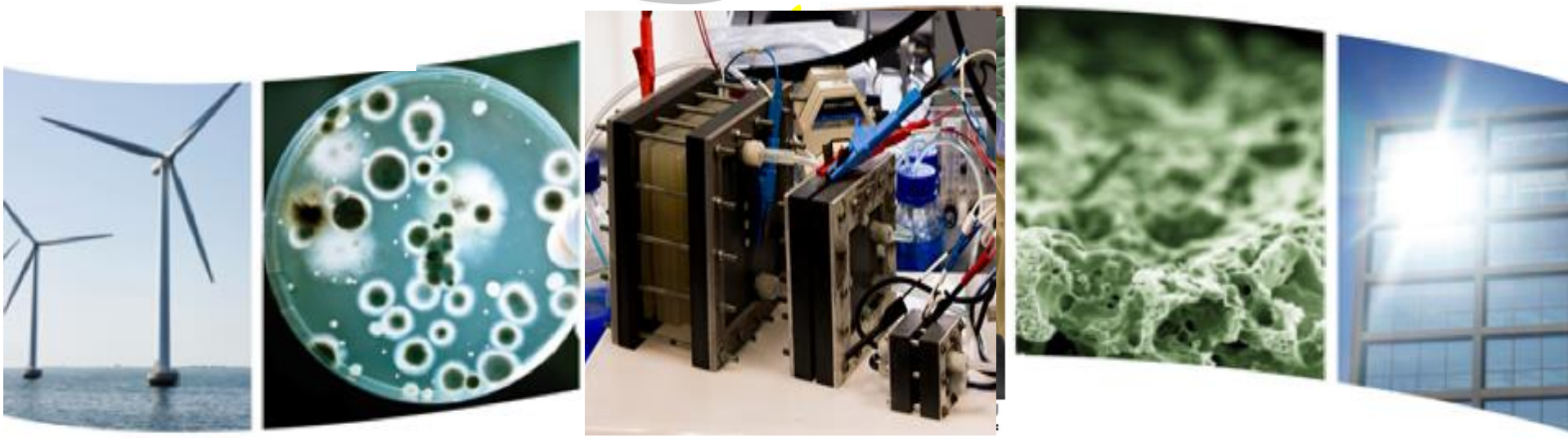


Energy storage and sustainable mobility

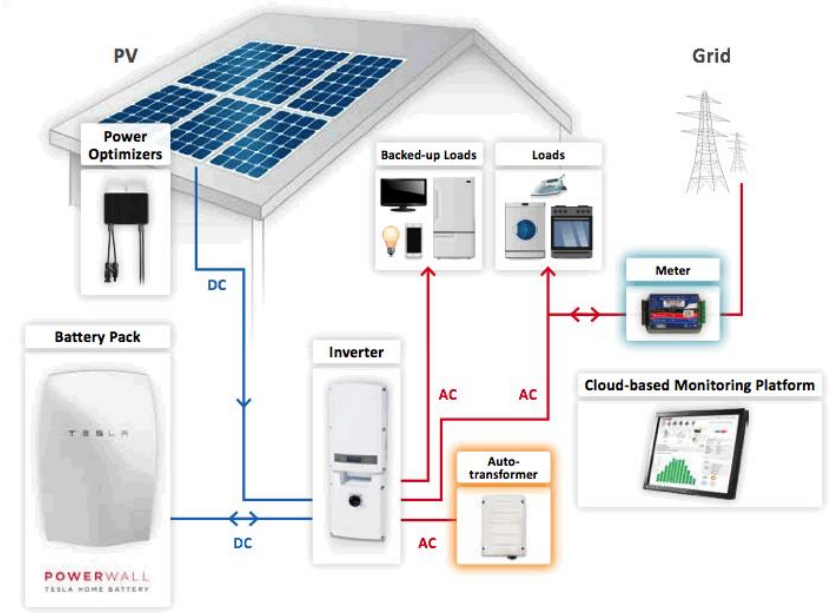
J.R.Morante

IREC, Catalonia Institute for Energy Research, Plaça de les Dones de Negre,1.
Sant Adrià del Besòs, 08930. Spain.
Department of Electronics, University of Barcelona, C/Martí i Franquès,1.
Barcelona,08028. Spain.

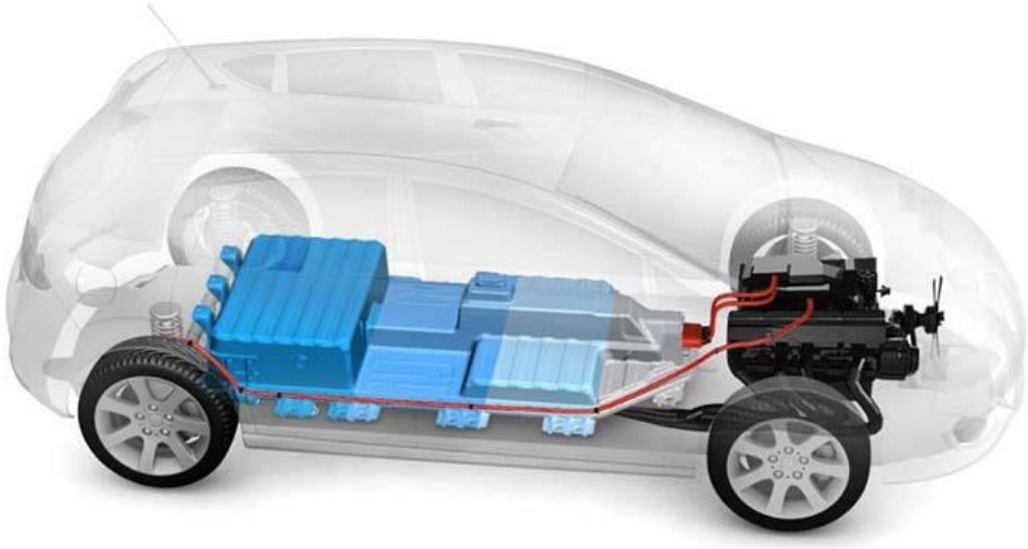
1 Energy density (Wh/Kg)

Celullar phone 7Wh

Portatil computer 70Wh



Residential 7kWh



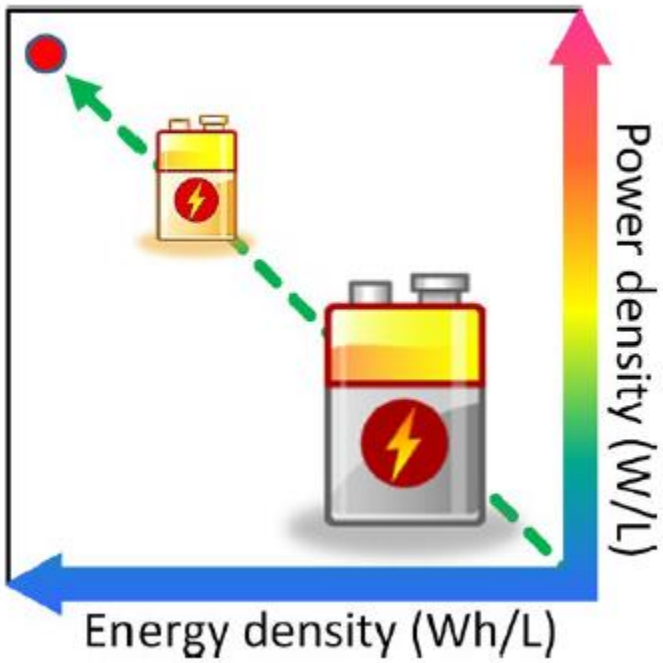
Electromobilité 70kWh

electro mobility

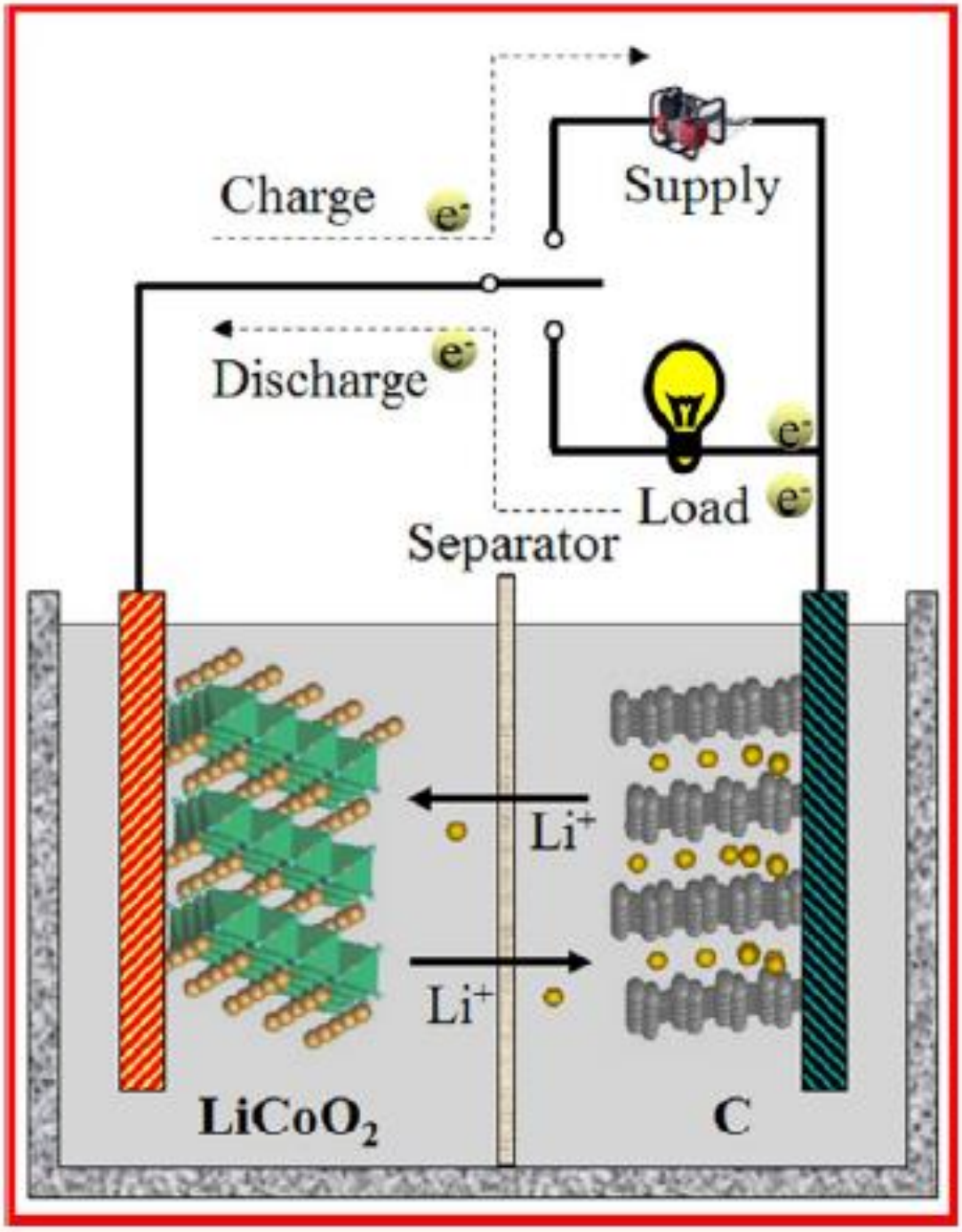
packs of batteries


TESLA

Illustration showing the basic components and operating principle of a Li-ion battery



Future Li-ion batteries should to be light and small without commitment on energy and power

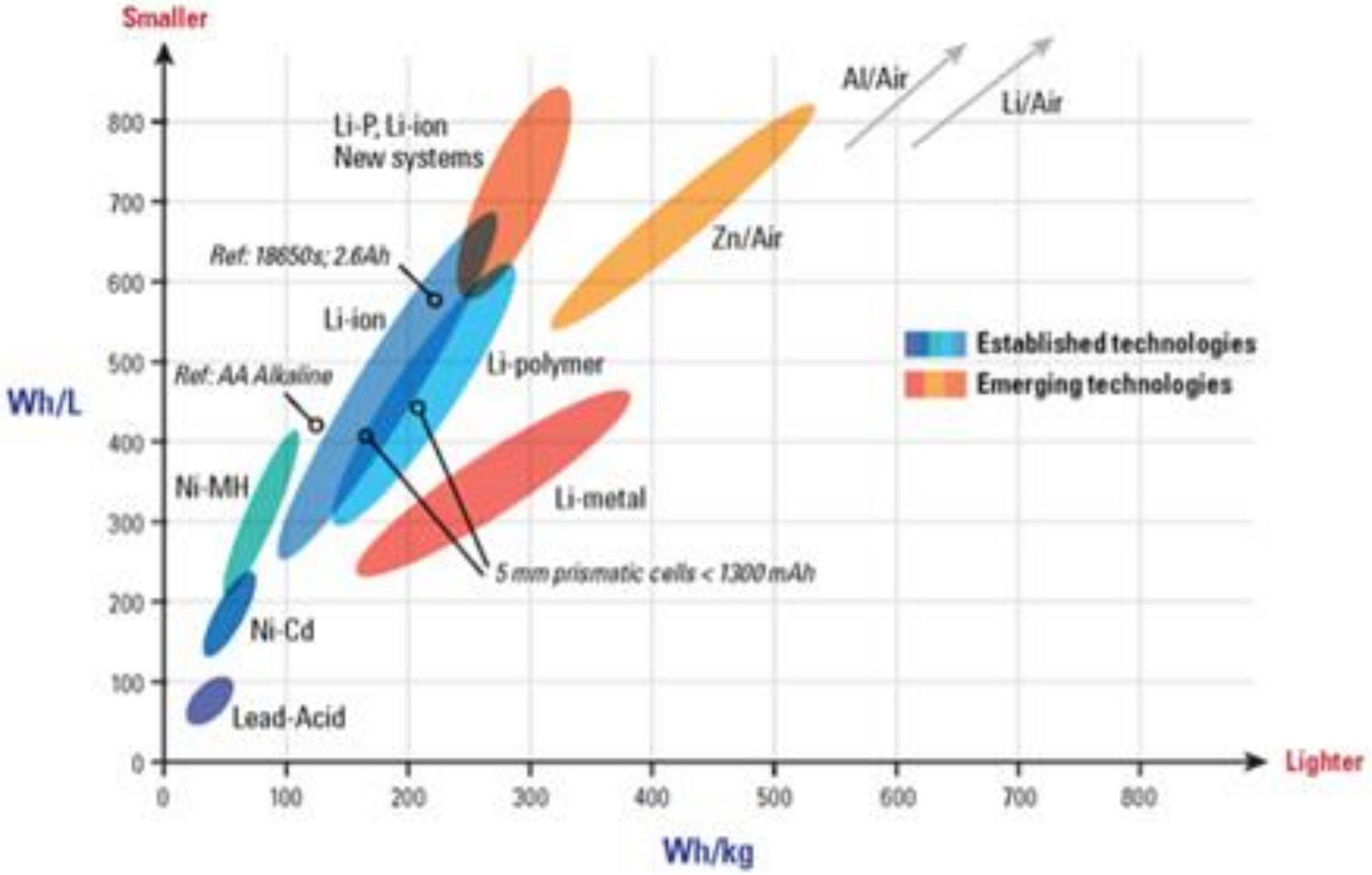


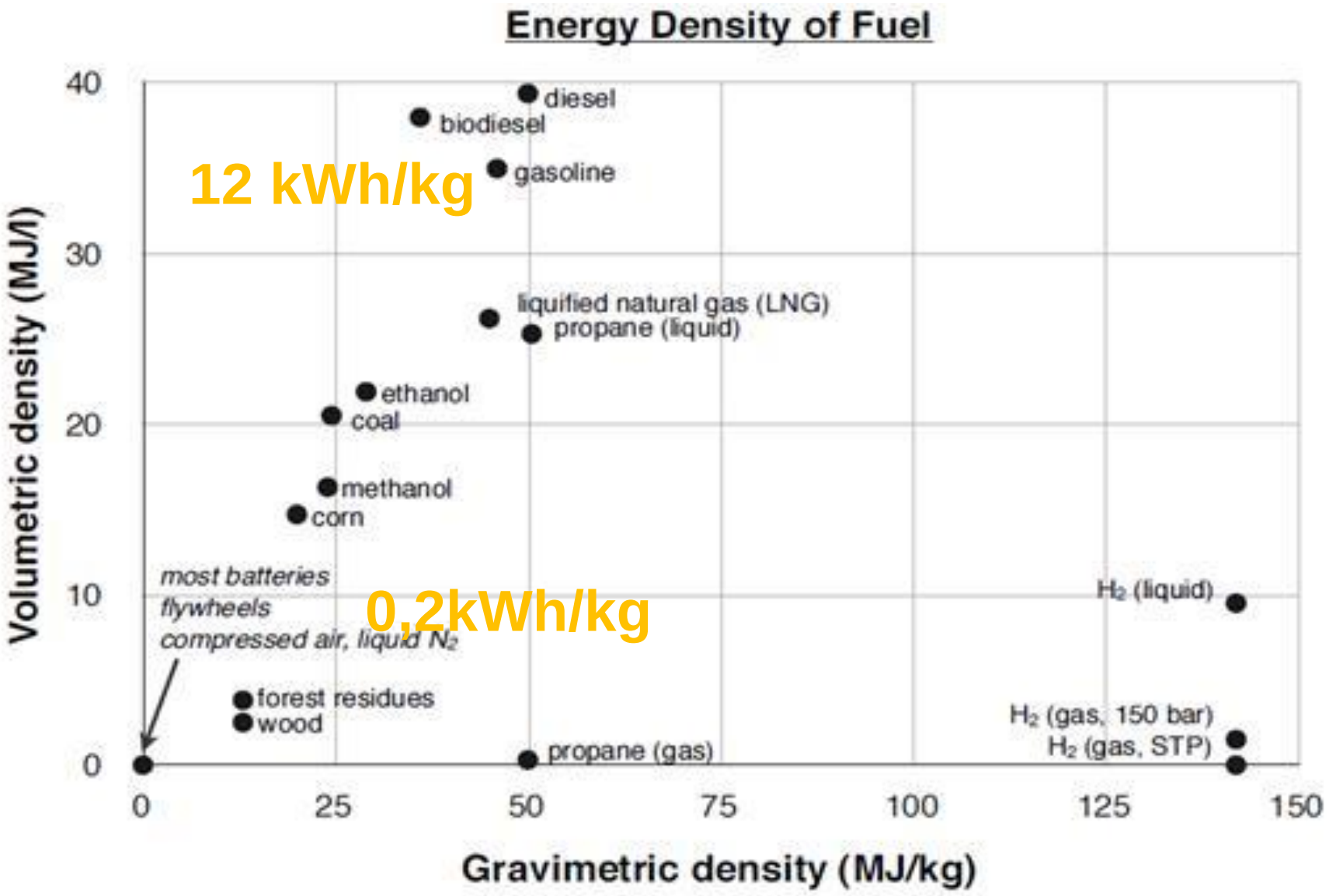
- Actuels Li ion cells used in current electric vehicles

	Cell Maker	Chemistry	Capacity	Configuration	Voltage	Weight	Volume	Ener dens	Spec Ener	Used in:	
		Anode/Cathode	Ah		V	Kg	liter	Wh/liter	Wh/kg	Company	Model
1	AESC	G/LMO-NCA	33	Pouch	3.75	0.80	0.40	309	155	Nissan	Leaf
2	LG Chem	G/NMC-LMO	36	Pouch	3.75	0.86	0.49	275	157	Renault	Zoe
3	Li-Tec	G/NMC	52	Pouch	3.65	1.25	0.60	316	152	Daimler	Smart
4	Li Energy Japan	G/LMO-NMC	50	Prismatic	3.7	1.70	0.85	218	109	Mitsubishi	i-MiEV
5	Samsung	G/NMC-LMO	64	Prismatic	3.7	1.80	0.97	243	132	Fiat	500
6	Lishen Tianjin	G-LFP	16	Prismatic	3.25	0.45	0.23	226	116	Coda	EV
7	Toshiba	LTO-NMC	20	Prismatic	2.3	0.52	0.23	200	89	Honda	Fit
8	Panasonic	G/NCA	3.1	Cylindrical	3.6	0.048	0.018	630	233	Tesla	Model S

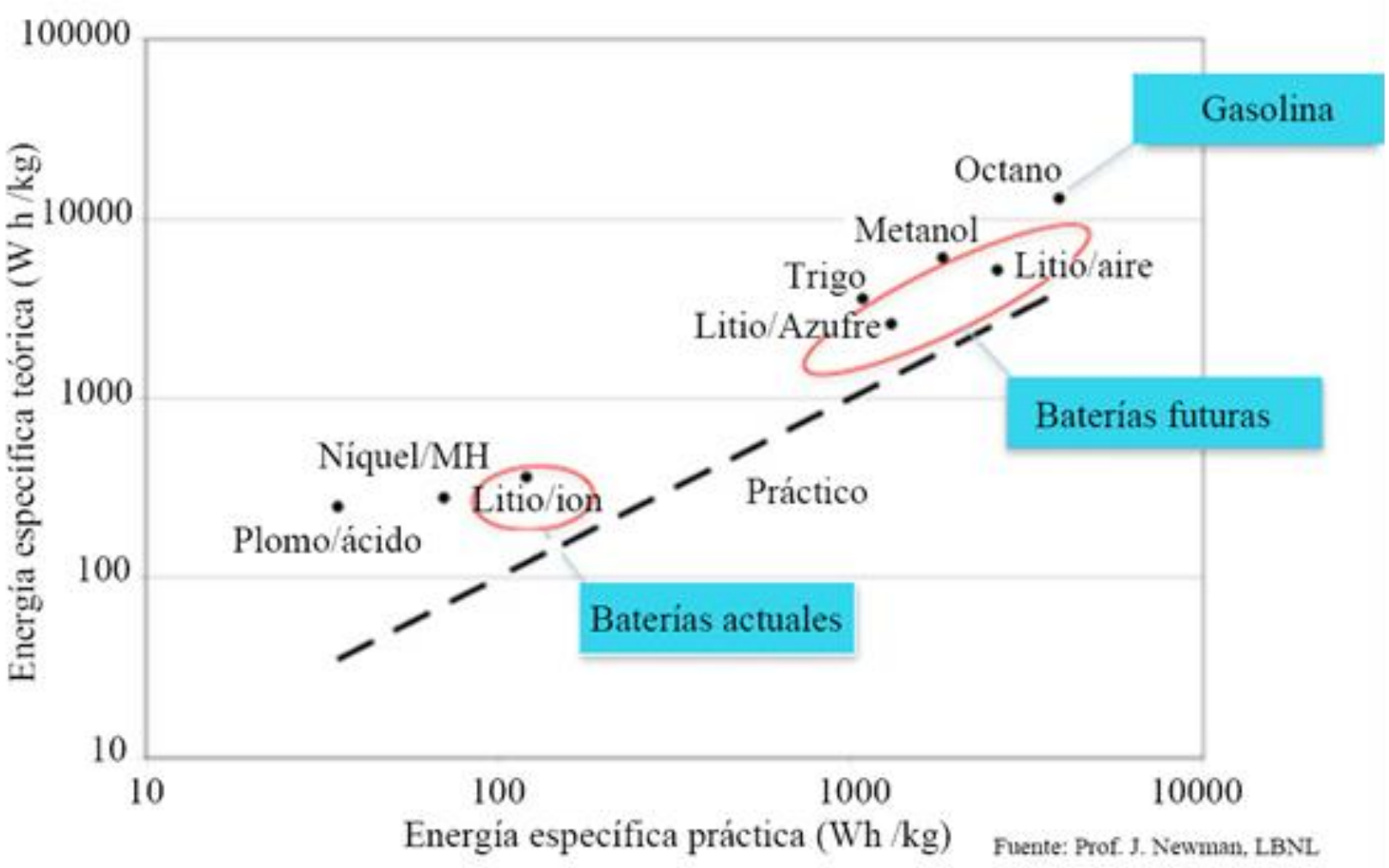
The current Tesla-Panasonic cell offers 50% more specific energy than the competition. This is mainly due to the use of highly active NCA cathodes and high density electrodes. the gap will be reduced to 20-25% in the next 3 years

From 2014 Total Battery Consulting, Inc.


Smaller
Lighter
Wh/L
Wh/kg
0
100
200
300
400
500
600
700
800
Li-P, Li-ion
New systems
Ref: 18650s; 2.6Ah
Li-ion
Li-polymer
Ref: AA Alkaline
Ni-MH
Li-metal
5 mm prismatic cells < 1300 mAh
Ni-Cd
Lead-Acid
Zn/Air
Al/Air
Li/Air
Established technologies
Emerging technologies

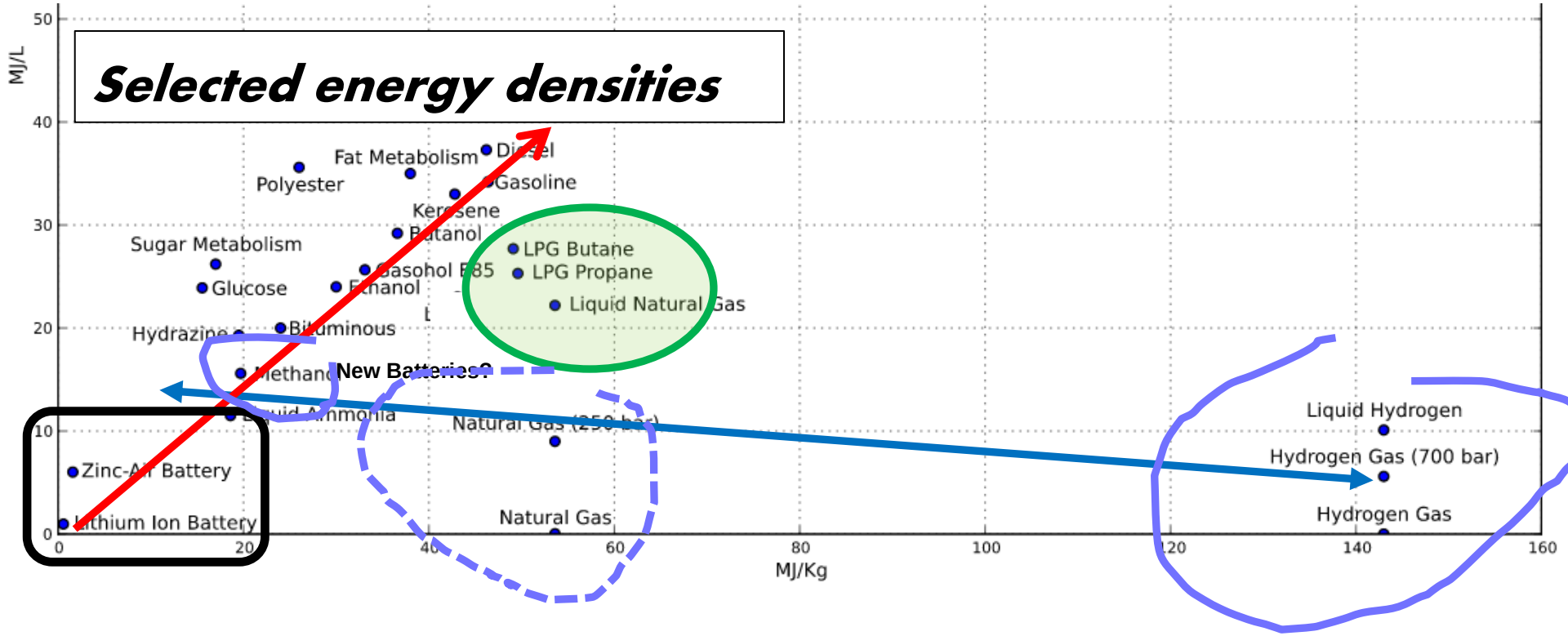


1 MJ es igual a 0,28 kWh


100000
10000
1000
100
10
Energía específica teórica (W h /kg)
10
100
1000
10000
Energía específica práctica (Wh /kg)
Gasolina
Octano
Metanol
Trigo
Litio/aire
Litio/Azufre
Baterías futuras
Níquel/MH
Litio/ion
Práctico
Plomo/ácido
Baterías actuales
Fuente: Prof. J. Newman, LBNL

Face à des énergies renouvelables intermittentes et fluctuantes:
UN DÉFI: COMMENT CONSERVER L'ÉNERGIE?

SOURCE: IREC



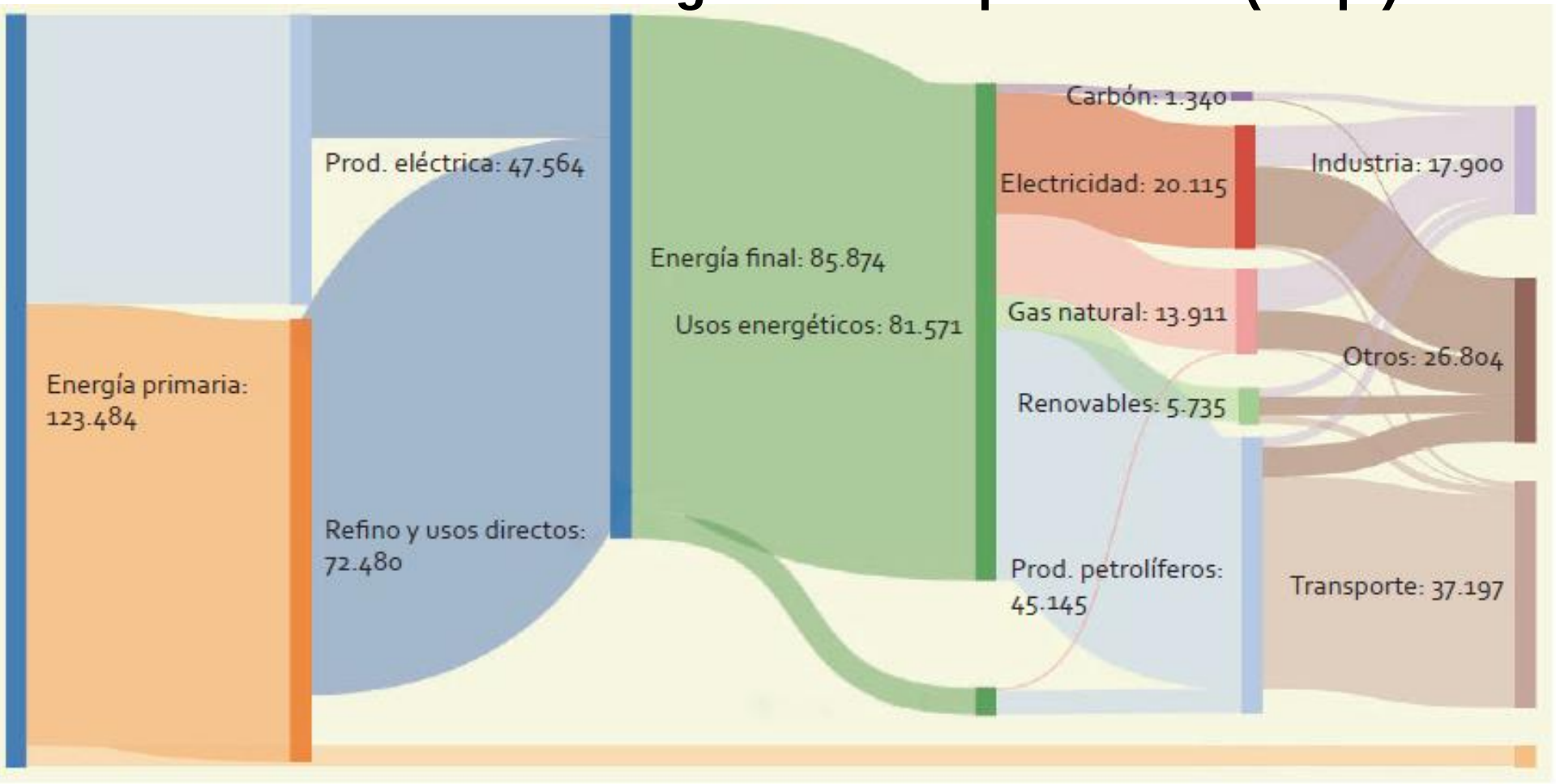
2 Efficiency

Rendimientos	Símbolo	%
Rto. De generación	η_g	43
Rto. De transporte y distribución	η_t	93,7
Rto. Del convertidor electrónico	η_c	97
Rto. De la batería	η_b	98,8
Rto. Del sistema mecánico	η_{mec}	80
Rto. Del motor eléctrico	η_{mot}	87,4
	Well to Wheel	26,9

~ 70%

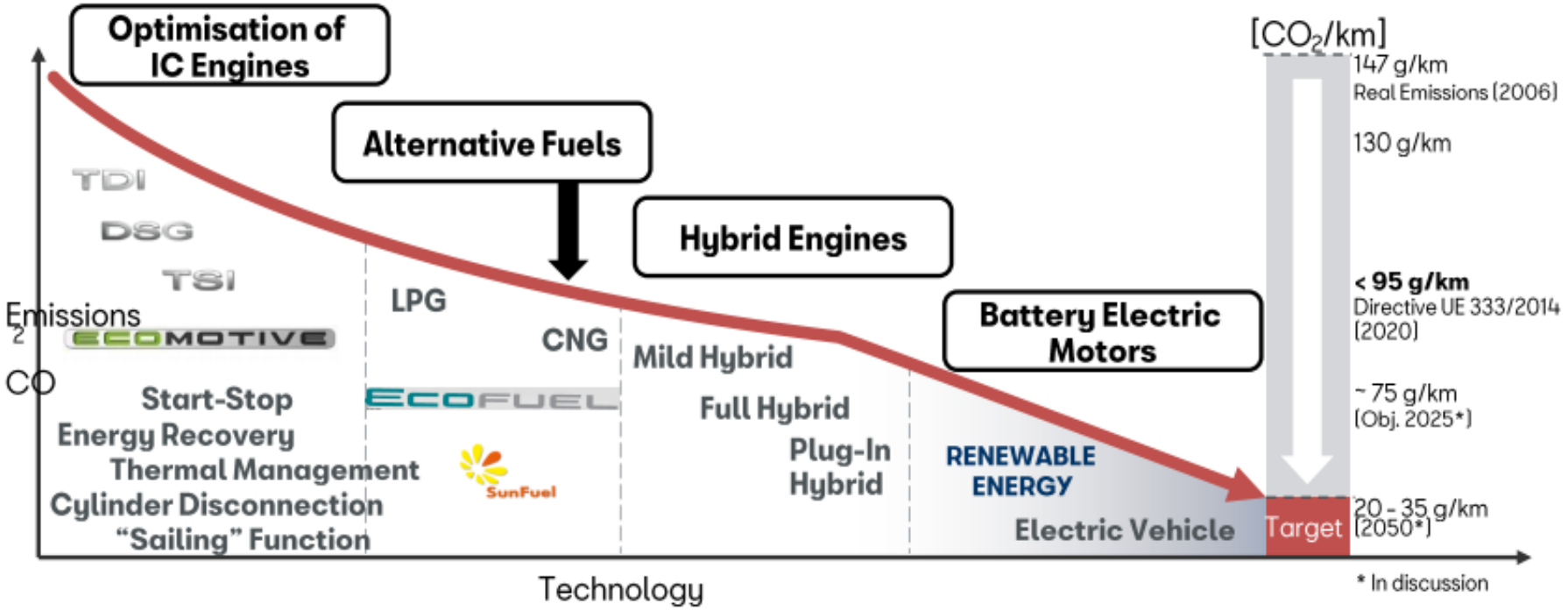
3CO_2, NO_x, particles emissions

Estructura energética de España 2016 (ktep)

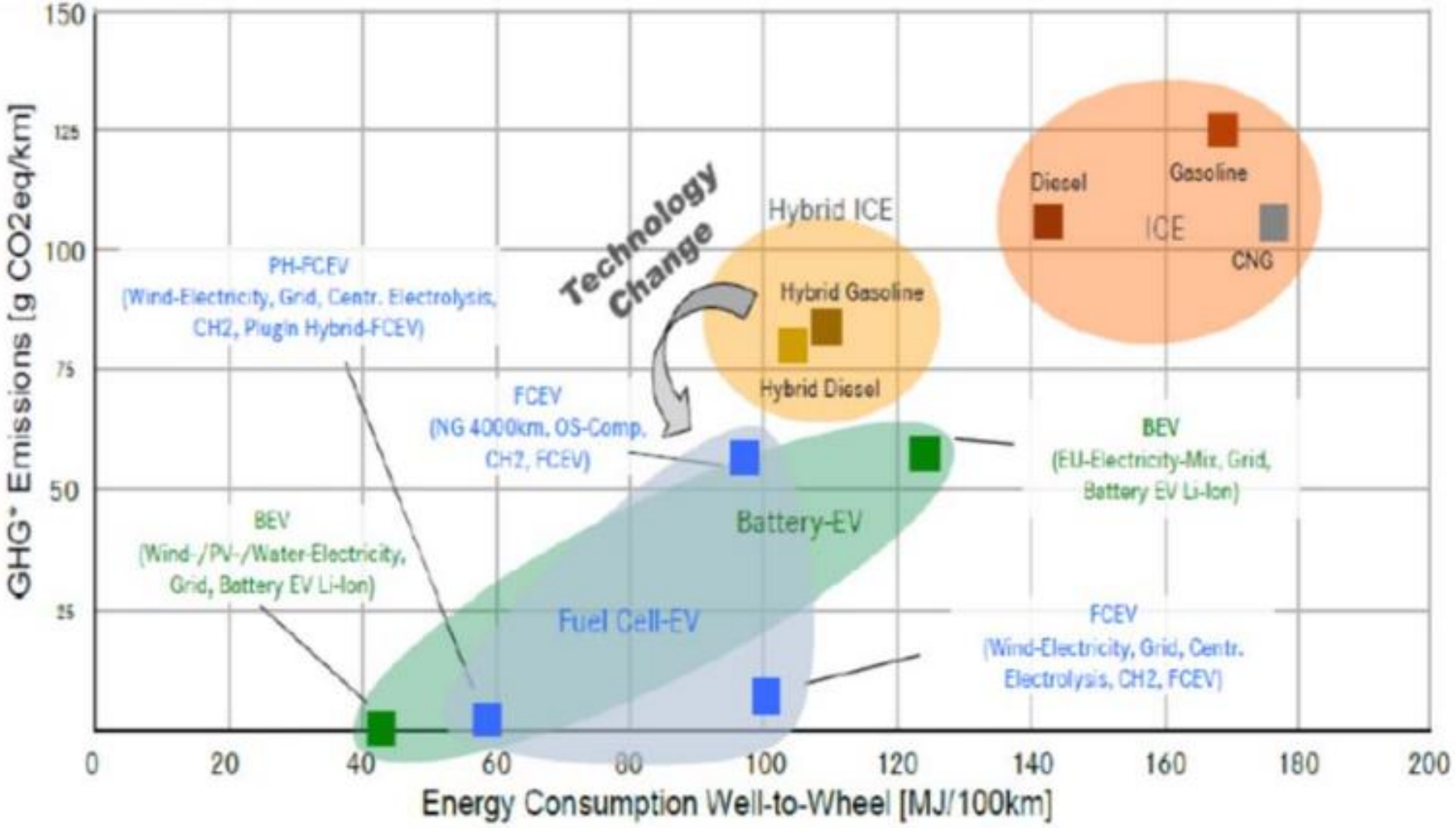


FUENTE: SEE

Reducción de CO_2 en flota automovilística



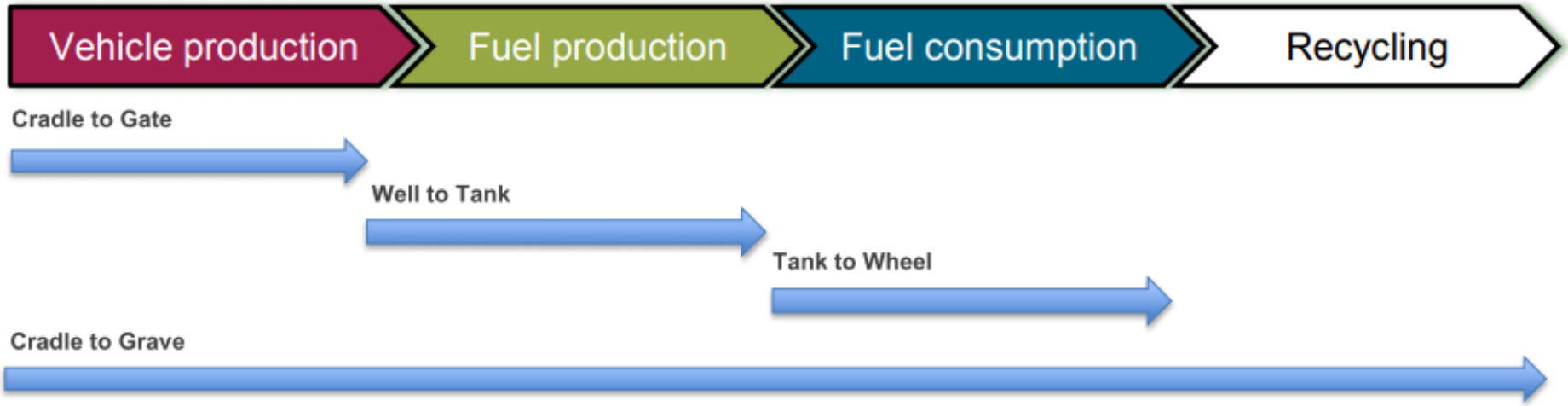
Tecnologías convencionales de propulsión no serán suficientes para alcanzar las fuertes reducciones de emisiones de CO_2 exigidas en el futuro



*GHG: Green House Gas

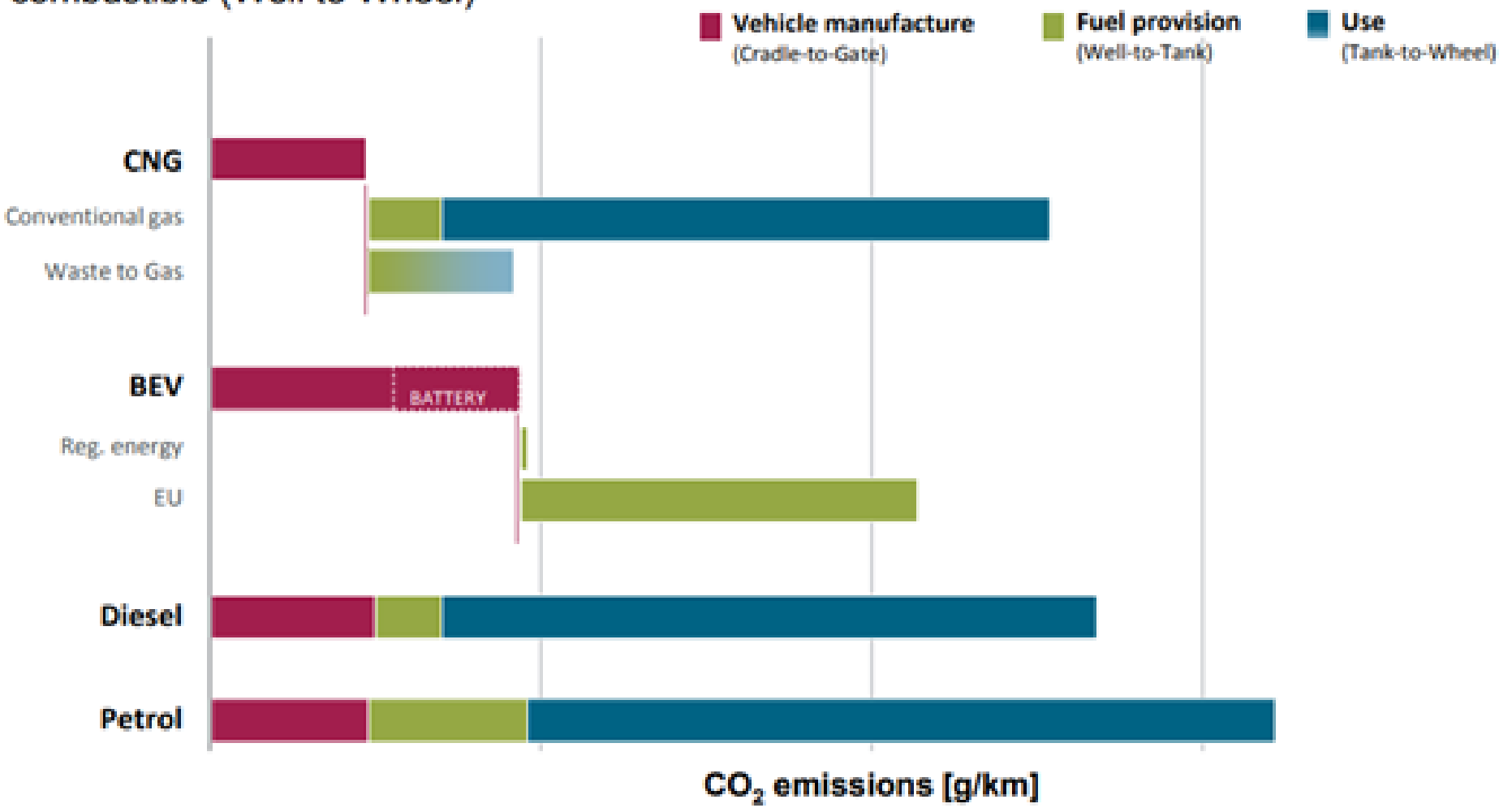
Source: JRC/EUCAR/CONCAWE (2013) WtW Report, Version 4

Consideraciones futuras para el CO_2 para el sector transporte: Cradle to Grave



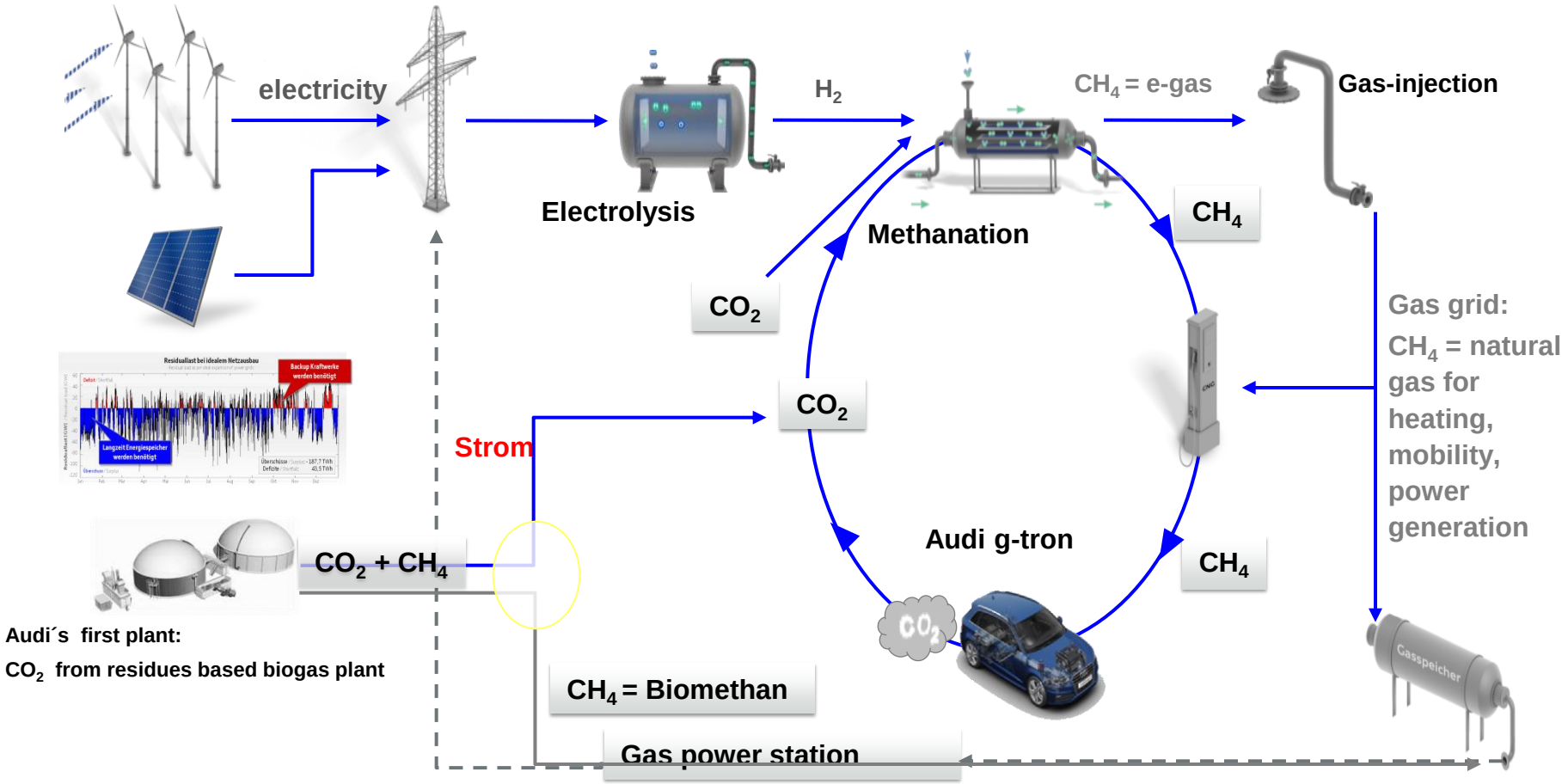
Fuente: SEAT

Comparativa Emisiones CO_2, con distintas fuentes renovables, en todo el life-cycle del combustible (Well to Wheel)



Con biometano, Well to Wheel reducciones en CO_2 vs. Gasolina pueden llegar a ser de hasta: 80% dependiendo de la fuente

Power-to-gas:
Linking of the electricity and mobility sector by Audi e-gas plant
Function of the Audi e-gas Project



Fuente: ETOGAS, Audi

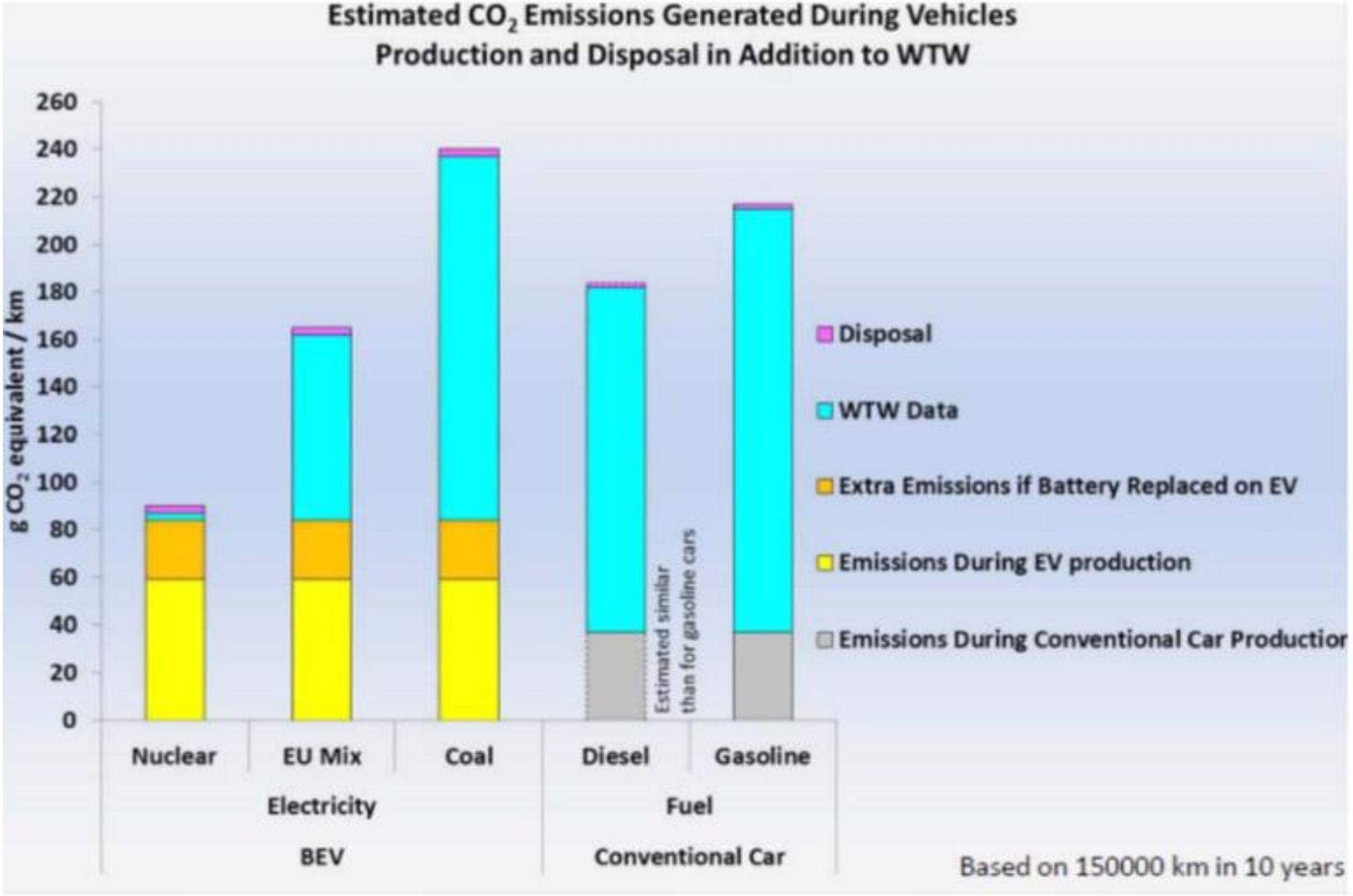
Projet P2G d'ETOGAS pour AUDI à Werlte (Allemagne): usine de 6,3 MWel

Electrolyzer hall

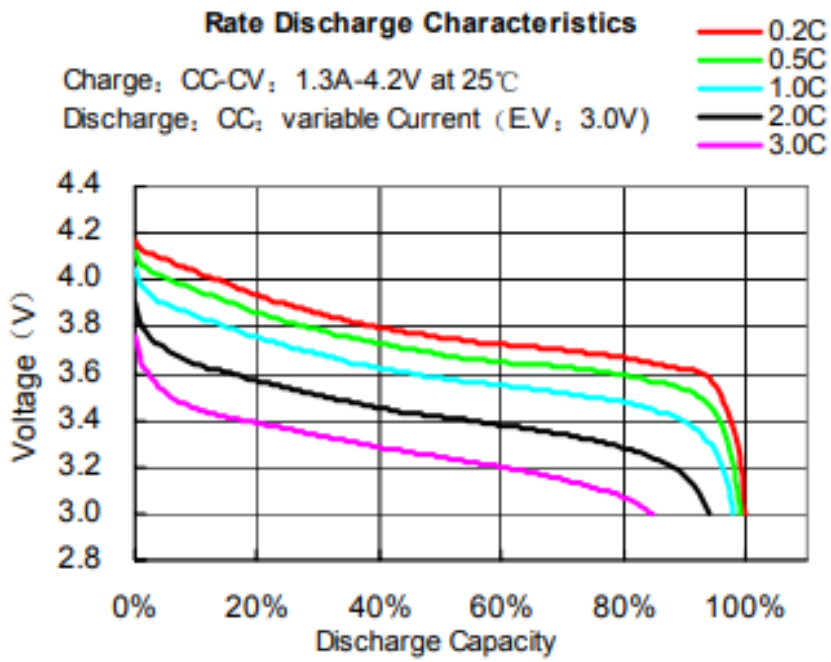
One of three 2MW$_{el}$ electrolyzers

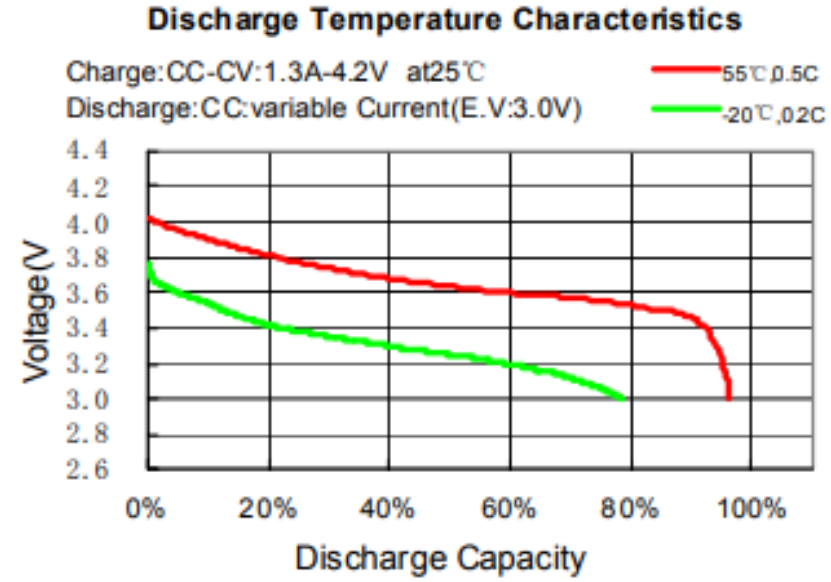
Methanation reactor

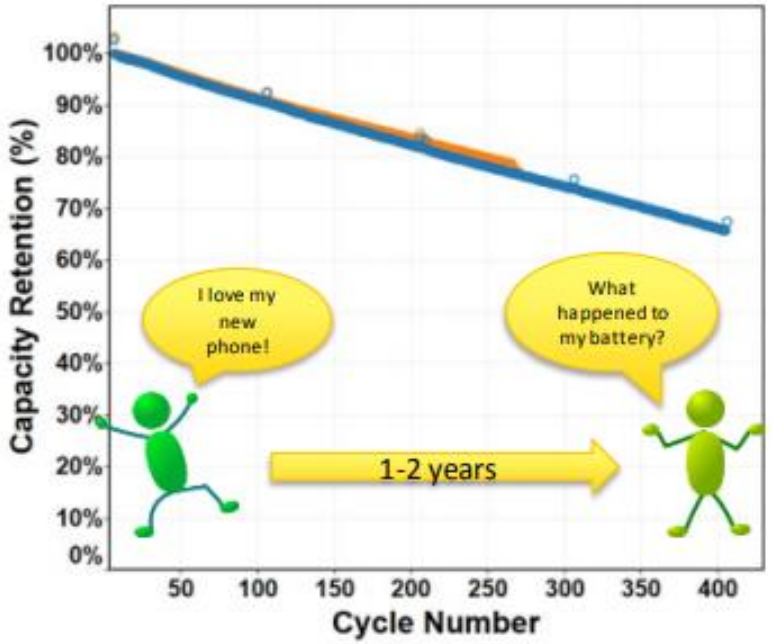
Power-to-Gas: usine de gaz Audi-e à Werlte (Allemagne) - usine de biogaz à droite, 330 Nm^3 / h de CO_2

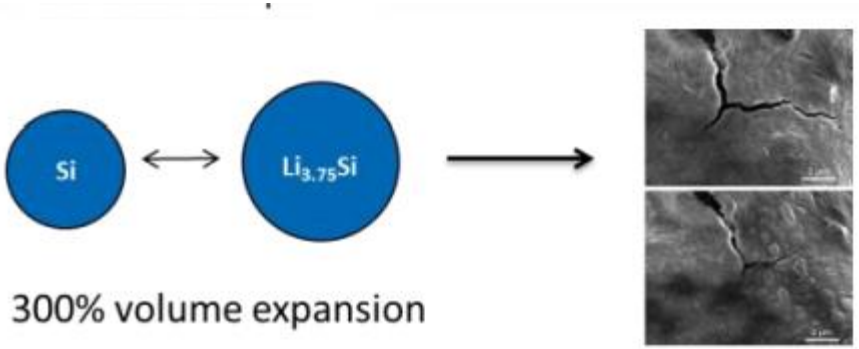

Estimated CO_2 Emissions Generated During Vehicles Production and Disposal in Addition to WTW
g CO_2 equivalent / km
260
240
220
200
180
160
140
120
100
80
60
40
20
0
Disposal
WTW Data
Extra Emissions if Battery Replaced on EV
Emissions During EV production
Emissions During Conventional Car Production
Estimated similar than for gasoline cars
Nuclear
EU Mix
Coal
Diesel
Gasoline
Electricity
Fuel
BEV
Conventional Car
Based on 150000 km in 10 years

4 degradation and life time.


Rate Discharge Characteristics
Charge：CC-CV：1.3A-4.2V at 25℃
Discharge：CC：variable Current（E.V：3.0V）
0.2C
0.5C
1.0C
2.0C
3.0C
Voltage（V）
4.4
4.2
4.0
3.8
3.6
3.4
3.2
3.0
2.8
0%
20%
40%
60%
80%
100%
Discharge Capacity

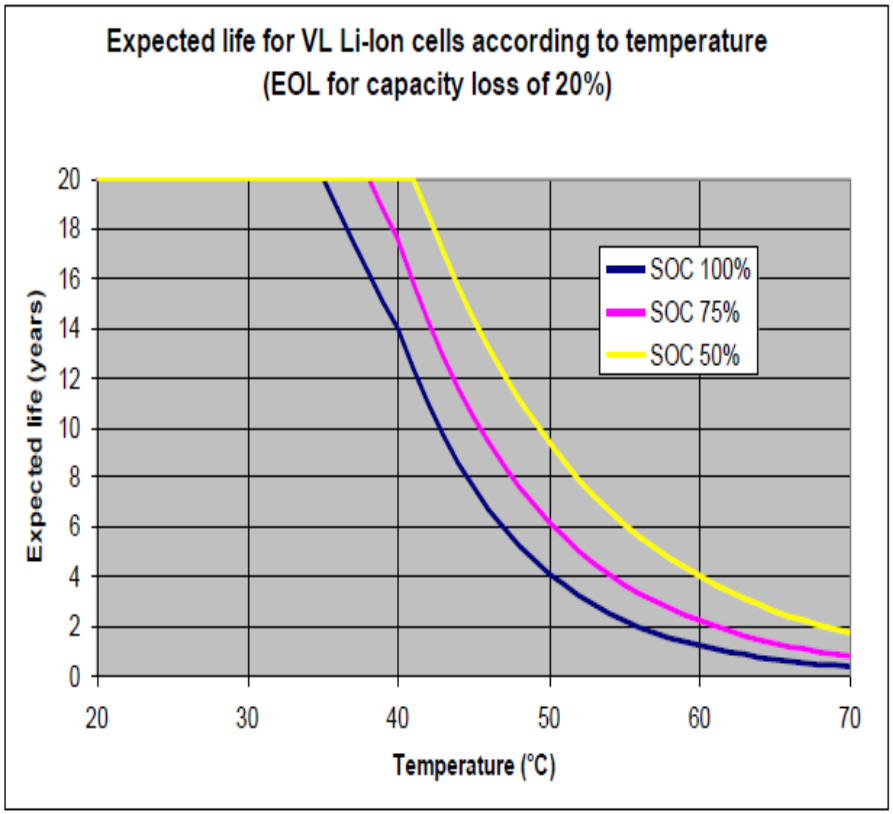

Discharge Temperature Characteristics
Charge:CC-CV:1.3A-4.2V at25℃
Discharge:CC:variable Current(E.V:3.0V)
55℃,0.5C
-20℃,0.2C
Voltage(V
4.4
4.2
4.0
3.8
3.6
3.4
3.2
3.0
2.8
2.6
0%
20%
40%
60%
80%
100%
Discharge Capacity


Capacity Retention (%)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
50
100
150
200
250
300
350
400
Cycle Number
I love my new phone!
What happened to my battery?
1-2 years


Si
Li3.75Si
300% volume expansion

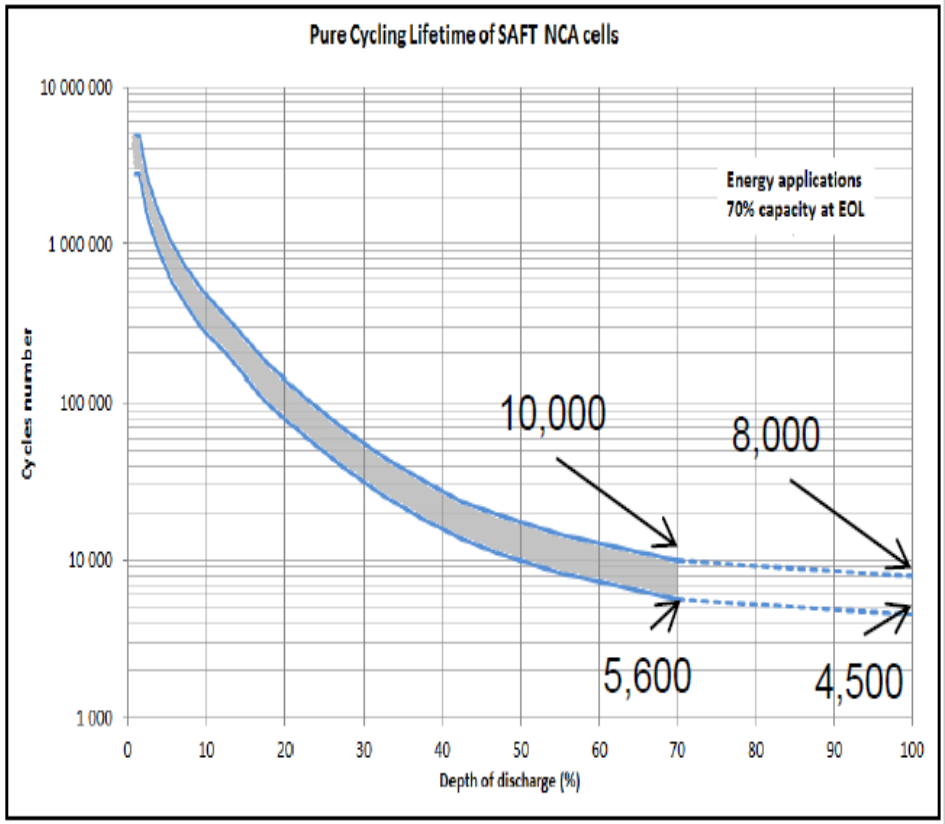
Calendar life

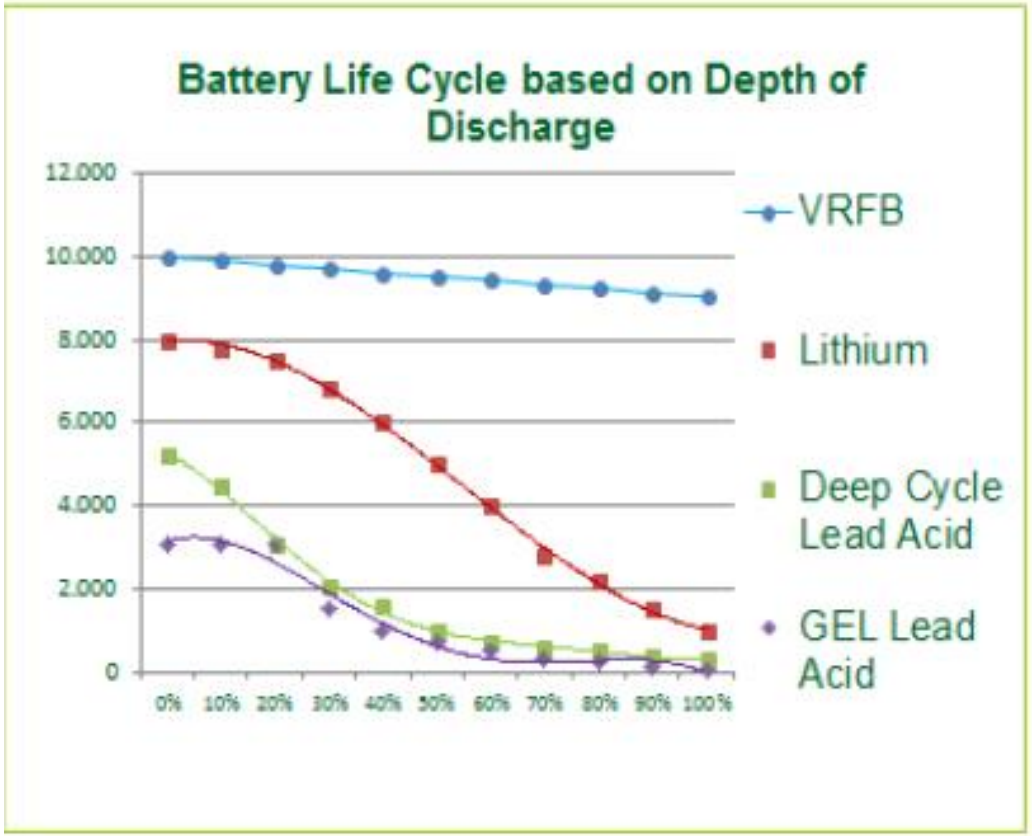
- in years
- depending on SOC & temperature
- and end of life criteria



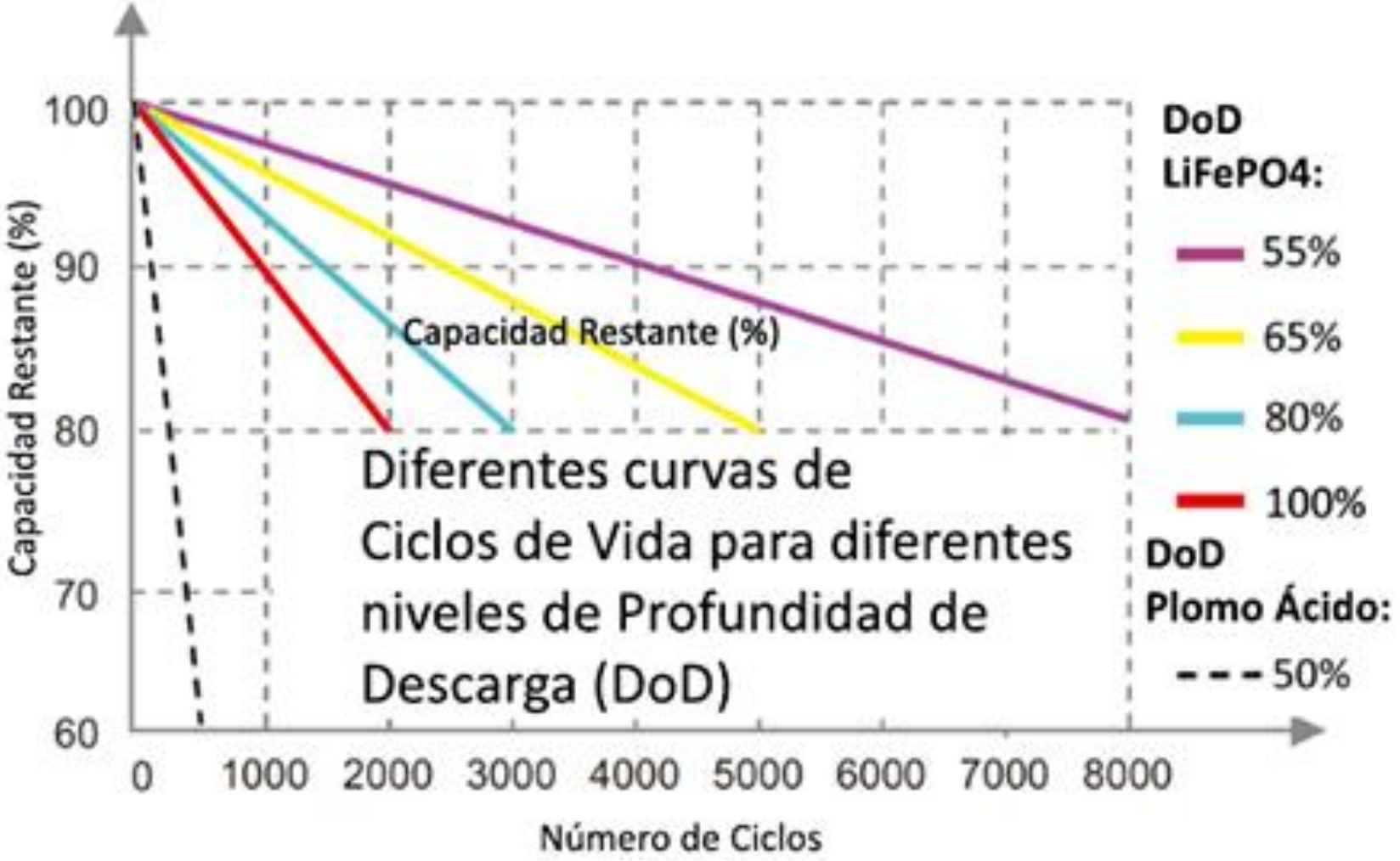
Cycle life

- in nb of cycles
- depending on DOD and charge rate
- and end of life criteria





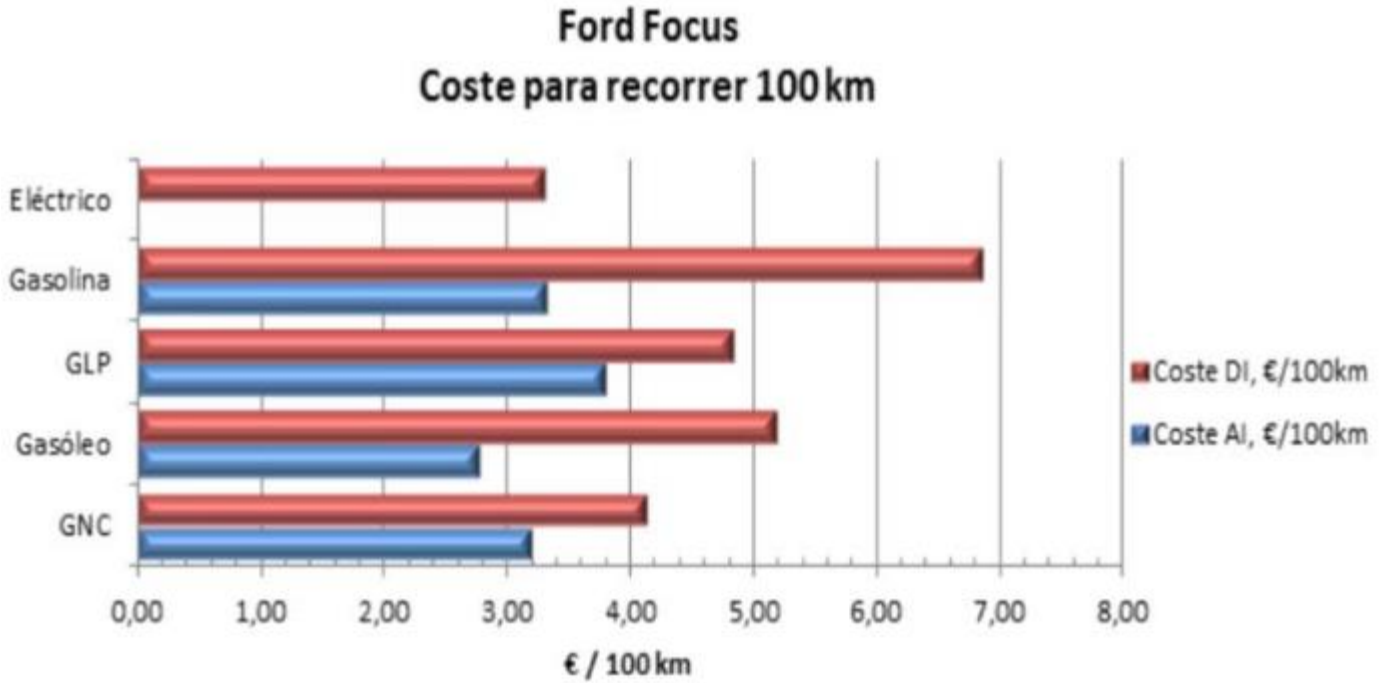
- **Low LCOE >20 year life**
  - Lowest cost over life in class
  - Modular from 5kW to 5MW to match loads, scale duration from hours to days
  - Stack life > 10,000 cycles, electrolyte indefinite life, re-usable & recyclable
- **Performance**
  - Deep discharge cycles, uses 100% of available capacity
  - Charge retention, almost indefinite in standby mode
  - 75-85% round trip efficiency
  - Partial cycles have 0 effect

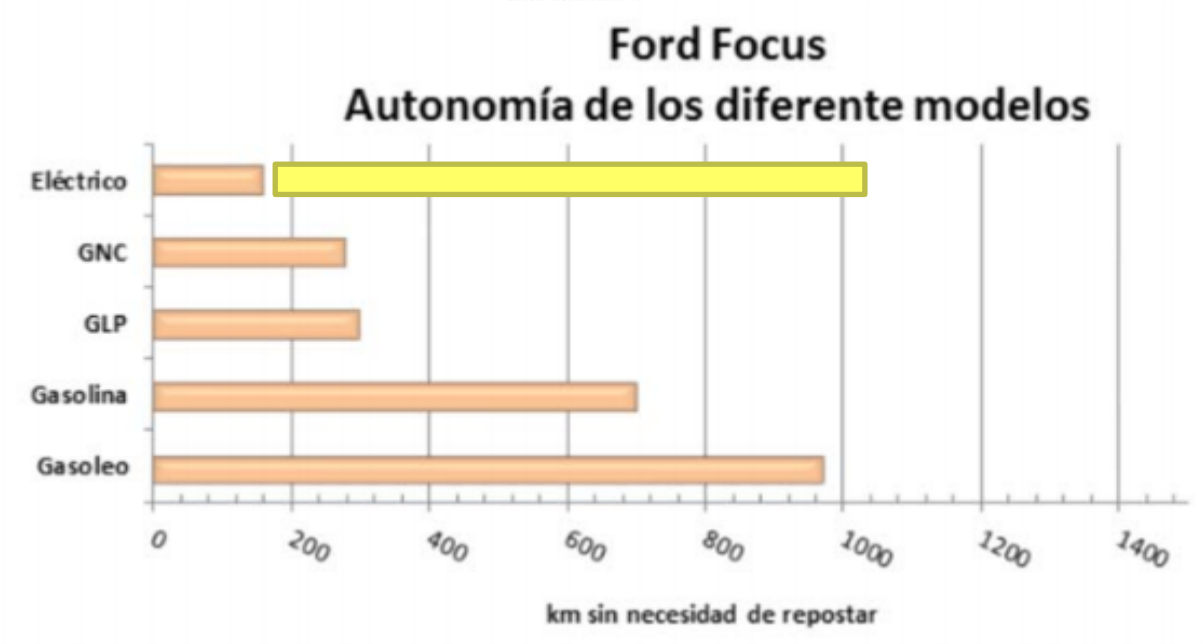

Capacidad Restante (%)
100
90
80
70
60
0
1000
2000
3000
4000
5000
6000
7000
8000
Número de Ciclos
Capacidad Restante (%)
Diferentes curvas de Ciclos de Vida para diferentes niveles de Profundidad de Descarga (DoD)
DoD LiFePO4:
55%
65%
80%
100%
DoD Plomo Ácido:
50%

5 Cost.

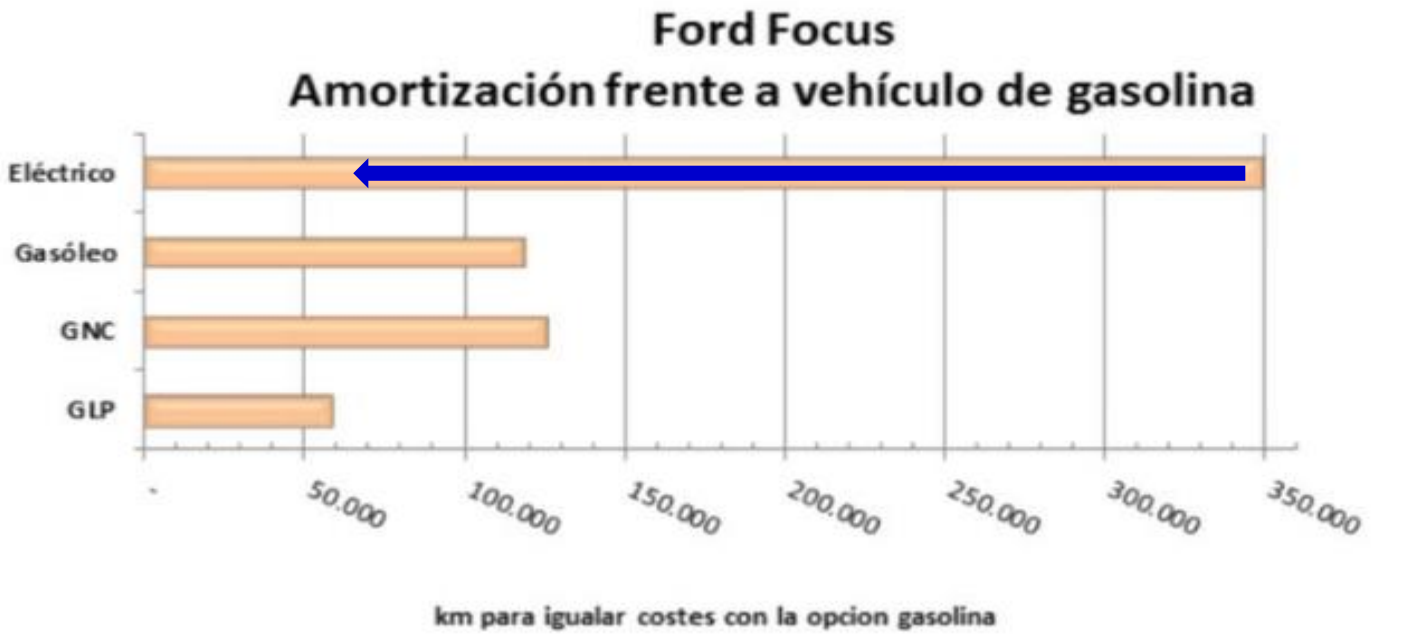
Modelo	Tipo combustible	Consumo, l/100km	Consumo, kg/100km	Consumo, kWh/100km
Ford Focus	GNC		4,1	
1.5 TDCi 120 CV	Gasóleo	4,1		
Ford Focus C-Max 1.6 Autogas (117 CV)	GLP	6,8		
1.0 EcoBoost (125 CV)	Gasolina	5,1		
Ford Focus electric (125 CV)	Eléctrico			17,5

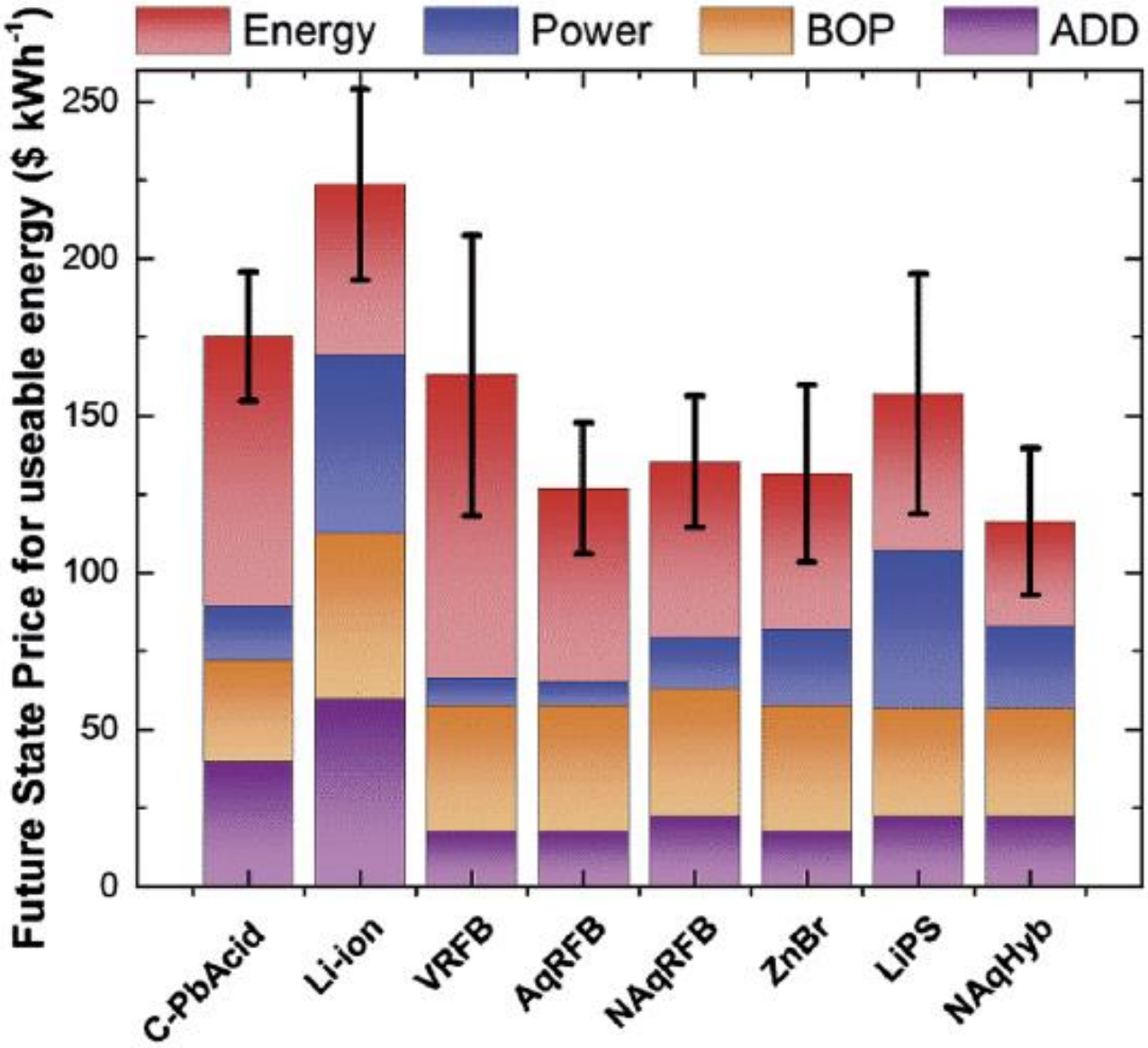
17,5 kWh*
0,20€/kWh=3,5€


Ford Focus
Coste para recorrer 100 km
Eléctrico
Gasolina
GLP
Gasóleo
GNC
Coste DI, €/100km
Coste AI, €/100km
0,00
1,00
2,00
3,00
4,00
5,00
6,00
7,00
8,00
€ / 100 km

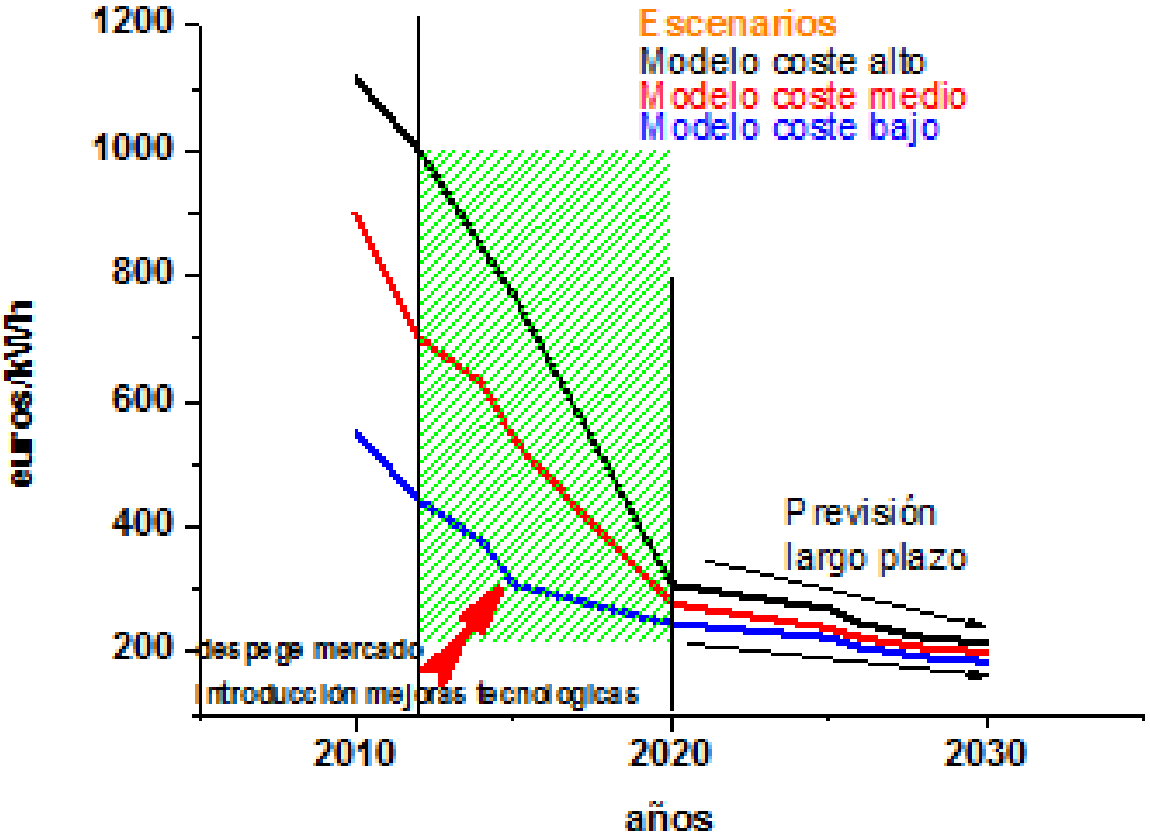

Ford Focus
Autonomía de los diferente modelos
Eléctrico
GNC
GLP
Gasolina
Gasoleo
0
200
400
600
800
1000
1200
1400
km sin necesidad de repostar

Modelo	Combustible	PVP, €
C- Max CNG (125 CV)	GNC	24.500
1.5 TDCi (120 CV)	Gasóleo	23.050
1.6 C-Max (117 CV)	GLP	22.250
1.0 Ecoboost (125 CV)	Gasolina	21.050
Ford Focus elec (125 CV)	Eléctrico	33.500

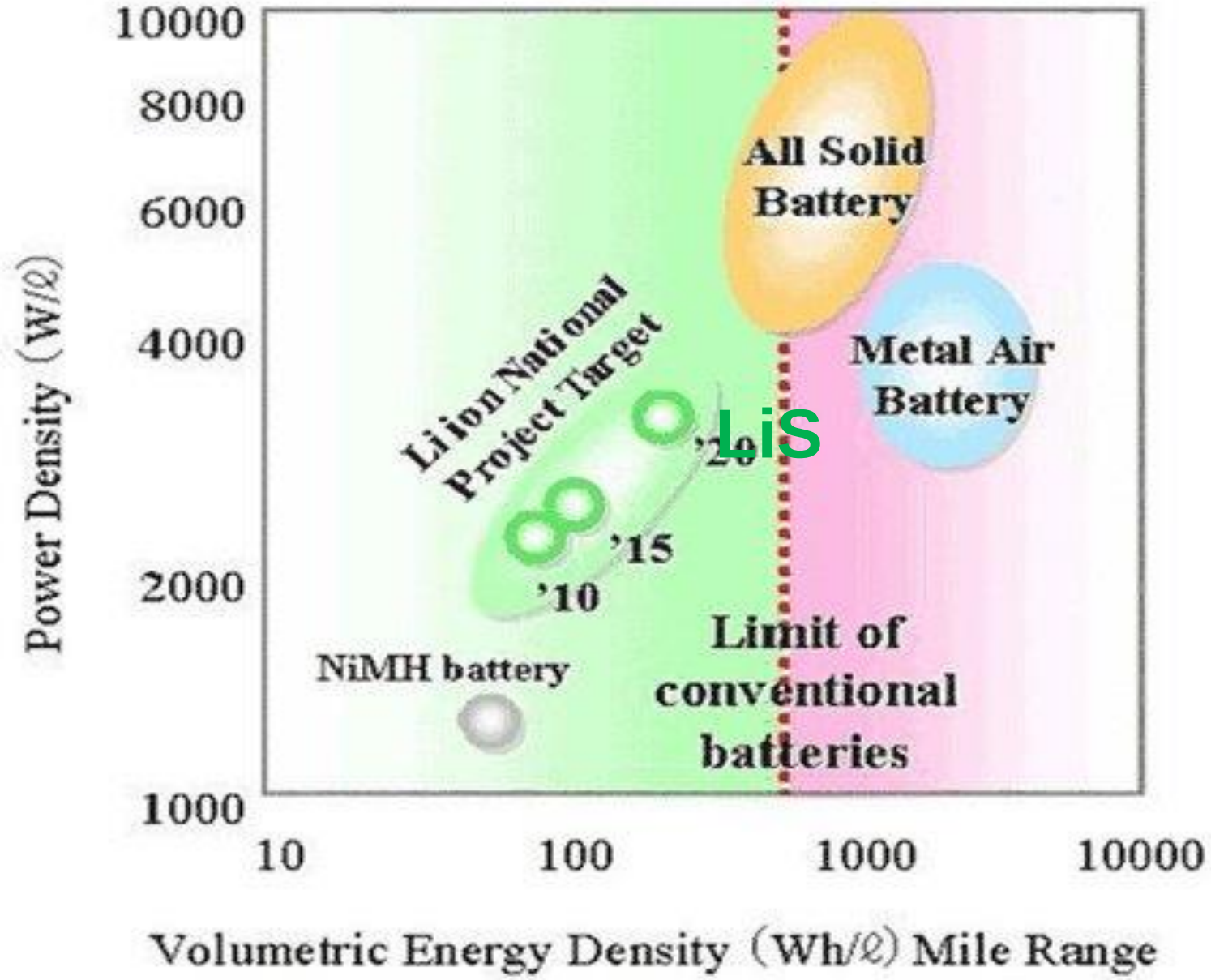


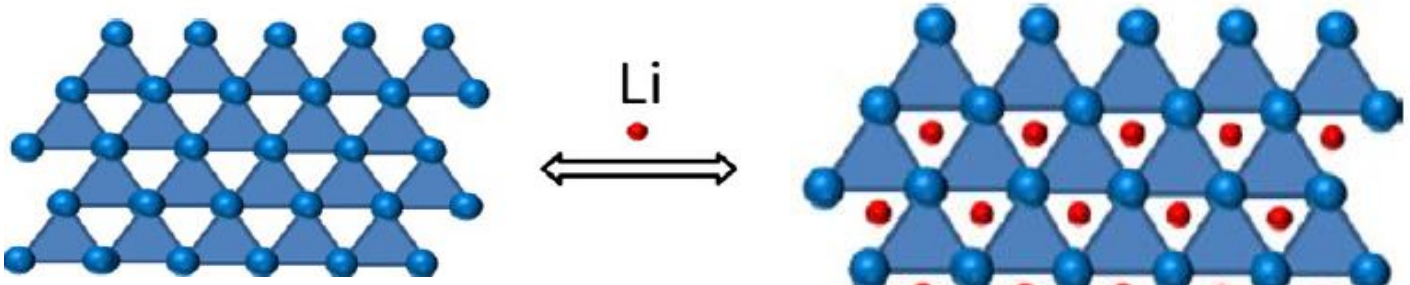


R. Darling et al. EES (2014)


1200
1000
800
600
400
200
euros/kWh
Escenarios
Modelo coste alto
Modelo coste medio
Modelo coste bajo
Previsión
largo plazo
despegue mercado
Introducción mejoras tecnológicas
2010
2020
2030
años

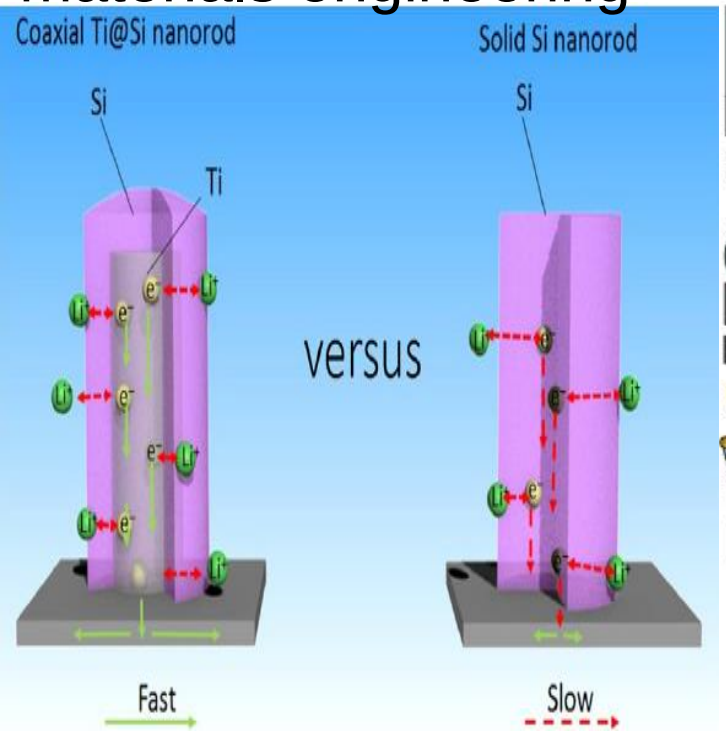
6 New research approaches.

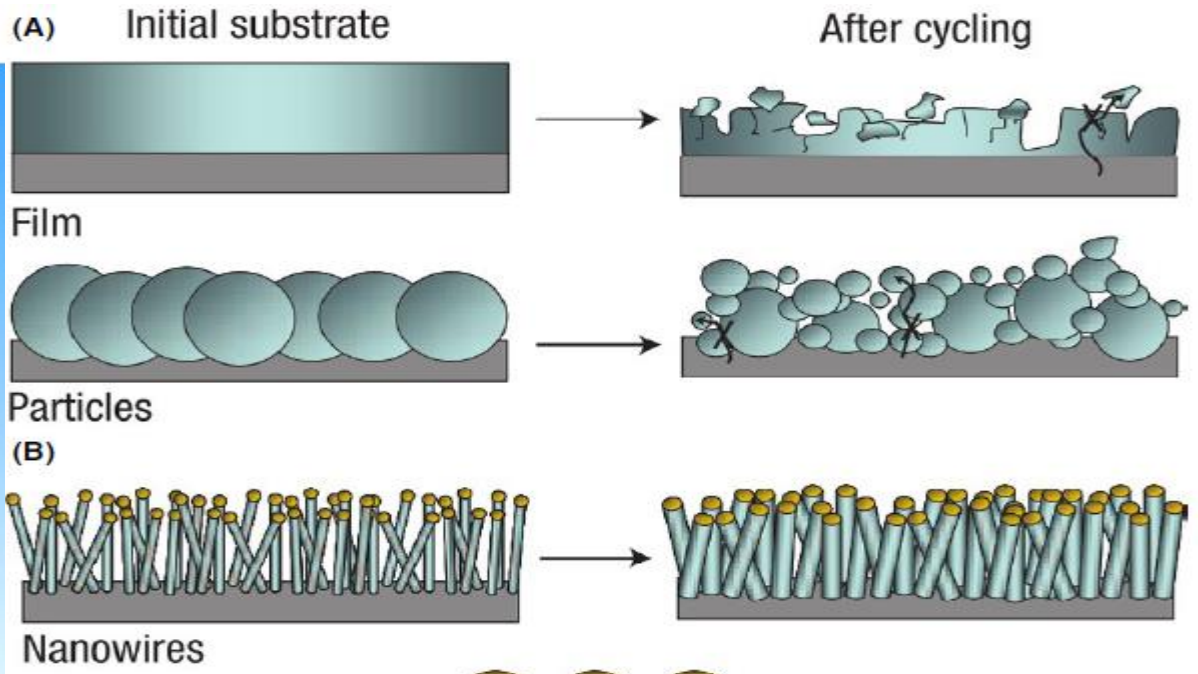

10000
8000
6000
4000
2000
1000
Power Density (W/ℓ)
All Solid Battery
Metal Air Battery
Li ion National Project Target
'20
'15
'10
LiS
NiMH battery
Limit of conventional batteries
10
100
1000
10000
Volumetric Energy Density (Wh/ℓ) Mile Range

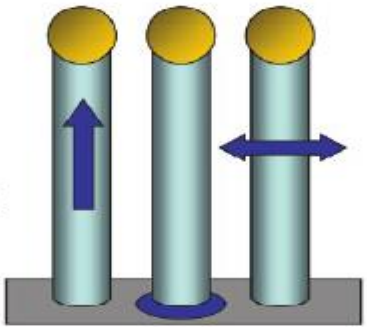


volume increase

many opportunities to apply brilliant ideas of science and materials engineering





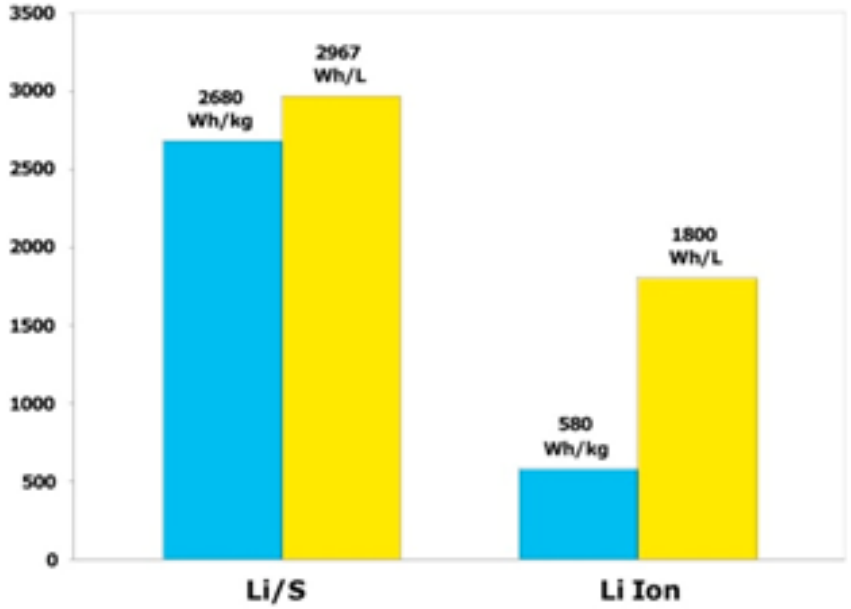


Efficient 1D electron transport

Facile strain relaxation

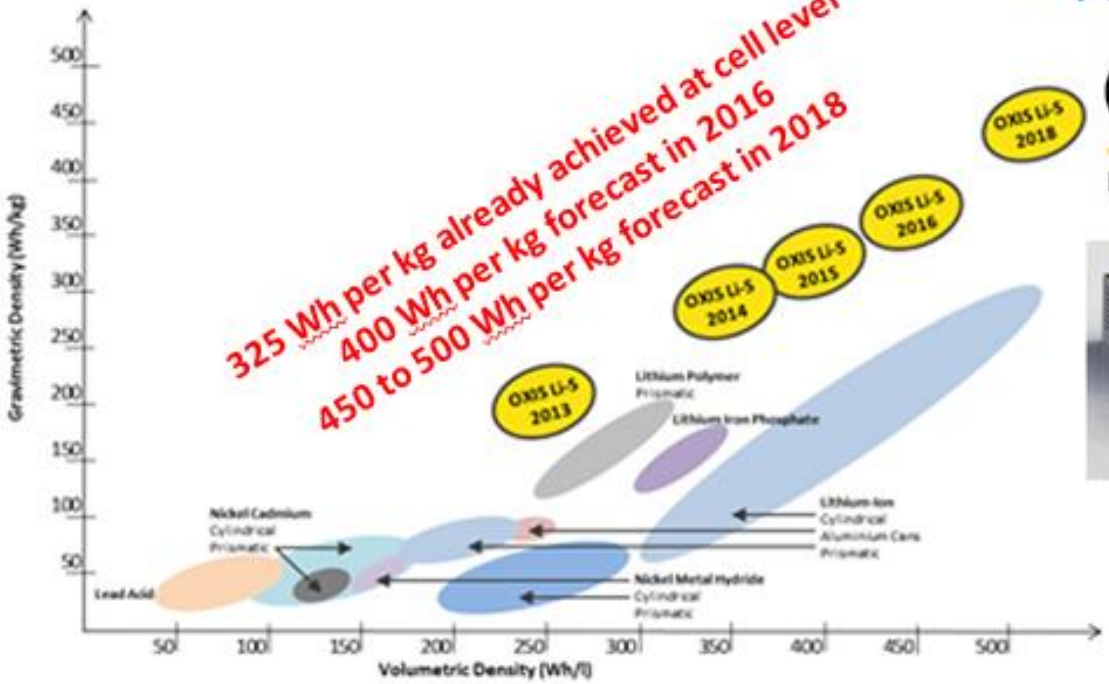
Institut de Recerca en Energia de Catalunya
Catalonia Institute for Energy Research

- High energy density



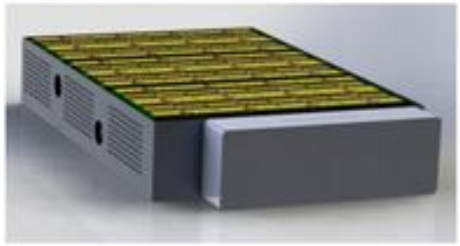
- High temperature range form -60 to 60ºC, demonstrated by SION POWER
- High Stability (5000 cycles)
- Research in carbon based electrodes and corrosion of the anodes

http://www.oxisenergy.com/



oxis ENERGY

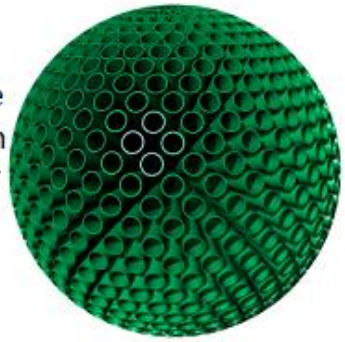
Next Generation Battery Technology



OXIS Li-S cells have achieved an excellent cycle life: cells can be cycled approximately 1500 times (80% Beginning-of-Life). In the next 2 years, they expect this to reach 2500 cycles.

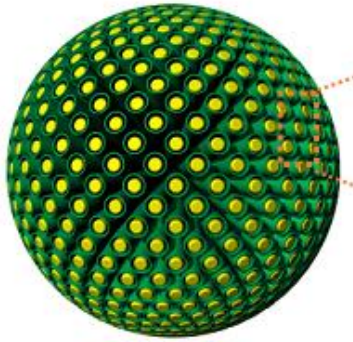
Selenide Reaction

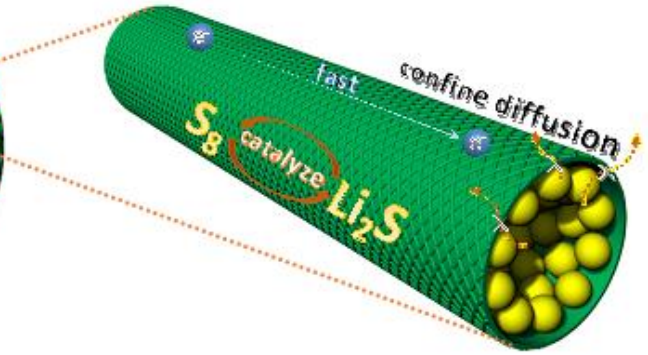
I



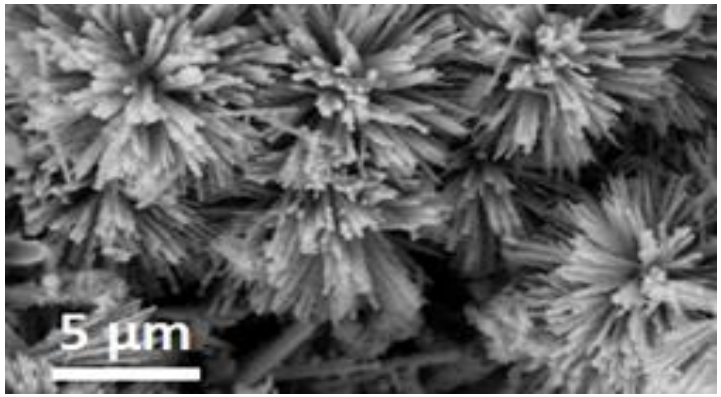
Fusion Process

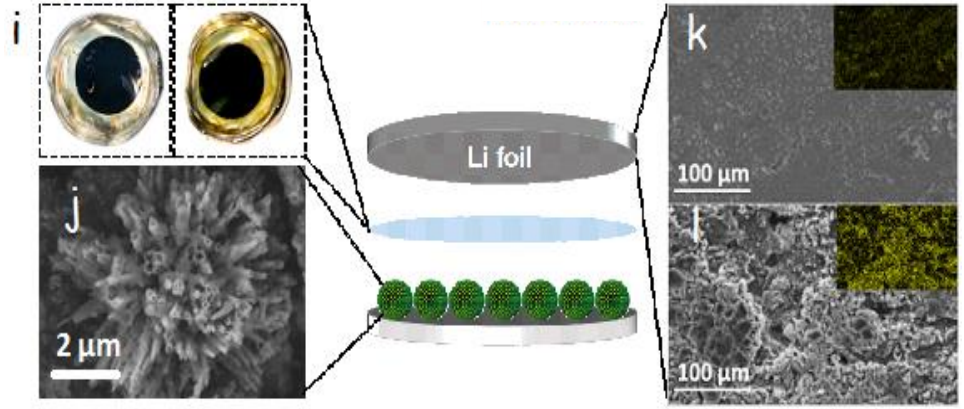
II

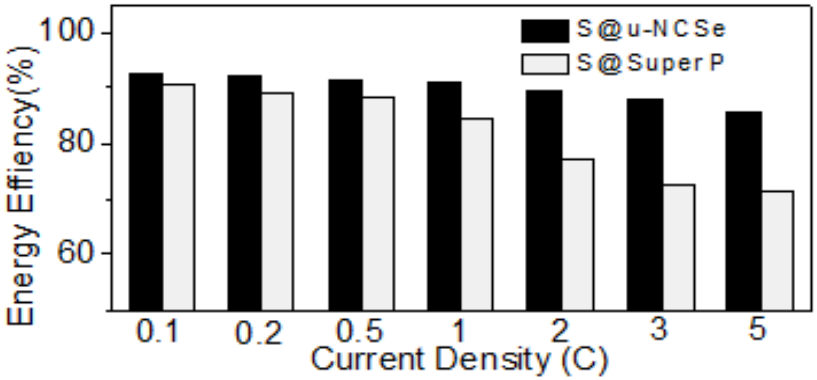


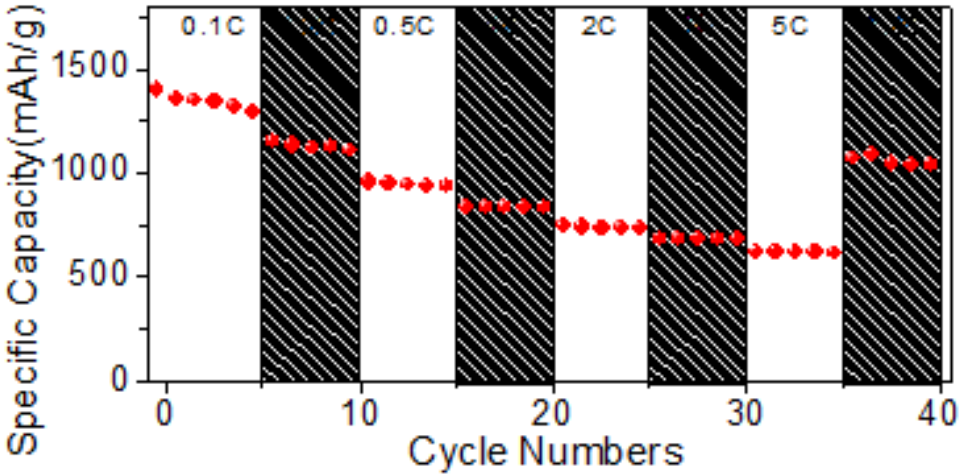


Precursor u-NCSe S@u-NCSe









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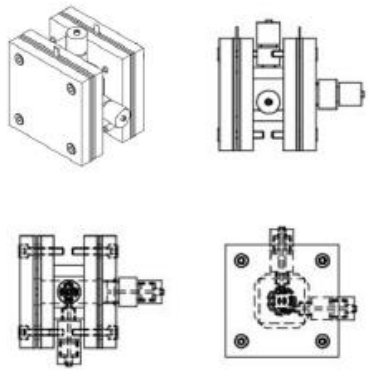
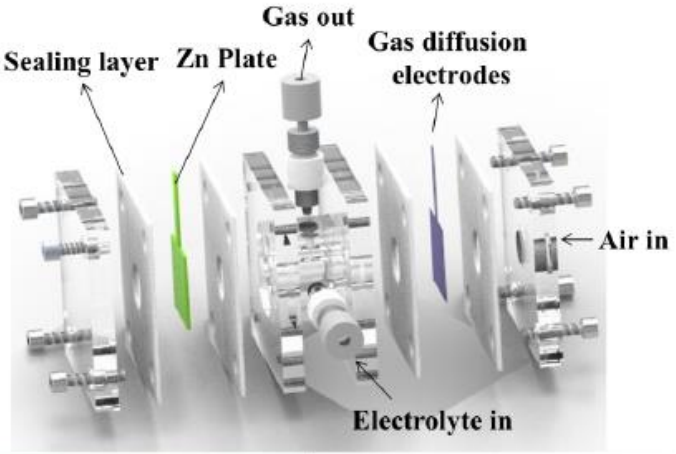
Lithium sulphur batteries

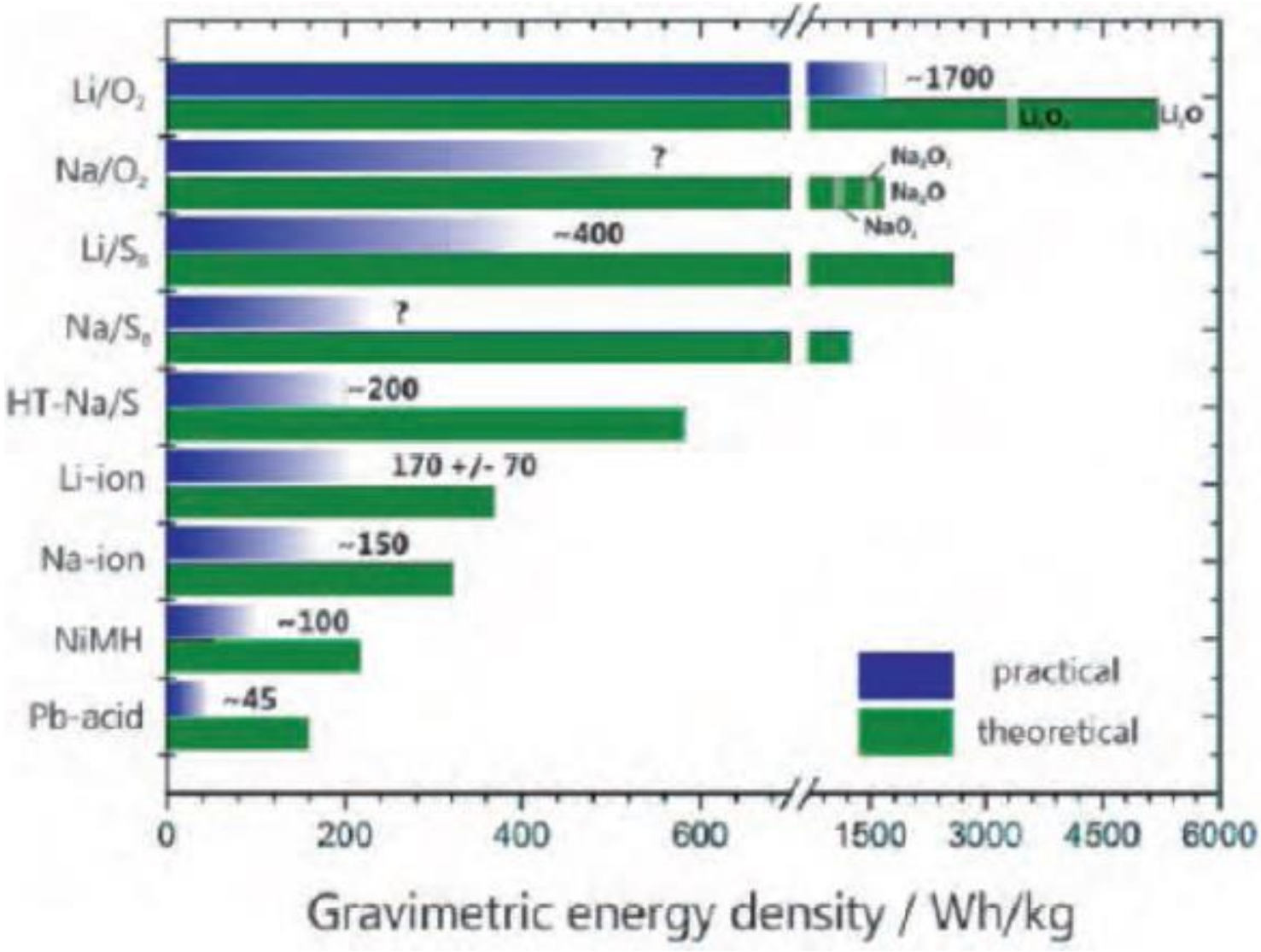
Coin cell batteries.





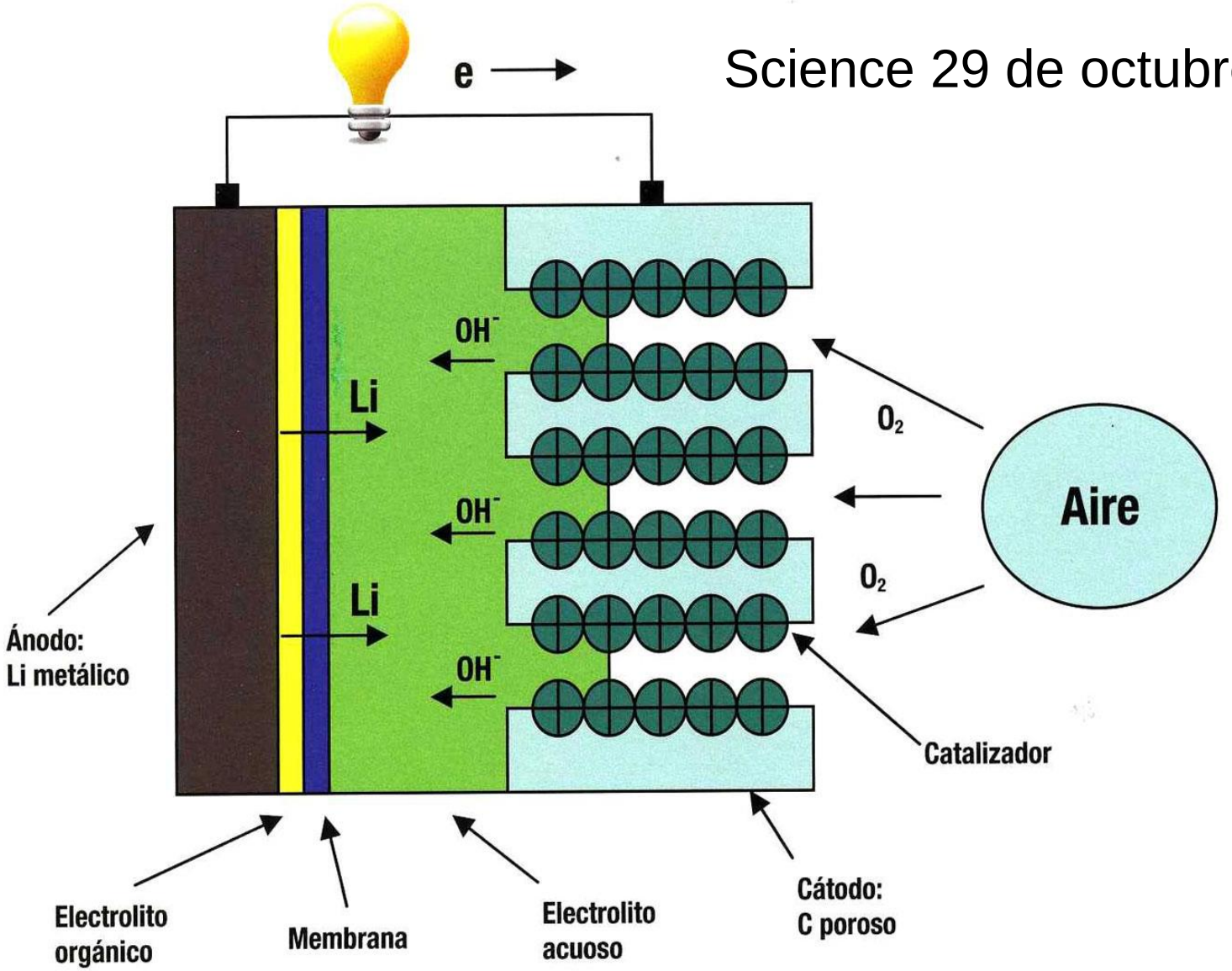
Metal Air batteries(

7 New models with mechanical recharge.



Energía específica teórica y práctica de diversos tipos de pares redox.

Science 29 de octubre 2015

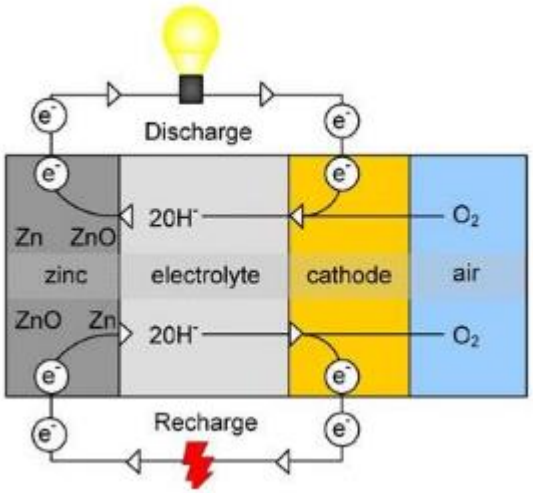


La nueva batería de litio-aire supone una buena noticia para el medio ambiente, porque tiene una densidad energética del 93,2% de la gasolina.

http://www.phinergy.com/company/

https://www.youtube.com/watch?v=k6kIJlggezE

http://www.israelscienceinfo.com/en/high tech/phinergy-israel-voiture-roule-lair-grace-batteries-metal-air/



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