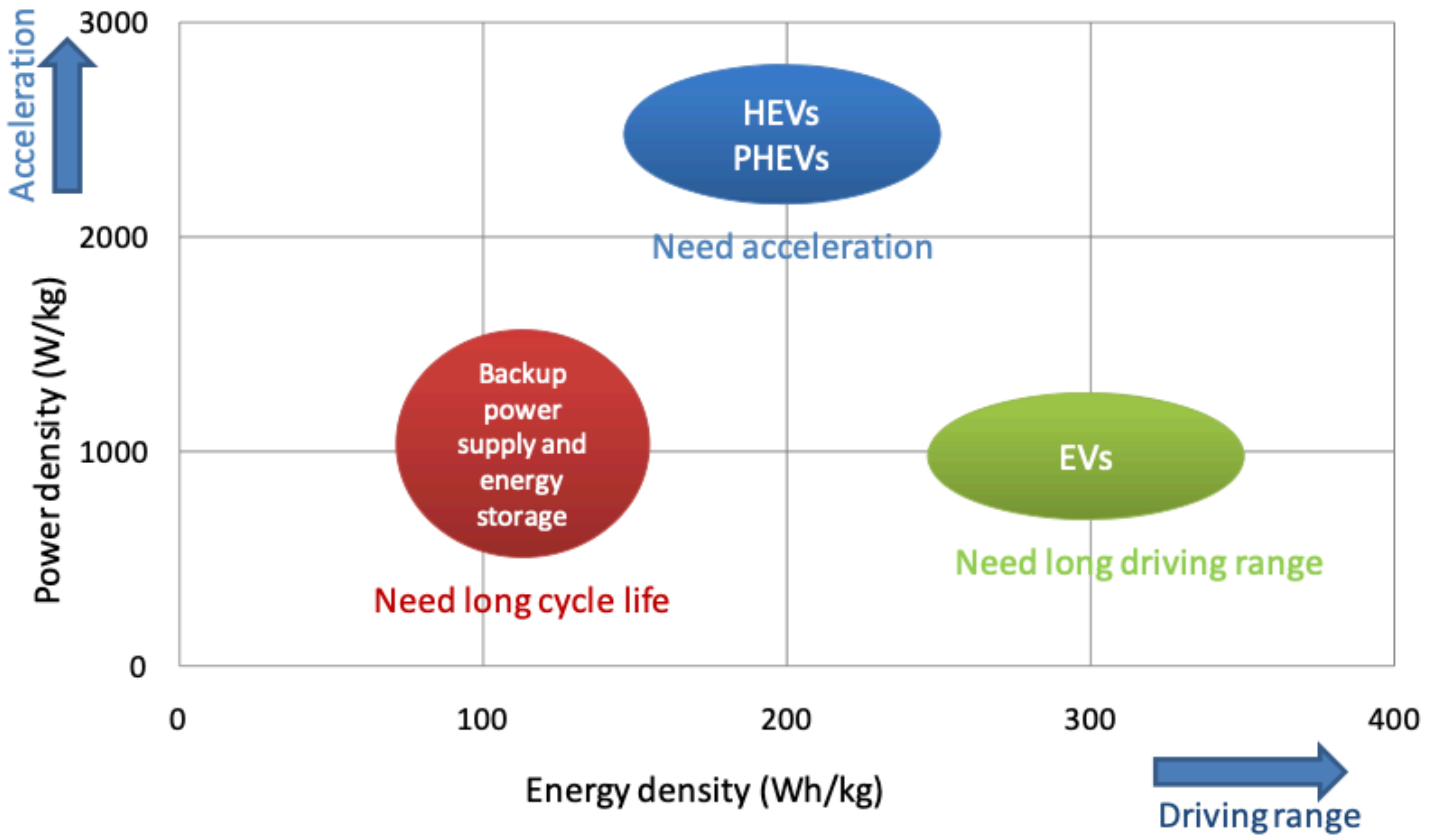
Densità di energia e potenza per batterie Litio ione per i veicoli elettrici



Source: CGGC based on (Electro to Auto Forum, 2009; NEDO, 2010)

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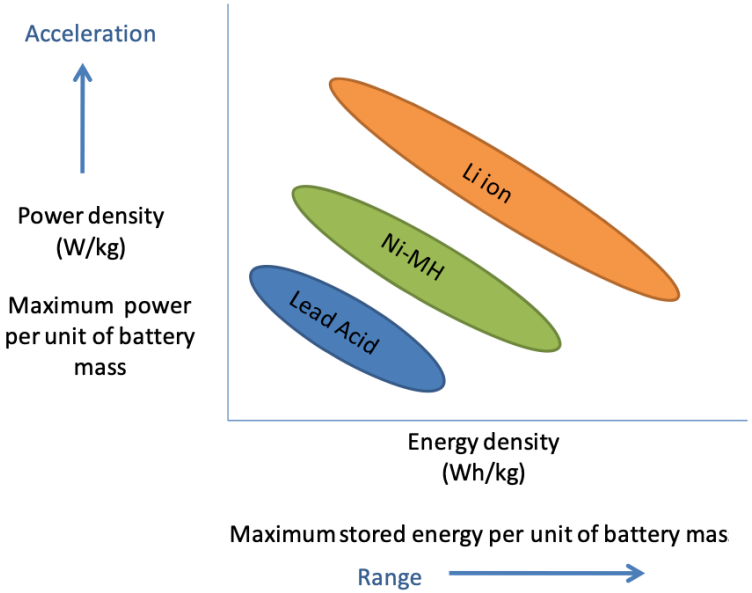
Advantages of lithium-ion batteries for vehicle use

Figure 2. Power (acceleration) and energy (range) by battery type



Source: CGGC based on (Abuelsamid, 2007)

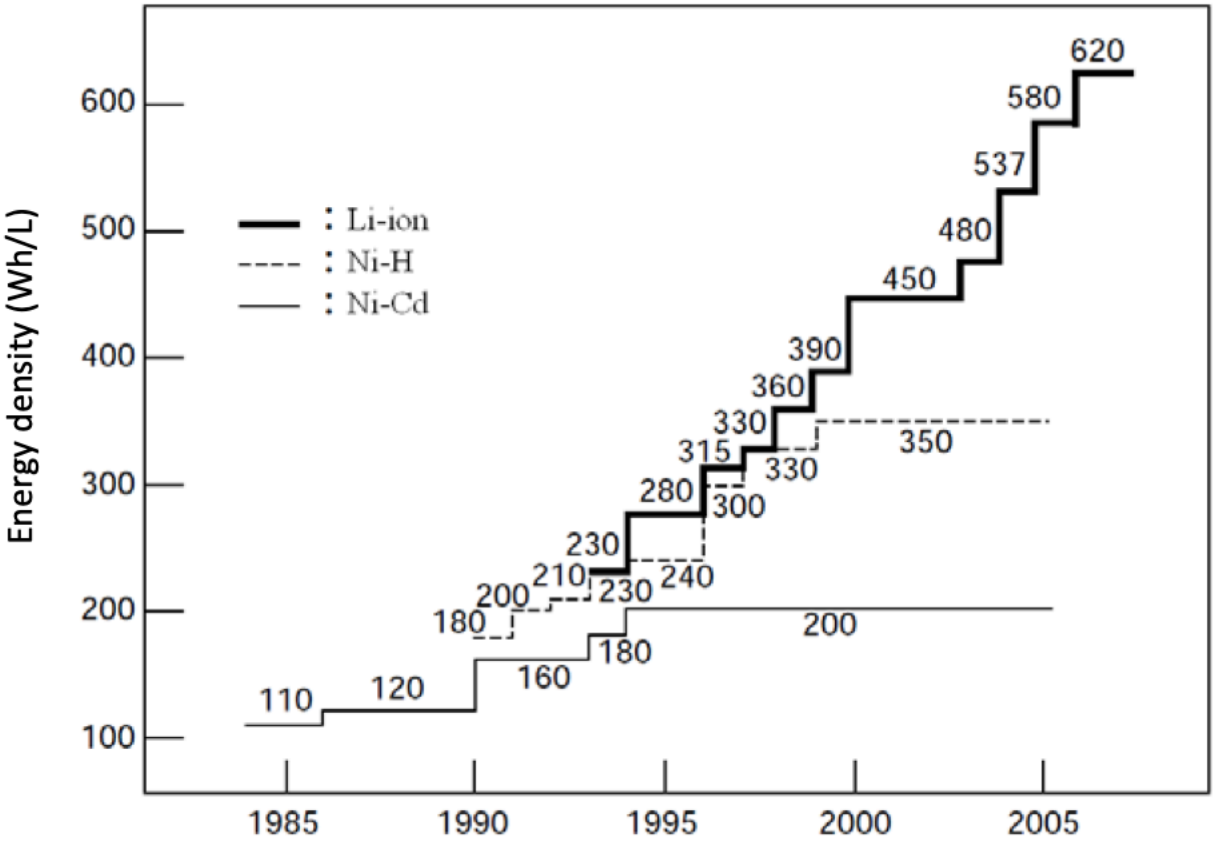
Table 1. Technical performance by existing battery type

Battery type	Lead acid	Ni-Cd	Ni-MH	Lithium-ion
Energy density [a] (Wh/Kg)	35	40-60	60	120
Power density (W/kg)	180	150	250-1000	1,800
Cycle life [c]	4,500	2,000	2,000	3,500
Cost ($/kWh)[d]	269	280	500-1,000	Consumer electronics: 300-800 Vehicles: 1,000-2,000
Battery characteristics	High reliability, low cost	Memory effect	Currently, best value and most popular battery for HEVs	Small size, light weight
Application	Car battery, forklift, golf cart, backup power	Replacement for flashlight battery	HEVs, replacement for flashlight battery	Consumer electronics

a: Chargeable electric energy per weight of battery pack
b: Proportion of dischargeable electric energy to charged energy
c: The number of charging/discharging cycles in battery's entire life
d: Calculated exchange rate is $1= 92.99 yen (05/14/2010 – www.oanda.com). Ranges given are approximate.
e: Lithium-ion batteries for consumer electronics have lower costs than those for vehicle use because of high-volume production and a mature market.

Source: (Deutsche Bank, 2009; METI, 2009a; Nishino, 2010; The Institute of Applied Energy, 2008; Woodbank Communications Ltd, 2005)

Miglioramenti in termini di **densità di energia** per anno



Source:(Ikoma, 2006)

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e ora vi spiego come è fatta una cella Litio ione..

ma intanto…..

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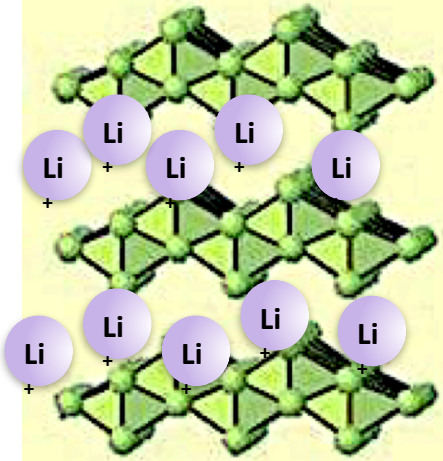
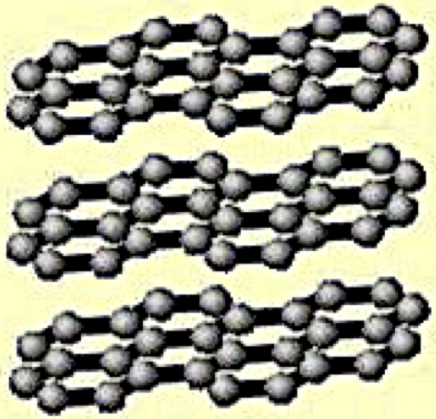
Lithium ion cells





Cathode : $LiMn_2O_4$ spinel
$LiCoO_2$ cobaltite

Anode : metallic Li foil
graphite
intercalation compounds

$$LiM^{+n}O_x \xrightarrow{\text{charge}} M^{+(n+1)}O_x + Li^+ + e$$

Metal oxidation

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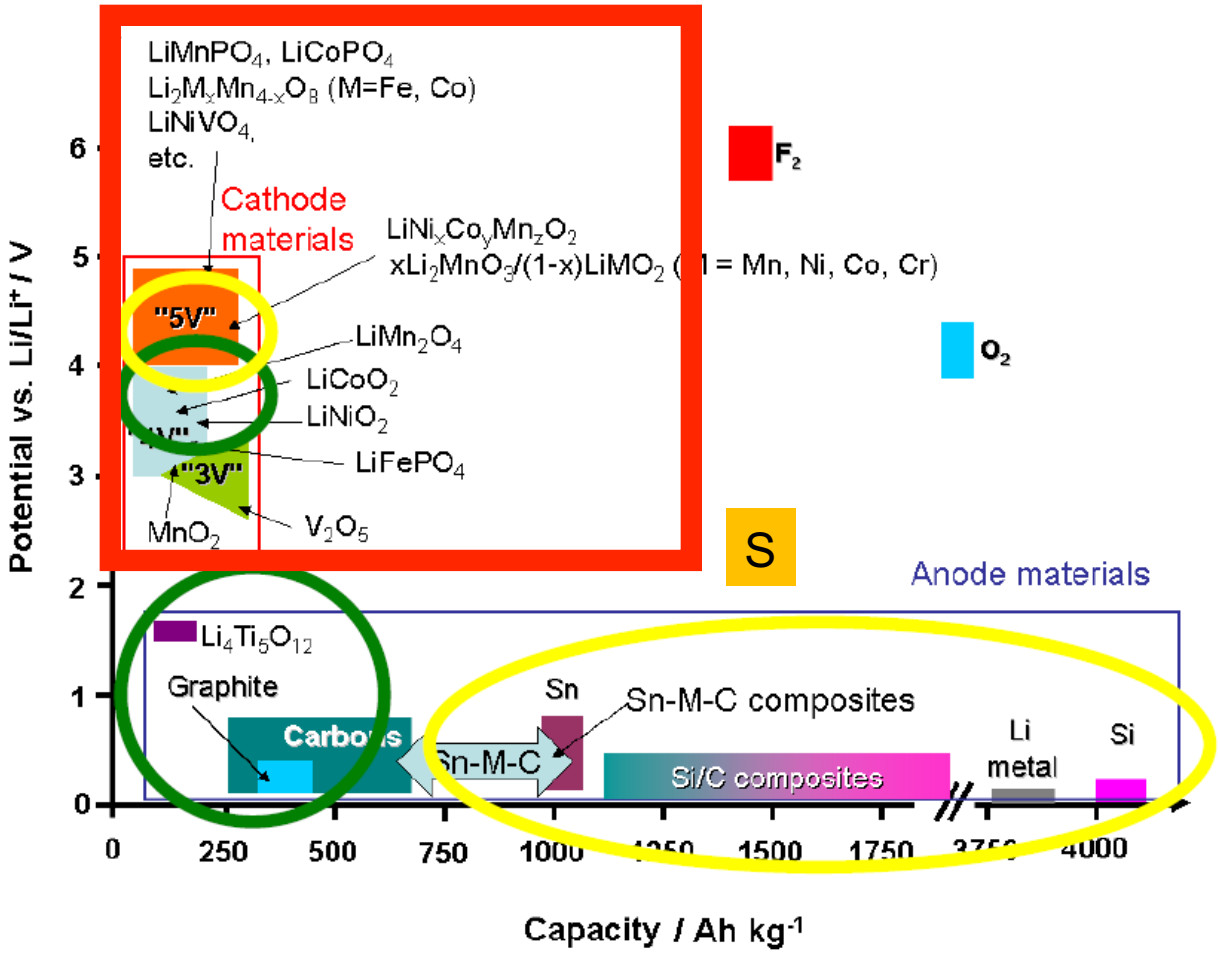

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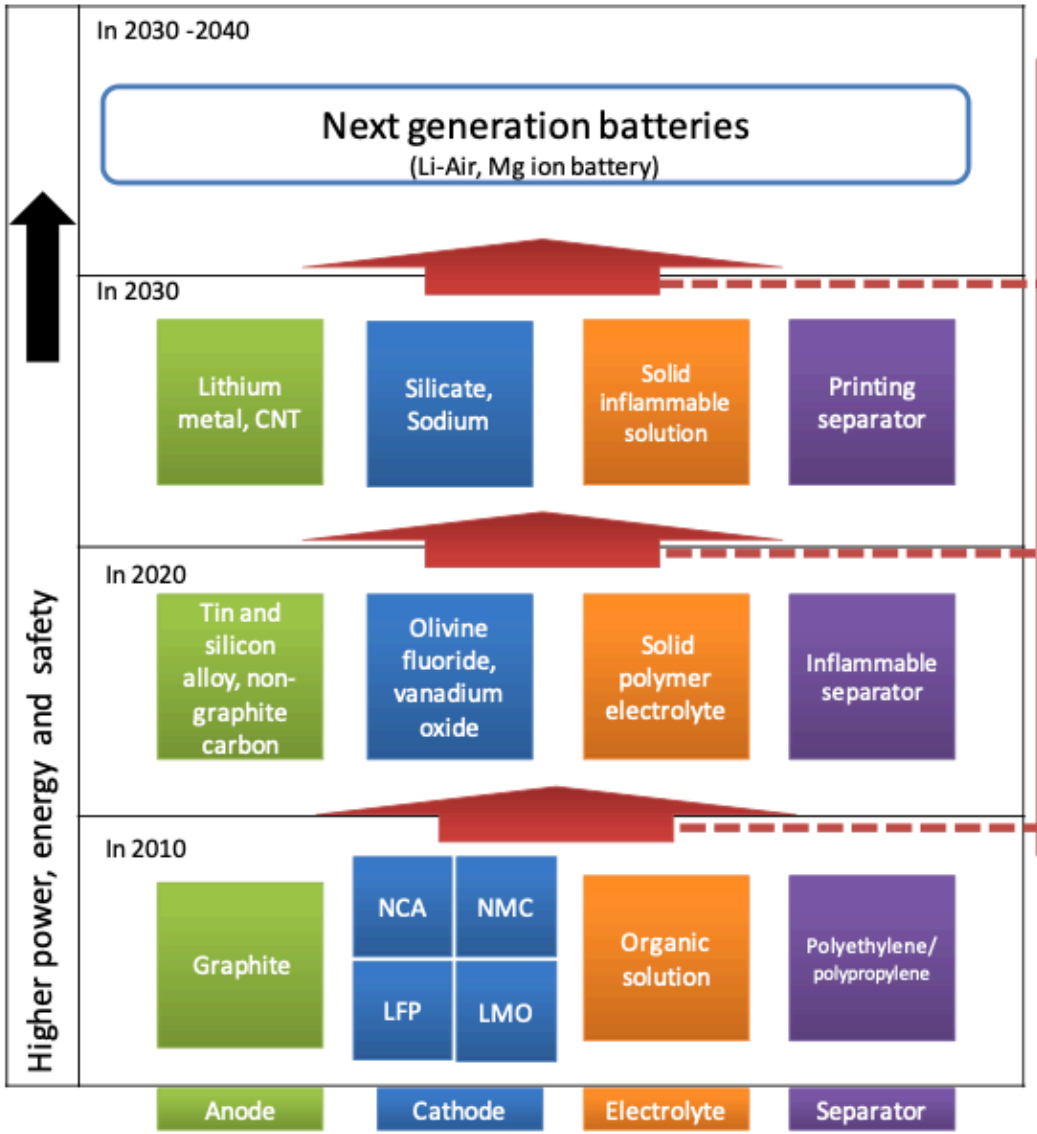
FUTURO

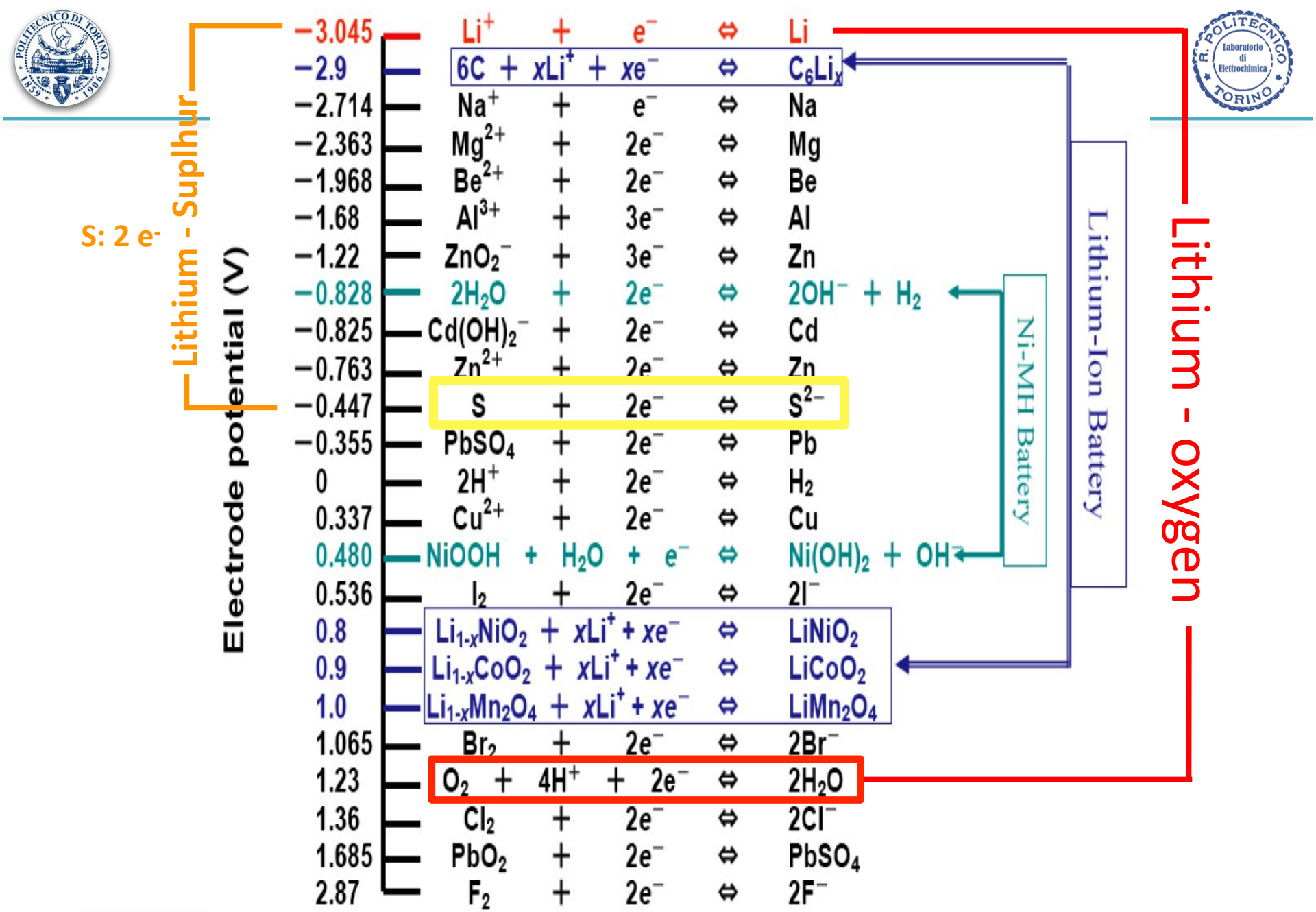
Lithium - ion battery roadmap



Nanotechnology to increase battery safety and battery performance

- Nano-sized anode/cathode with higher power density
- Nano-sized anode/cathode with higher energy density
- Nano-sized anode/cathode to increase battery charging speed
- Nanomaterials to increase electric conductivity of anode and cathode (ex. CNT)
- Nanomaterials to increase thermal stability
- Nanotechnology to overcome adverse conditions
- Nanomaterial property and size control technology
- Nanomaterial evaluation technology

Source: CGGC based on (DOE, 2009; NEDO, 2008)



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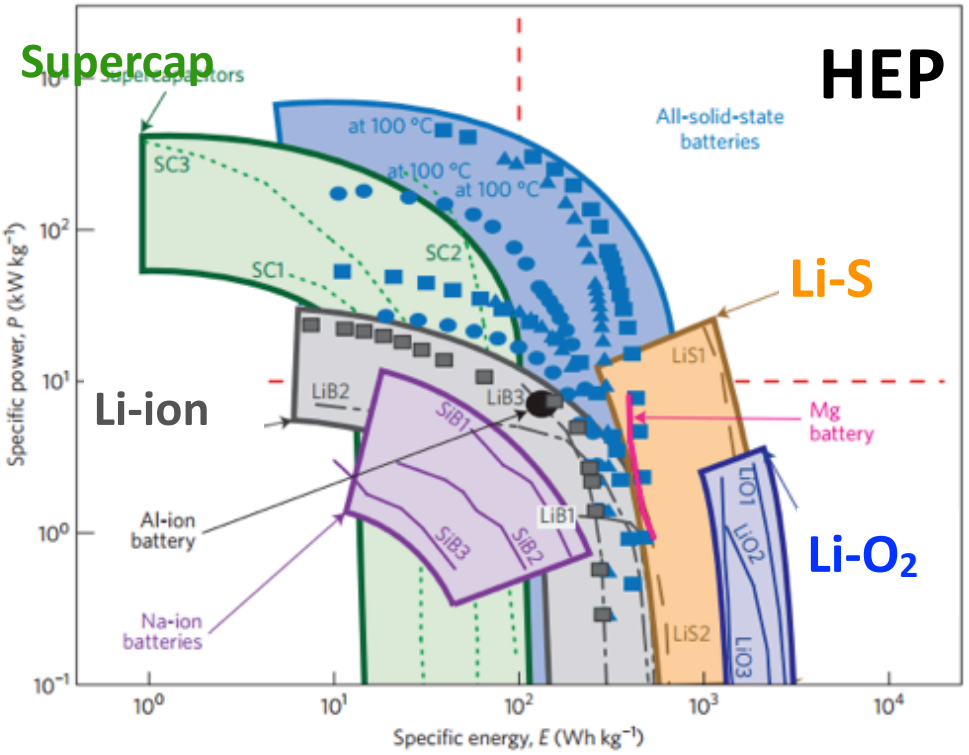

Li-S higher TRL

Li-Air lower TRL

Challenge:
High energy together with high power

is it possible?

HEP

■ $Li_4Ti_5O_{12}$/$LiNbO_3$-coated $LiCoO_2$
● $Li_4Ti_5O_{12}$ + LGPS/LGPS/$LiNbO_3$-coated $LiCoO_2$ + LGPS
▲ $Li_4Ti_5O_{12}$ + LSiPSCl/LSiPSCl/$LiNbO_3$-coated $LiCoO_2$ + LSiPSCl
■ Graphite + LPS/LPS | LGPS/$LiNbO_3$-coated $LiCoO_2$ + LGPS

SC1: activated carbon/activated carbon
SC2: reduced graphene oxide RuO_2/RuO_2-polyaniline
SC3: activated carbon/activated carbon

LiB1: graphi
LiB2: Li/LiF
LiB3: Li_4Ti_5

SiB1: $Na_3V_2(PO_4)_3$ (NVP) + graphene/NVP + graphene
SiB2: NVP + CNT/NVP + CNT
SiB3: NVP + activated carbon (AC)/NVP + AC
Al-ion battery: Al/graphite
Mg battery: Mg/V_2O_5

LiS1: Li/S (graphene + single-walled CNT)
LiS2: Li/S

LiO1: Li/O_2 (graphene)
LiO2: Li/O_2 (carbon nan
LiO3: Li/O_2 (carbon nan

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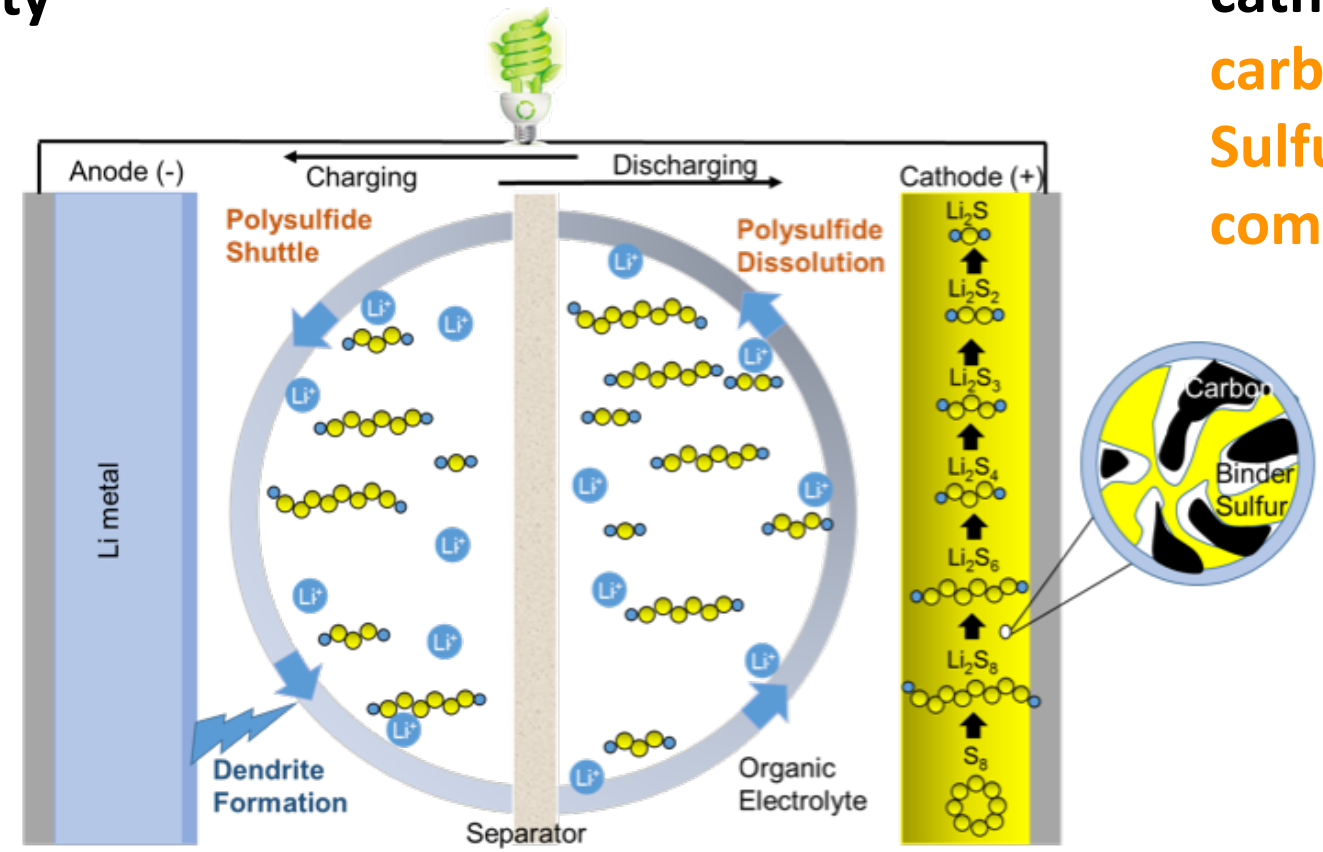
Lithium Sulphur (conversion)

high capacity anode:
Li metal



cathodes:
carbon / Sulfur composite

2 electrons process

High energy density
(theor 1675 mAh/g)

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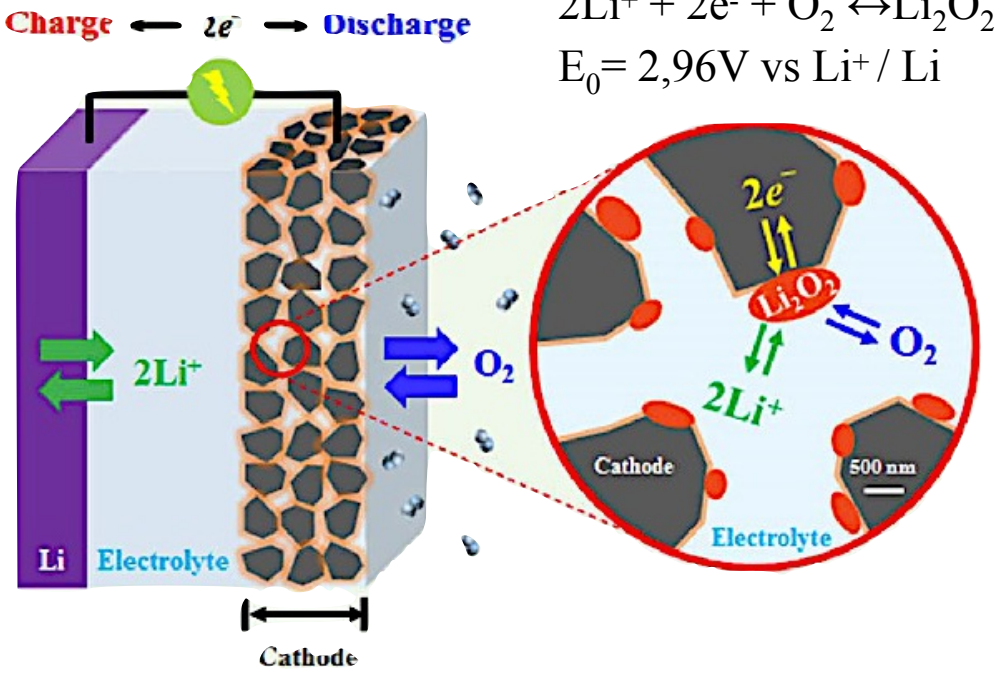
Lithium air

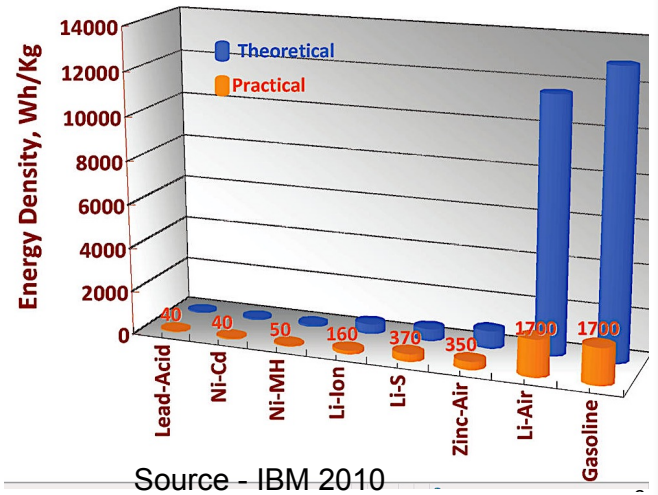
Non aqueous system:

$2Li^+ + 2e^- + O_2 \leftrightarrow Li_2O_2$

$E_0 = 2{,}96V$ vs Li^+ / Li



- theoretical specific energy: 11500 Wh kg^{-1} (practical 1000-3000 Wh kg-1)



Source - IBM 2010

*Y. Shao, S. Park, J. Xiao, J-G. Zhang, Y. Wang, J. Liu, ACS Catal., **2012**, 2, 844-857*

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ma vale la pena?

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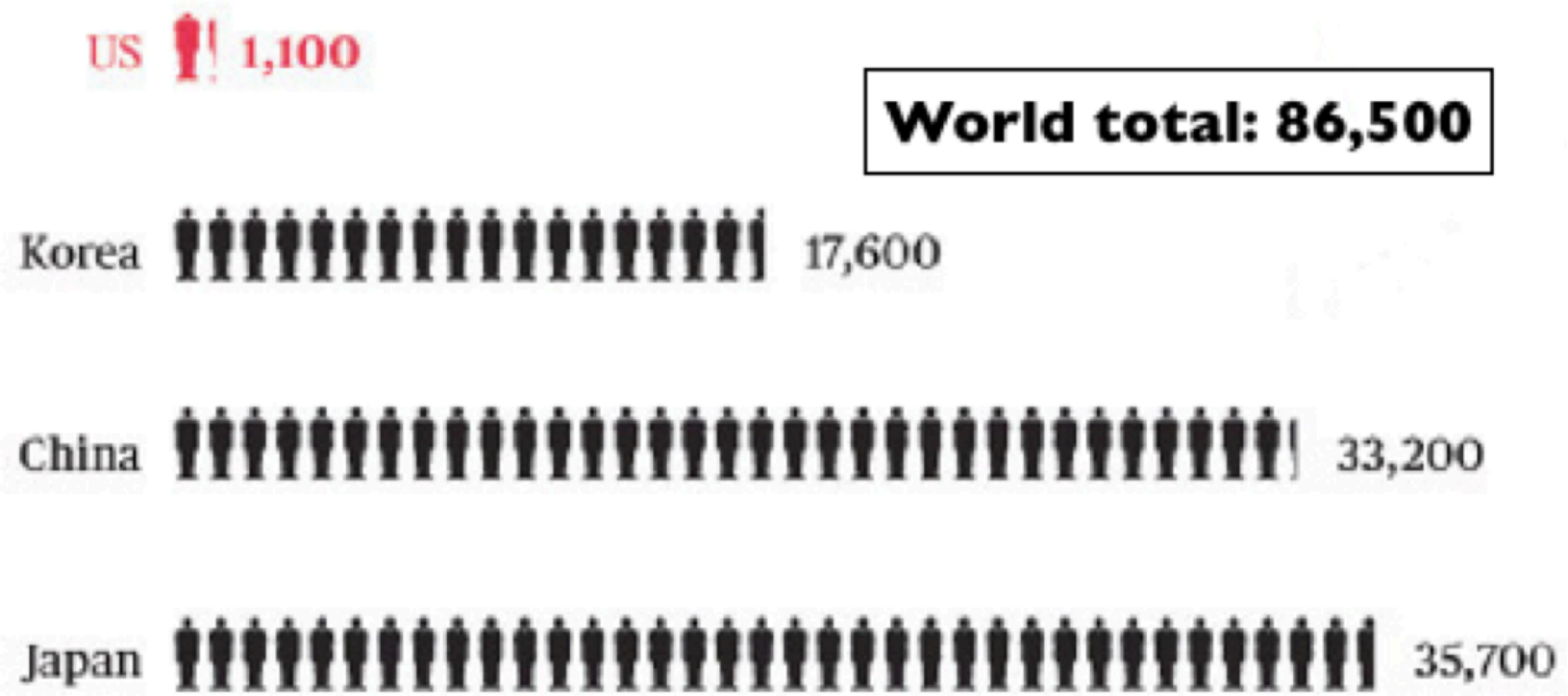
posti di lavoro nelle aziende di batterie Li-ione nel 2010



Source: (Grove, 2010)

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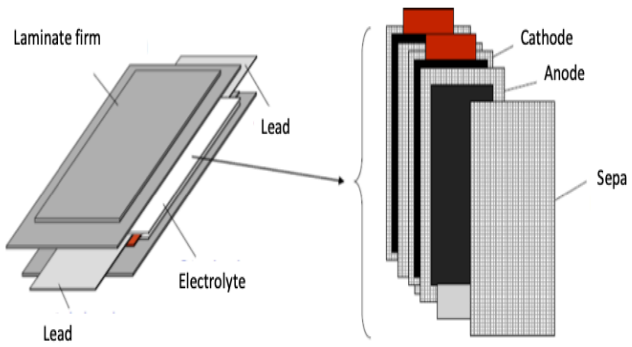
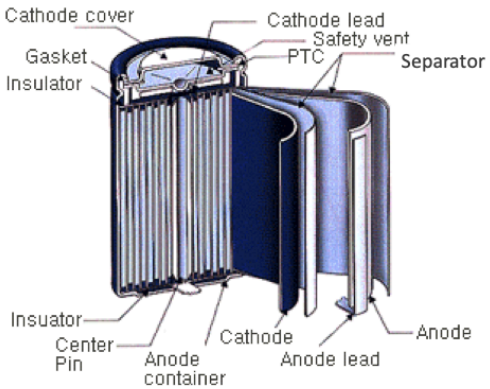
La Batteria è un sistema complesso.. lavoro per tutti

Figure 13. Structure of a stack lithium-ion battery

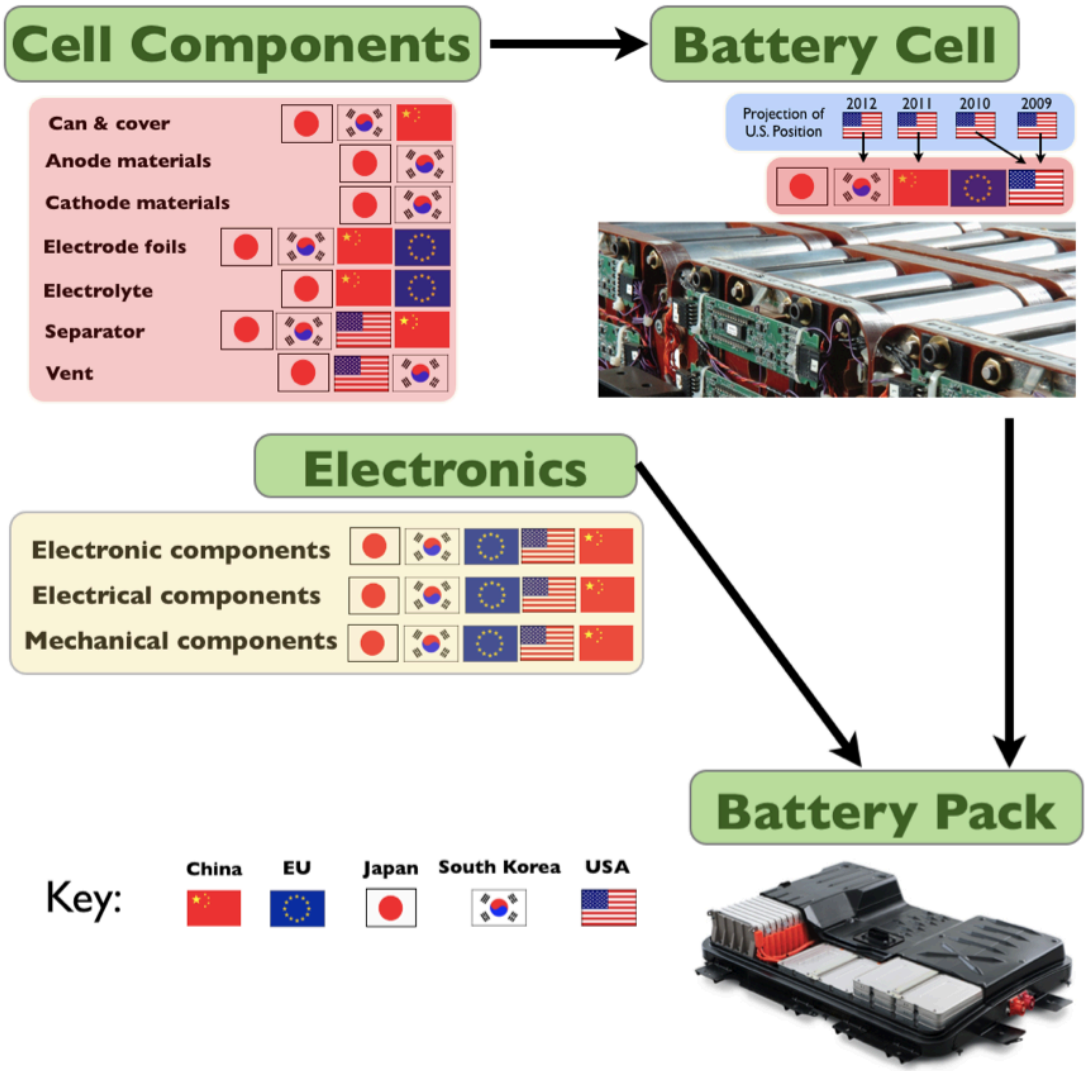


Source: (Kishida et al., 2004)



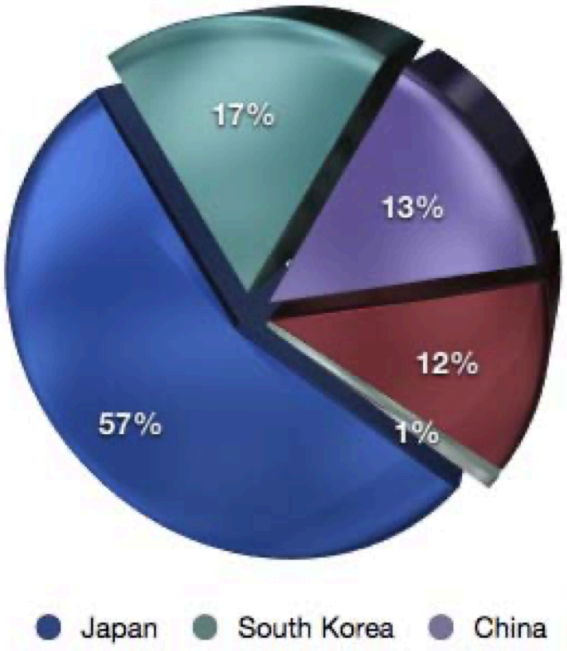
Source: (GM-Volt, 2008)

Figure 8. Lithium-ion cell & battery manufacturing, market share, by country



Source: CGGC and (Davis, 2010; Dunn, 2010; Ellerman, 2010). Images:(Abuelsamid, 2007; Argonne National Laboratory, 2010; inhabitat, 2010)

Il mercato globale di batterie Li-ione



1. Sanyo (Japan)	23%
2. Samsung (Korea)	15%
3. Sony (Japan)	14%
4. BYD (China)	8.3%
5. LG Chem (Korea)	7.4%
6. BAK (China)	6.6%
7. Panasonic (Japan)	6.0%
8. Hitachi Maxell (Japan)	5.3%
9. ATL (China)	3.8%
14. A123 Systems (U.S.)	**1%**

Source: CGGC, based on(METI, 2010; NEDO, 2009)

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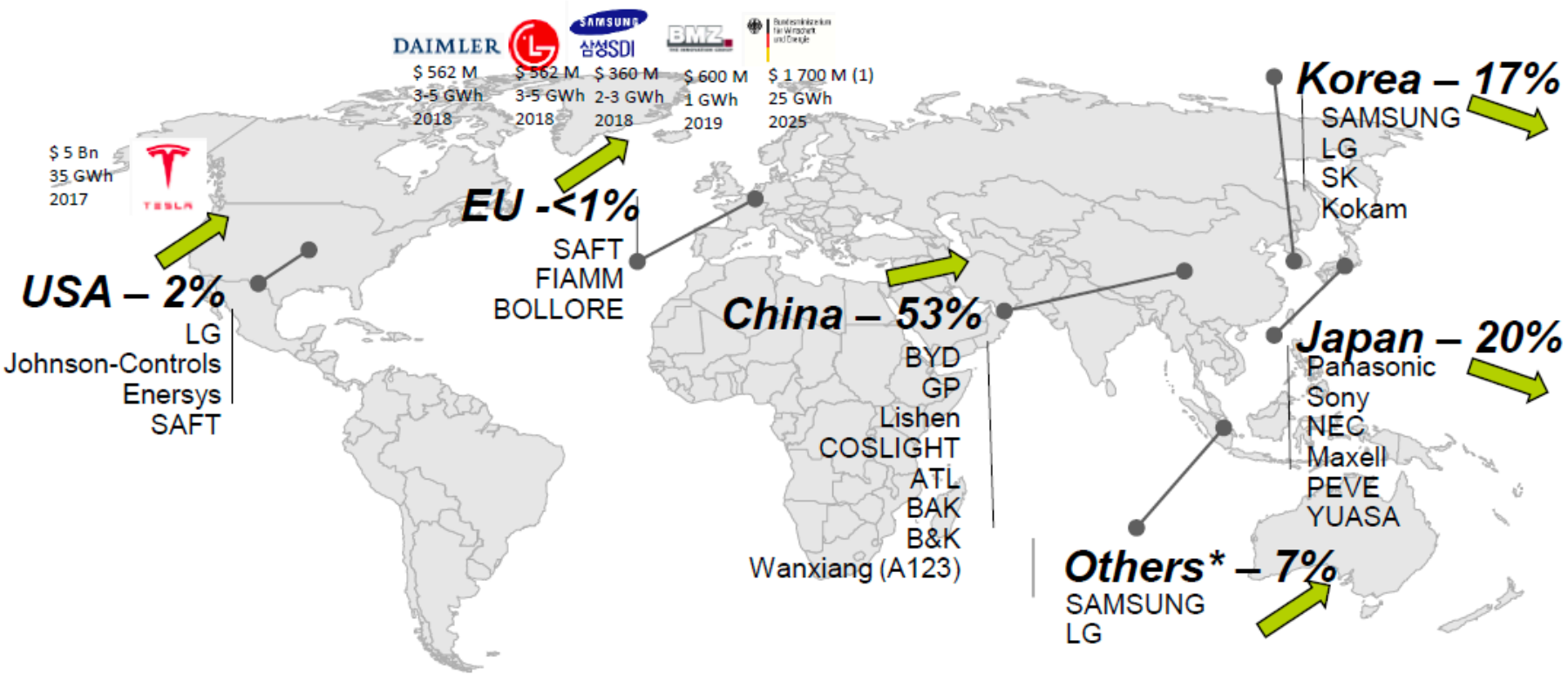

Source: AVICENNE 2017

** OTHERS: Malaysia mostly*
(1) Government subsidies only

and Europe?
new opportunities?

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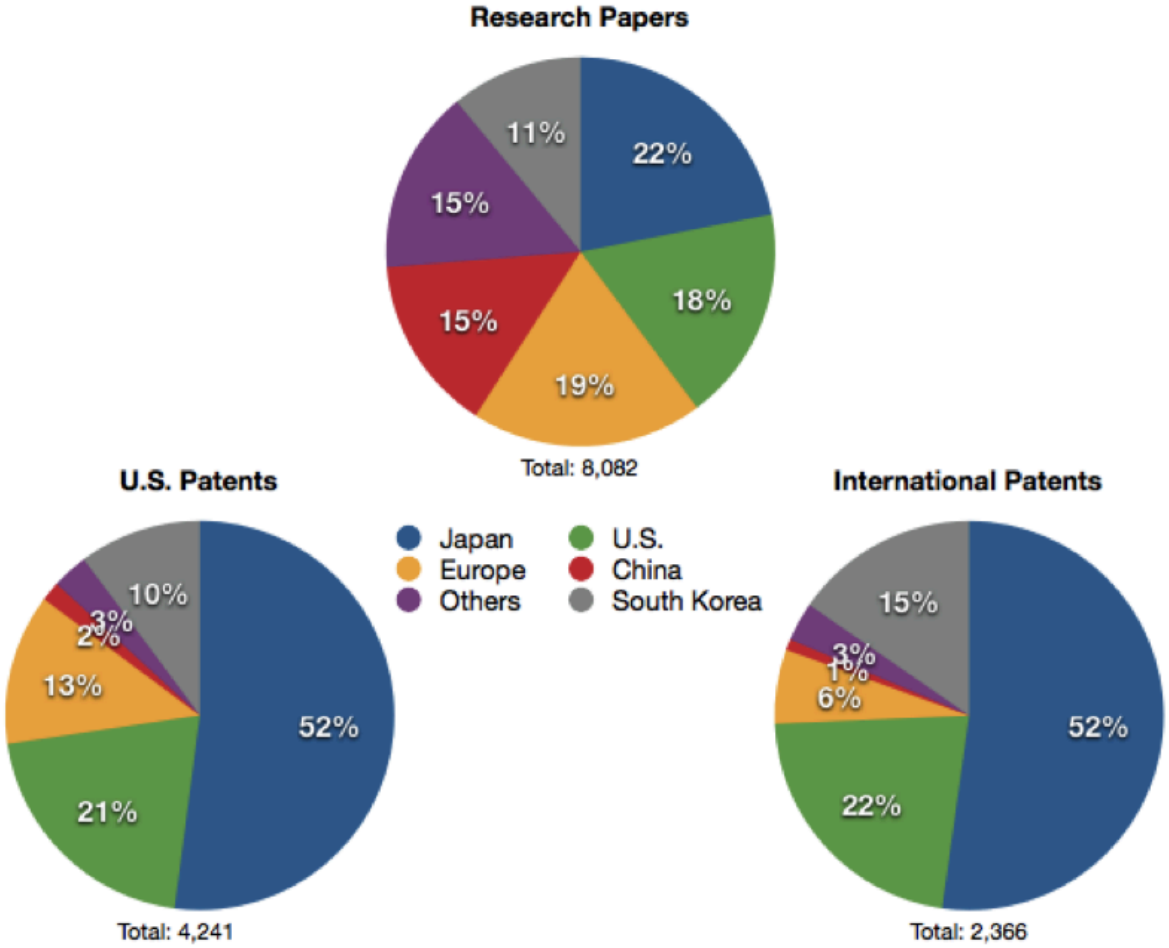
le conoscenze nell'ambito



Source: (METI, 2009b).

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[8] These include patents for non-automotive applications.

[9] Research papers include 46 academic papers in journals such as Journal of Power Sources, Journal of Physical Chemistry, Chemistry of Materials, Nature and Science (METI, 2009b).

Ma l'EUROPA .. cosa fa?

ma intanto…..

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in Europe

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A LONG-TERM RESEARCH INITIATIVE IN THE BATTERY R&I LANDSCAPE

TRL 1 TRL 2 TRL 3 TRL 4 TRL 5 TRL 6 TRL 7 TRL 8 TRL 9

Scope	Long-term research	Short-to-medium term research	Industrialization
Actors	BATTERY 2030+ The European Battery Community	HORIZON 2020 / Horizon Europe	European Battery Alliance
Roadmap	A long-term research roadmap (FETPROACT-04-2019 CSA)	SET-Plan	Industrial roadmaps

POLITO
Only Italian Partner

Regional IPCEI

BATTERIES EUROPE

INTERREG
AMBP

November 20th roadmap workshop in Brussels

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Confirmed Working Group Chairs and Co-Chairs for first year of operation

Thematic Working Groups	WG1 New & Emerging Battery Technologies	WG2 Raw Materials and Recycling	WG3 Advanced Materials	WG 4 Manufacturing and Cell Design	WG5 Application and Integration-Mobile	WG6 Application and Integration-Stationary
Chair	*Kristina Edström* **Uppsala University**	Ilkka Kojo **Outotec**	Fabrice Stassin **Umicore**	Oscar M. Crespo **CIDETEC**	Simon Perraud **CEA**	Luigi Lanuzza **ENEL**
Sherpa	*Ivana Hasa*, **KIT**	*Mari Lundström*, **Aalto university**	Marcel Meeus, **EMIRI**	Arno Kwade, **TU Braunschweig**	*Lucie Beaumel* **EGVIA**	*Rachele Nocera*, **ENEA**
Co Chair	Stefano Passerini **Helmholtz Institute**	Olli Salmi **EIT Raw Materials**	*Silvia Bodoardo* **Politecnico di Torino**	Carlo Novarese, **FAAM/Lithops**	Franz Geyer **BMW**	Javier Olarte **CIC Energigune**
Co-Chair	Philippe Stevens **EDF**	Alain Vassart **EBRA**	Daniel Gloesener, **Solvay**	Michael Krausa **KLIB**	Josef Affenzeller **AVL**	Jesus Varela Sanz **Iberdrola**
	Research	Industry				

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2020. A new decade… New opportunities

Homepage > L'angolo della stampa > Aiuti di Stato: la Commissione approva un sostegno pubblico di 3,2 miliardi di € da parte di sette S

Lingue disponibili: italiano

Comunicato stampa | 9 dicembre 2019 | Bruxelles

Aiuti di Stato: la Commissione approva un sostegno pubblico di 3,2 miliardi di € da parte di sette Stati membri a favore di un progetto paneuropeo di ricerca e innovazione in tutti i segmenti della catena del valore delle batterie

Commission approves €3.2 billion support by seven Member States for project of common European interest for battery value chain

Raw and advanced materials	Cells and modules	Battery systems	Repurposing, recycling and refining
BASF	ACC	BMW	BASF
Eneris	BMW	Endurance	Endurance
Keliber	Endurance	Enel X	Elemental
Nanocyl	Eneris	Eneris	Eneris
Solvay	FAAM	Kaitek	FAAM
Terrafame	SEEL	SEEL	Fortum
Umicore	VARTA		SEEL
			Umicore

https://ec.europa.eu/commission/presscorner/detail/it/ip_19_6705

Over 300 GWh/a Li-Ion Battery Cell Production Capacity Announced in Europe

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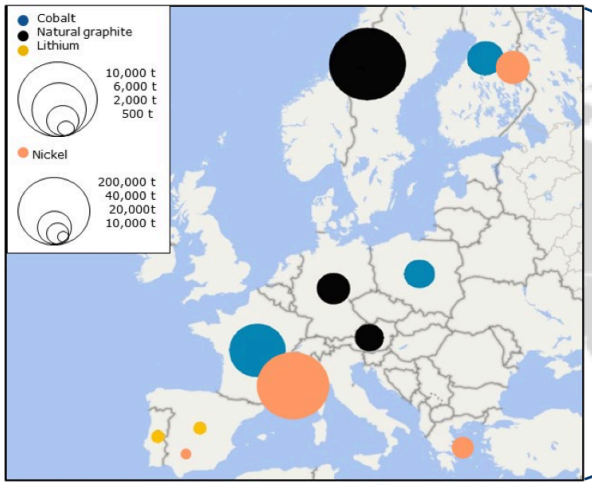
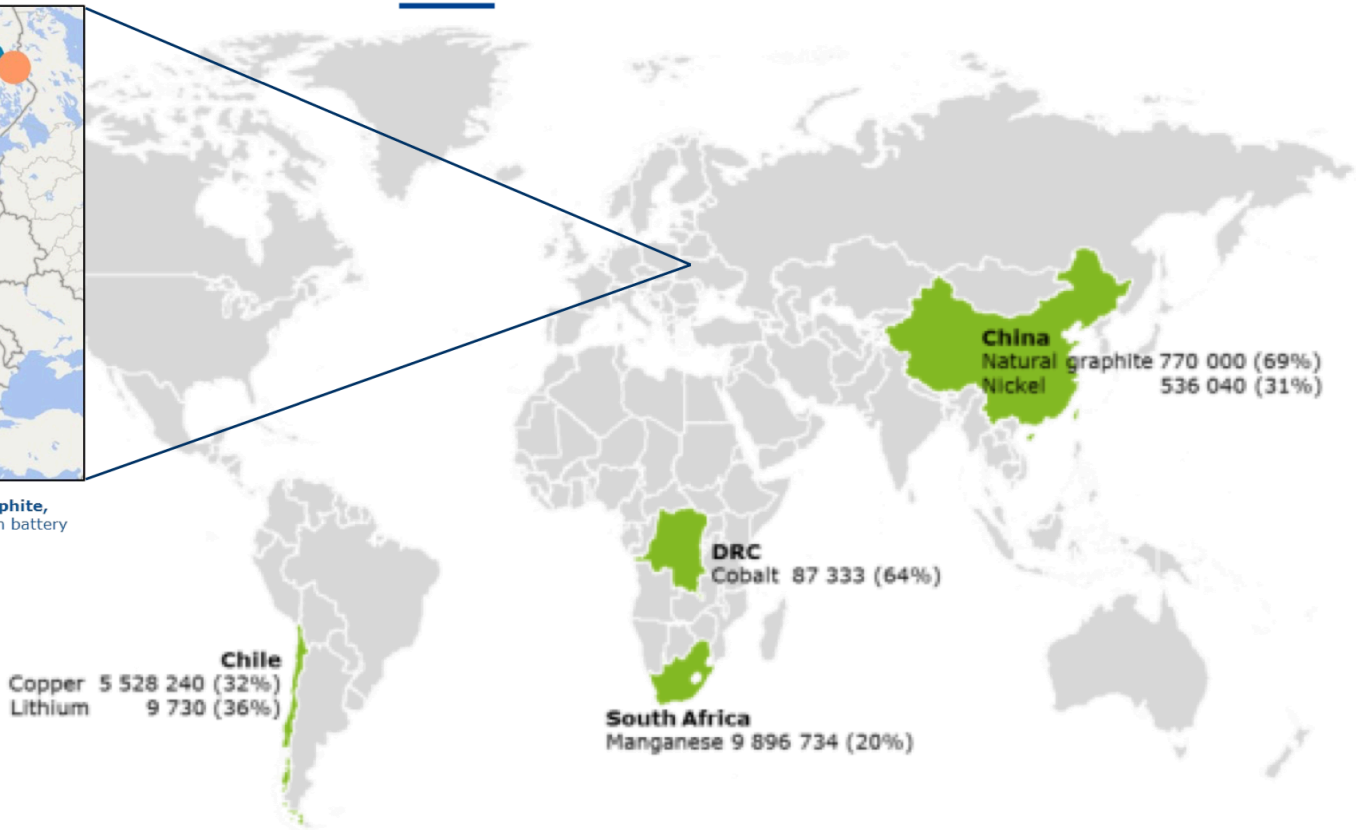
Ma i materiali in Europa… ci sono?

Global and EU production of battery materials

Raw Materials Initiative EU Critical Raw Materials



Mining production in Europe: cobalt, lithium, natural graphite, nickel; metallic content, tonnes (2016) (Source: Survey on battery raw materials RMSG, 2018)



Raw Materials

(tonnes, percent of global supply)
Study on the review of the list of critical raw materials 2017

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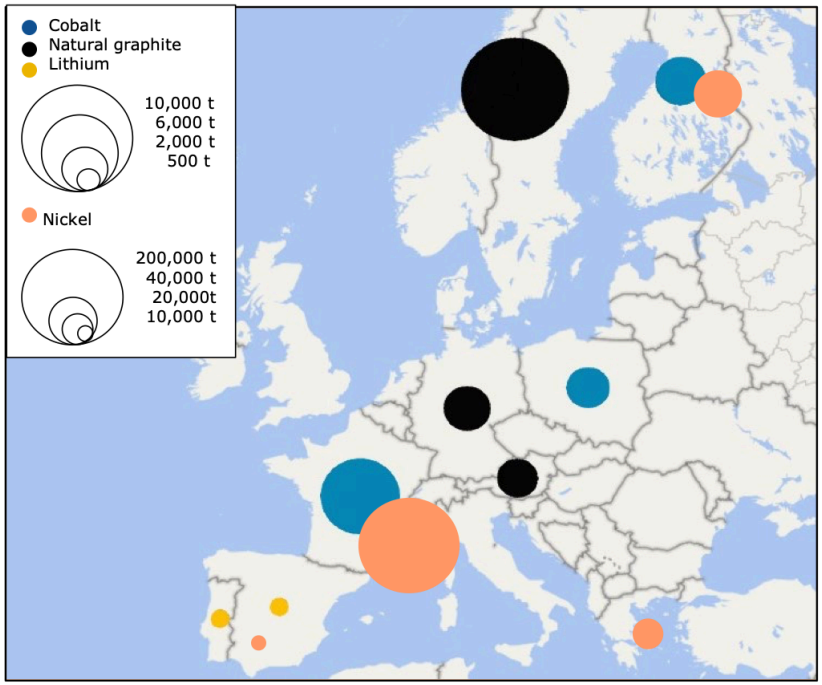
Mining production



Mining production in Europe: cobalt, lithium, natural graphite, nickel; metallic content, tonnes (2016) (Source: Survey on battery raw materials RMSG, 2018)

Cobalt: 9,698 t (7.7%)
Lithium: 322 t (0.9%)
Natural graphite: 12,650 t (1.1%)
Nickel: 270,126 t (13.8%)

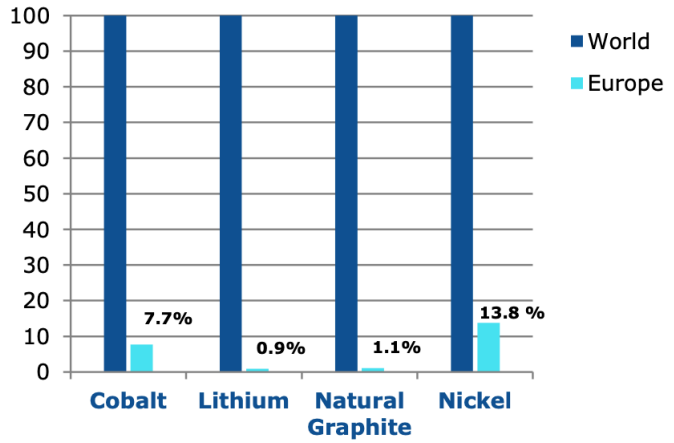


Figure 2 – World share of European production (2016) (Source: Survey Member States- RMSG, 2018)

Raw Materials

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e il litio?

Ongoing projects

Mobility package
Action Plan on Batteries
Battery raw materials

Commercial projects

Lithium (reserves)

- Alvarrões, Mina do Barroso (PT): 38,940 t
- Keliber (FI): 35,750 t

Potentially commercial projects

Lithium (resources;(reserves))

- Alvarrões, Mina do Barroso: 79,110 t
- Argemela, Sepeda (PT): 89,810 t
- Cinovec (CZ): 1,285,790 t
- Keliber (FI): 50,970 t
- San Jose (ES): 313,860 t
- Wolfsberg: 51,160 t
- Zinnwald (DE): 132,740 t

Non-commercial projects

- Co (10); Li (3); Graphite (2);Ni (21)

Exploration projects

- Co (10); Li (3); Graphite (2);Ni (21)

Lithium projects

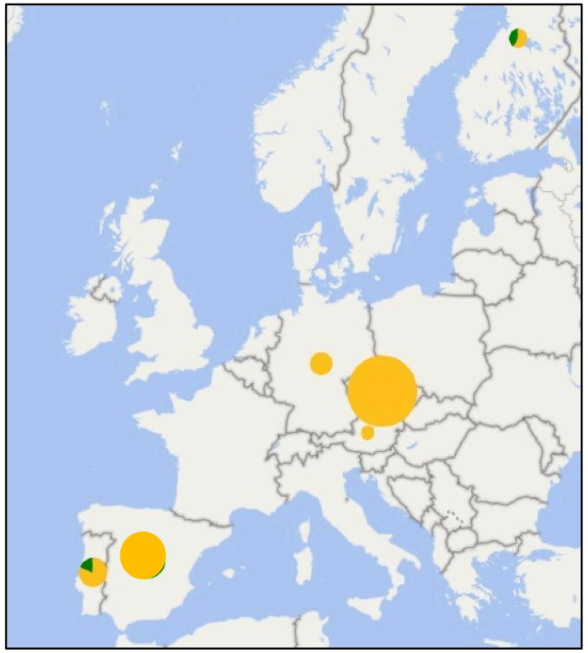

Figure 5 – Lithium potentially commercial projects (2016)
(Source: Survey on battery raw materials - RMSG, 2018)

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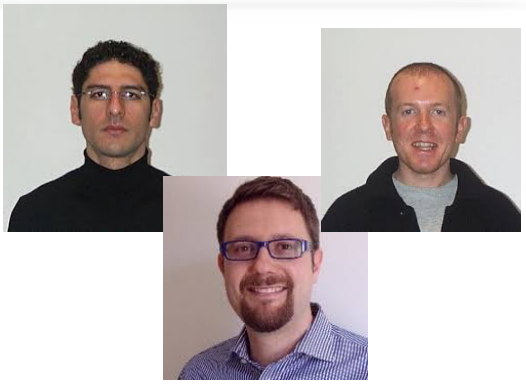
POLITO TASK FORCE ON BATTERIES

EC-lab, PEIC, CARS interdipartimental labs

Task force on modeling:

Daniele Marchisio DISAT - materials production process
Pietro Asinari DENERG - electrode-electrolyte interface
Massimo Santarelli DENERG - Electrochemical and thermal model



Task force on battery pack, BMS and Power electronics

Paolo Guglielmi DENERG- module and battery pack assembly
Radu Bojoi DENERG - BMS
Michele Pastorelli DENERG- power electronics

Electric vehicle applications and integration

Massimiliana Carello DIMEAS - EVs

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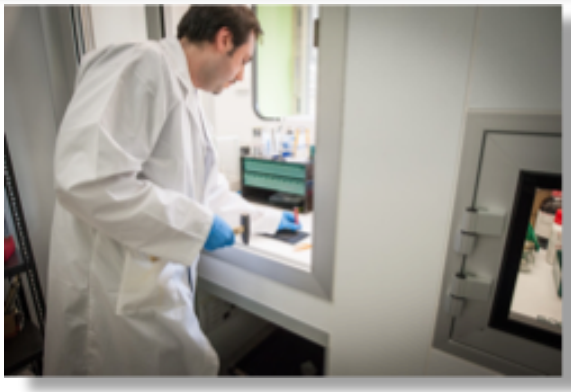
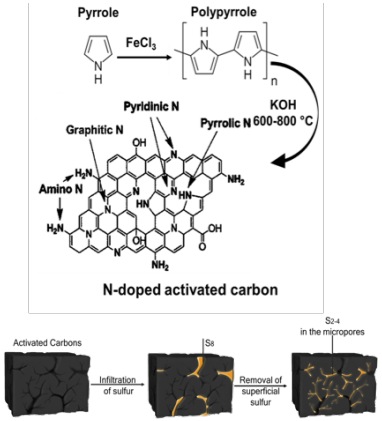
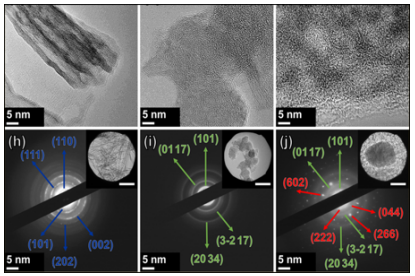
Electrochemistry group @Polito

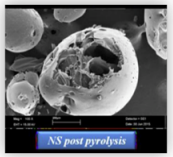


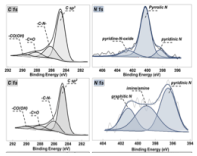
material synthesis



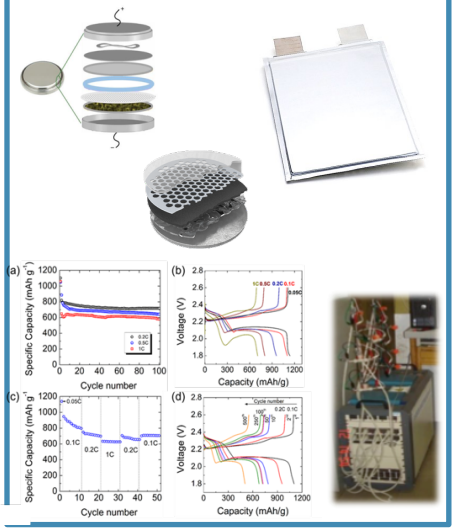
characterization







cell assembly & testing @ labscale



testing battery packs & modules

ENERGY CENTER

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Thank you Electrochemistry Group

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Thank you
for your kind attention

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