

TECHNOLOGY

BATTERIES FOR ENGINEERING

DEVELOPMENT

APPLICATIONS

INNOVATION

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institutos **lactec**

BORN INNOVATIVE

TOPICS



- 1. INTRODUCTION (terminology, battery construction and operation characteristics)**
- 2. BATTERY TECHNOLOGIES (lead acid, Ni-MH, lithium ion, zebra, metal-air)**
- 3. APPLICATIONS (Portability, renewal sources, Smart Grid, sizing and testing batteries, safety concerns)**
- 4. NEXT GENERATION (battery challenges, new technologies, the future of energy storage)**

Battery Challenges

- 1. High Energy and Power densities**
- 2. Safety**
- 3. Environment concerns**
- 4. Recyclability**
- 5. Costs**
- 6. Materials availability**

Battery Challenges

1. High Energy and Power densities



Every year new batteries are announced (more powerful, with higher cycle life, calendar life, with fast recharging characteristics, cheaper,

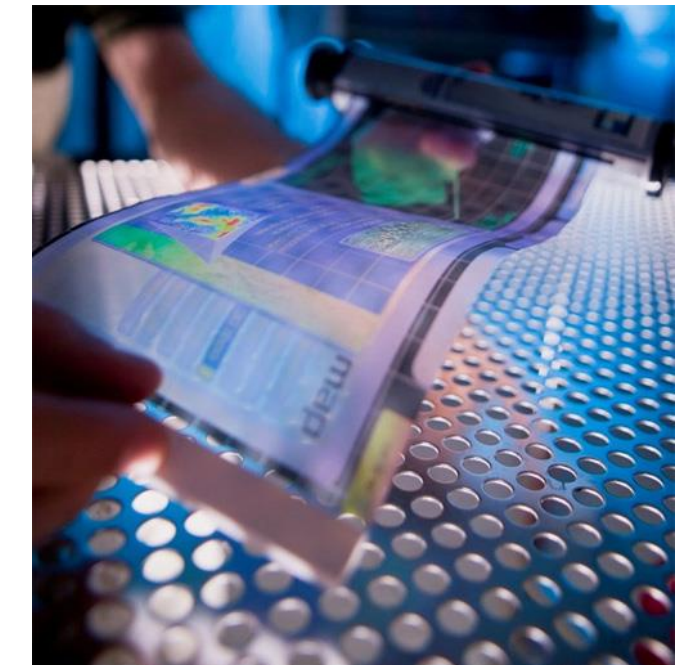
Battery Challenges

1. High Energy and Power densities

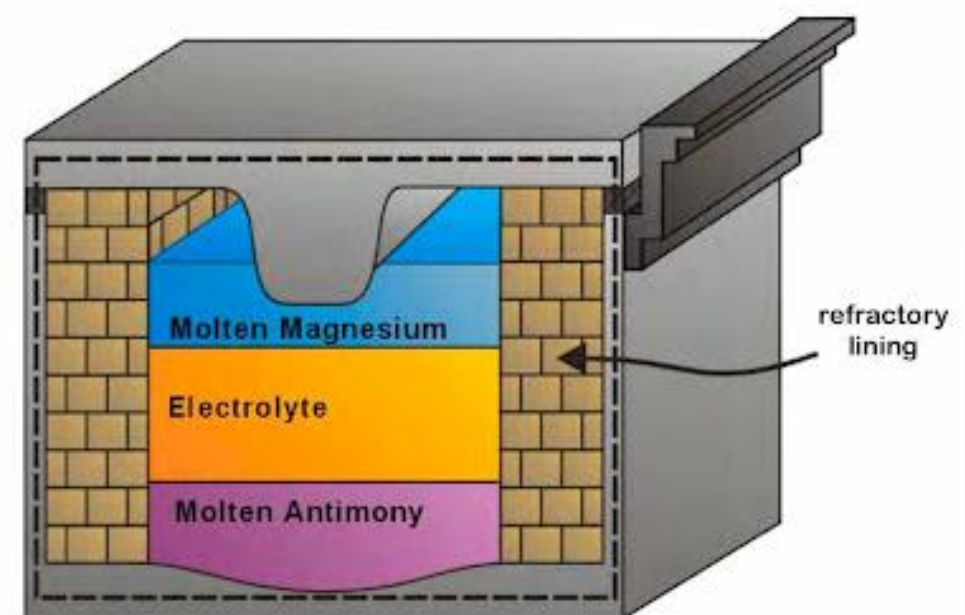
GM and Envia Systems, announced batteries for electric vehicles with 450 km autonomy



AIST Tsukuba



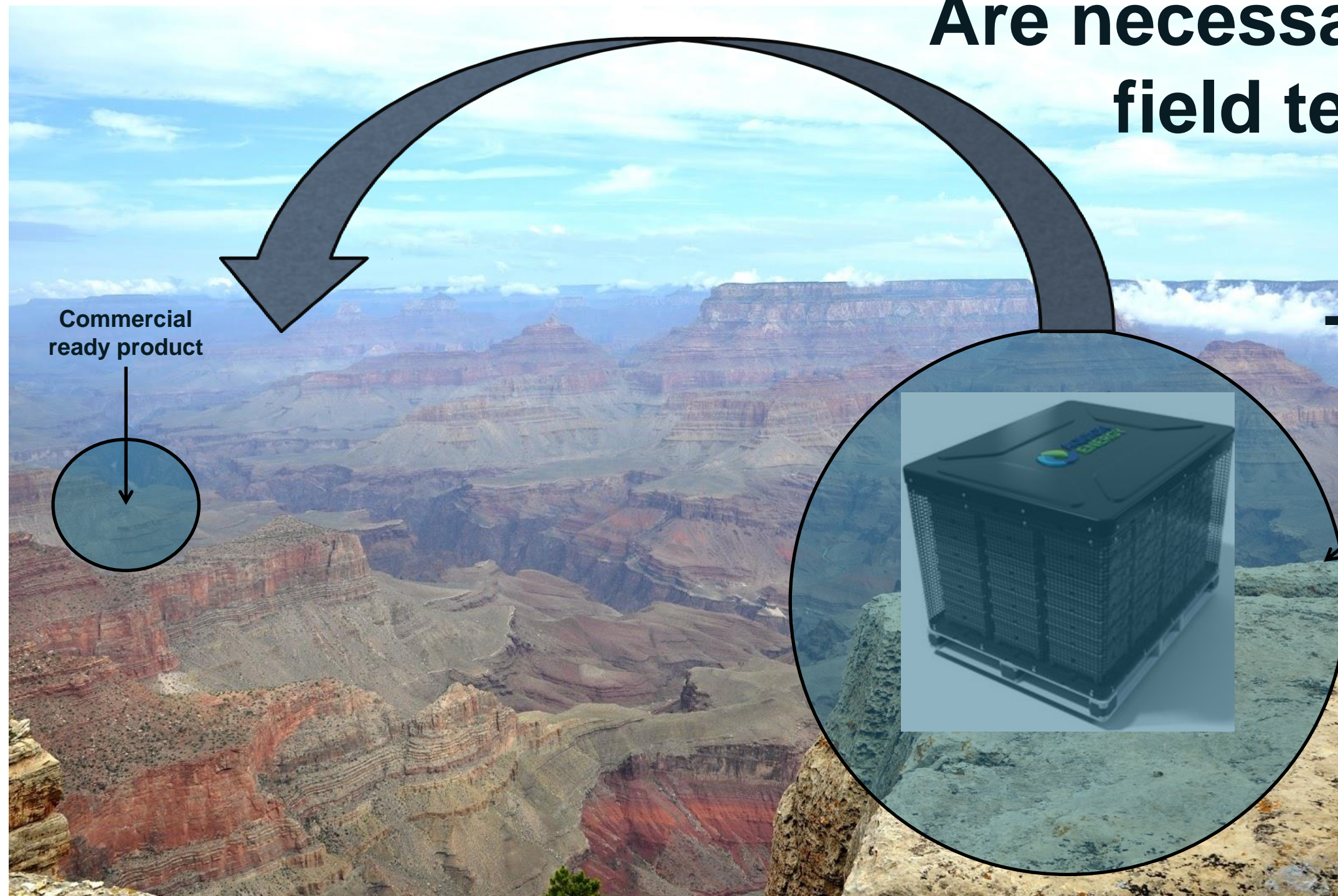
Liquid metal battery (MIT)



But from laboratory to commercial ready product.... Is like...

Battery Challenges

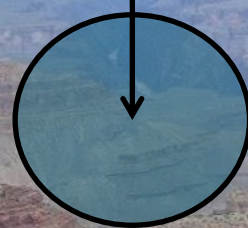
1. High Energy and Power densities



Are necessary many field tests

Laboratory Tested Product

Commercial ready product



Battery Challenges

2. Safety

Dynamite = 4 Mj/kg = 1100 Wh / kg

TNT = 5 Mj/kg = 1390 Wh / kg

Metal-air batteries = 3000 – 6000 Wh /kg

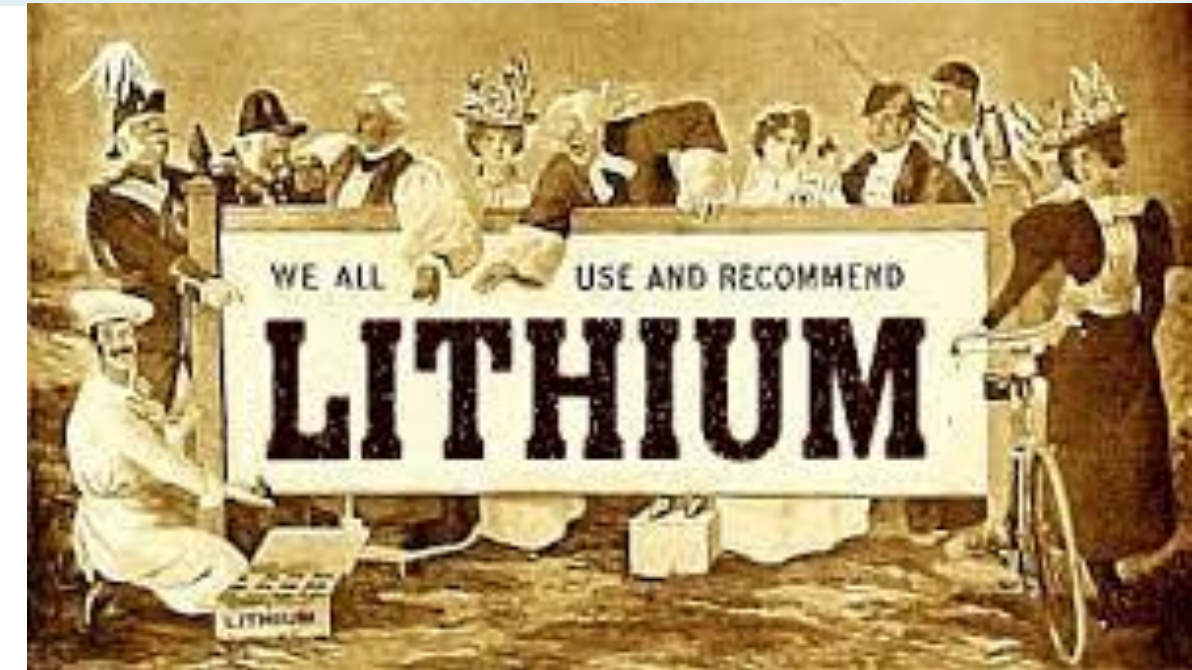
Stair (St. Andrews air) Technology



Battery Challenges

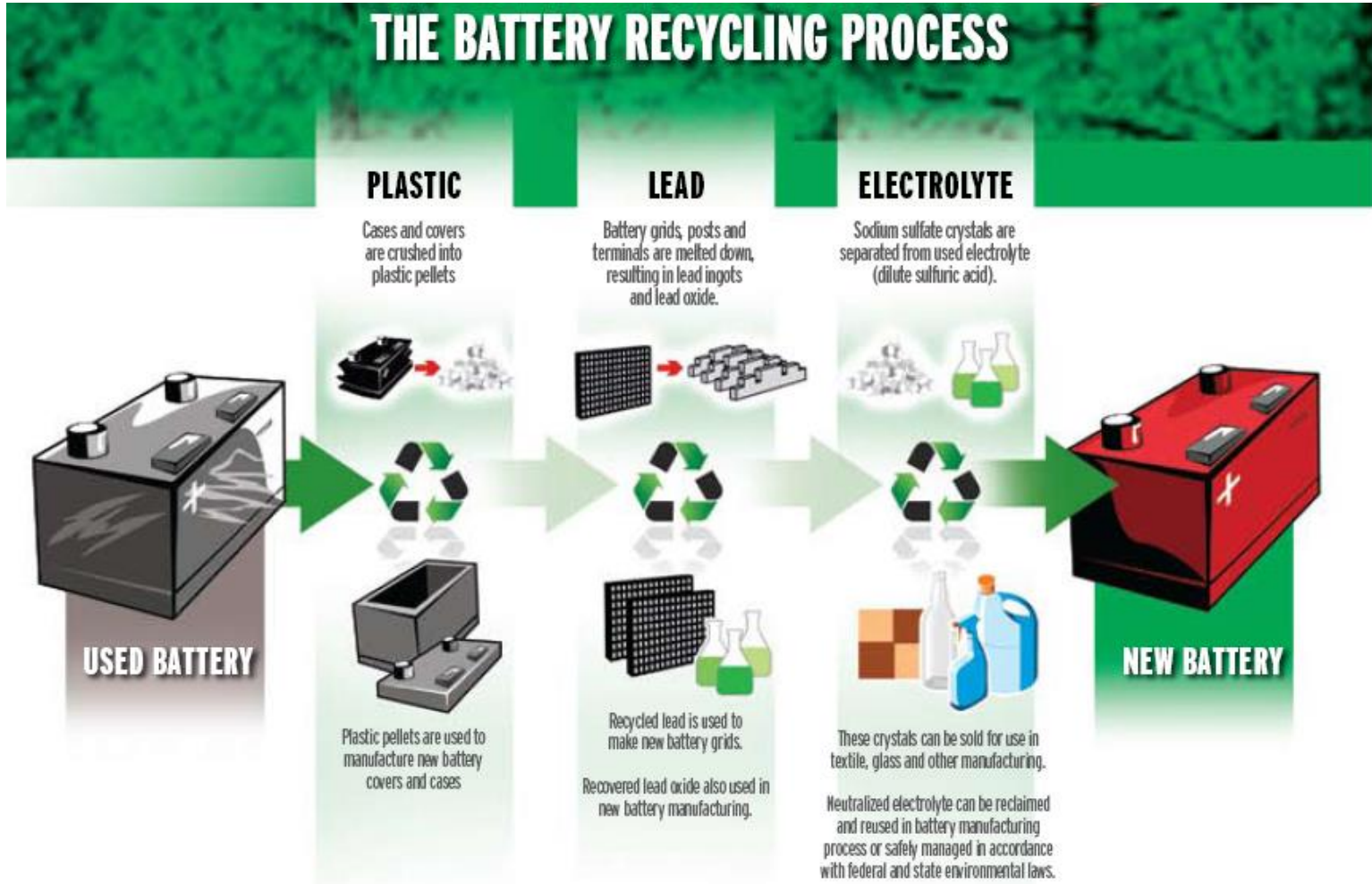
3. Environment concerns

New battery technologies must use environmentally friendly materials



Battery Challenges

4. Recyclability



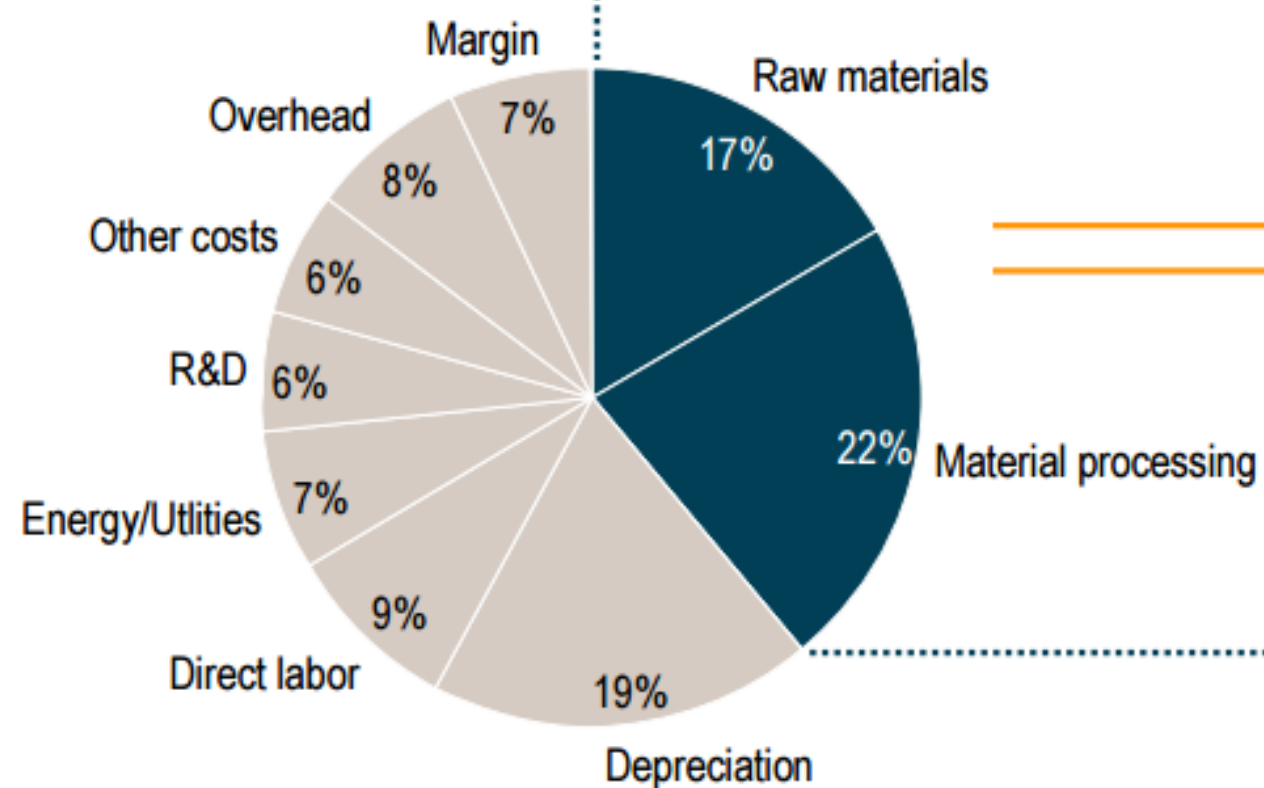
Battery Challenges

5. Cost issues

Importance of different materials in cell battery cost structure

Battery cell cost breakdown, 2010¹⁾

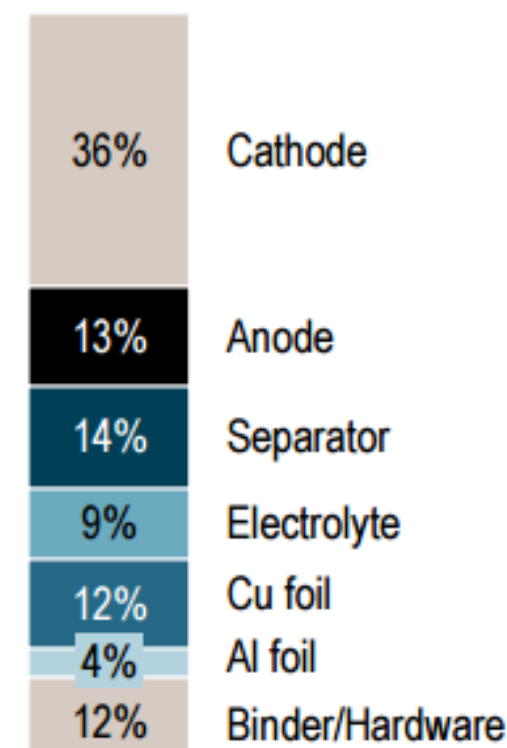
Total cost: approx. USD 500/kWh



Material cost split, 2010¹⁾

~USD 195/kWh

~75%
(approx. 30% of
total cell costs)

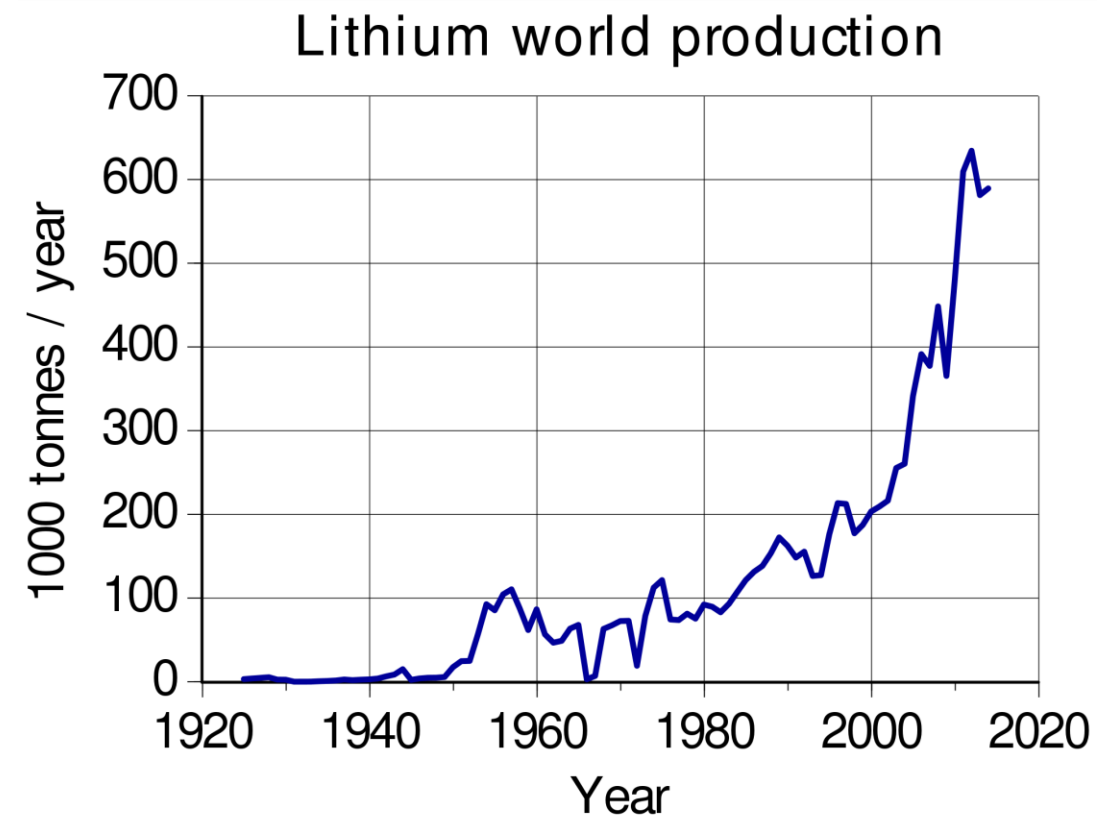


Material cost breakdown

1) Approximate values for ternary mixture (NMC), depend on the chemistry and quality, excl. module/pack components (connectors, housing, BMS, cooling module)

Battery Challenges

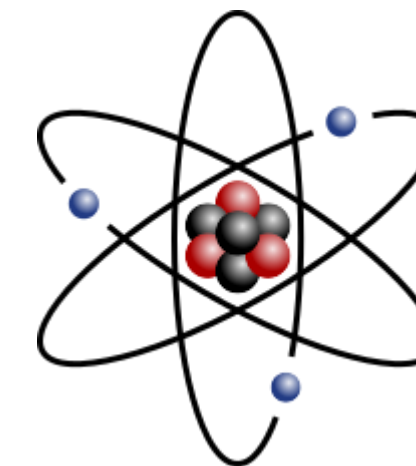
6. Materials availability



Battery New Technologies

Periodic Table of the Elements

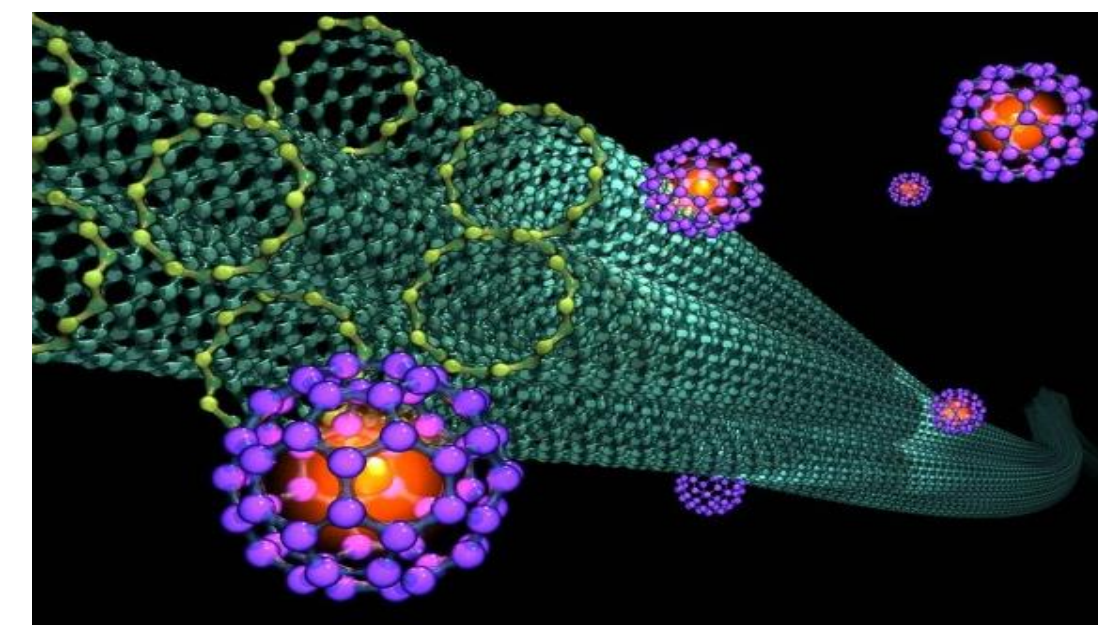
1 1A 1A H Hydrogen 1.008	2 IIA 2A He Helium 4.003																
3 Li Lithium 6.941	4 Be Beryllium 9.012											5 B Boron 10.811	6 C Carbon 12.011	7 N Nitrogen 14.007	8 O Oxygen 15.999	9 F Fluorine 18.998	10 Ne Neon 20.180
11 Na Sodium 22.990	12 Mg Magnesium 24.305	3 IIIB 3B	4 IVB 4B	5 VB 5B	6 VIB 6B	7 VIIB 7B	8 VIII 8	9 VIII 8	10 VIII 8	11 IB 1B	12 IIB 2B	13 Al Aluminum 26.982	14 Si Silicon 28.086	15 P Phosphorus 30.974	16 S Sulfur 32.066	17 Cl Chlorine 35.453	18 Ar Argon 39.948
19 K Potassium 39.098	20 Ca Calcium 40.078	21 Sc Scandium 44.956	22 Ti Titanium 47.867	23 V Vanadium 50.942	24 Cr Chromium 51.996	25 Mn Manganese 54.938	26 Fe Iron 55.845	27 Co Cobalt 58.933	28 Ni Nickel 58.693	29 Cu Copper 63.546	30 Zn Zinc 65.38	31 Ga Gallium 69.723	32 Ge Germanium 72.631	33 As Arsenic 74.922	34 Se Selenium 78.971	35 Br Bromine 79.904	36 Kr Krypton 84.798
37 Rb Rubidium 84.468	38 Sr Strontium 87.62	39 Y Yttrium 88.906	40 Zr Zirconium 91.224	41 Nb Niobium 92.906	42 Mo Molybdenum 95.95	43 Tc Technetium 98.907	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.906	46 Pd Palladium 106.42	47 Ag Silver 107.868	48 Cd Cadmium 112.411	49 In Indium 114.818	50 Sn Tin 118.711	51 Sb Antimony 121.760	52 Te Tellurium 127.6	53 I Iodine 126.904	54 Xe Xenon 131.294
55 Cs Cesium 132.905	56 Ba Barium 137.328	57-71	72 Hf Hafnium 178.49	73 Ta Tantalum 180.948	74 W Tungsten 183.84	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.217	78 Pt Platinum 195.085	79 Au Gold 196.967	80 Hg Mercury 200.592	81 Tl Thallium 204.384	82 Pb Lead 207.2	83 Bi Bismuth 208.980	84 Po Polonium [208.982]	85 At Astatine 209.987	86 Rn Radon 222.018
87 Fr Francium 223.020	88 Ra Radium 226.025	89-103	104 Rf Rutherfordium [261]	105 Db Dubnium [262]	106 Sg Seaborgium [266]	107 Bh Bohrium [264]	108 Hs Hassium [269]	109 Mt Meitnerium [268]	110 Ds Darmstadtium [269]	111 Rg Roentgenium [272]	112 Cn Copernicium [277]	113 Uut Ununtrium unknown	114 F1 Flerovium [289]	115 Uup Ununpentium unknown	116 Lv Livermorium [298]	117 Uus Ununseptium unknown	118 Uuo Ununoctium unknown



No new elements...more technology!

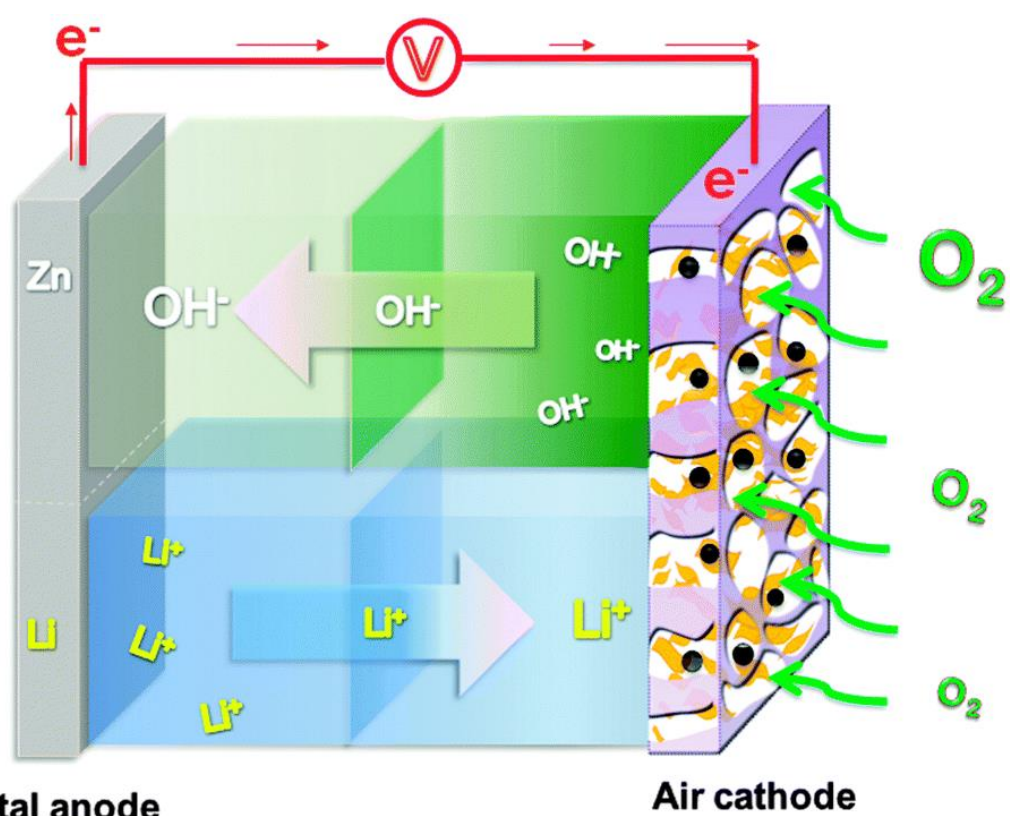
Lanthanide Series	57 La Lanthanum 138.905	58 Ce Cerium 140.116	59 Pr Praseodymium 140.908	60 Nd Neodymium 144.243	61 Pm Promethium 144.913	62 Sm Samarium 150.36	63 Eu Europium 151.964	64 Gd Gadolinium 157.25	65 Tb Terbium 158.925	66 Dy Dysprosium 162.500	67 Ho Holmium 164.930	68 Er Erbium 167.259	69 Tm Thulium 168.934	70 Yb Ytterbium 173.055	71 Lu Lutetium 174.967
Actinide Series	89 Ac Actinium 227.028	90 Th Thorium 232.038	91 Pa Protactinium 231.036	92 U Uranium 238.029	93 Np Neptunium 237.048	94 Pu Plutonium 244.064	95 Am Americium 243.061	96 Cm Curium 247.070	97 Bk Berkelium 247.070	98 Cf Californium 251.080	99 Es Einsteinium [254]	100 Fm Fermium 257.095	101 Md Mendelevium 258.1	102 No Nobelium 259.101	103 Lr Lawrencium [262]

- Alkali Metal
- Alkaline Earth
- Transition Metal
- Basic Metal
- Semimetal
- Nonmetal
- Halogen
- Noble Gas
- Lanthanide
- Actinide

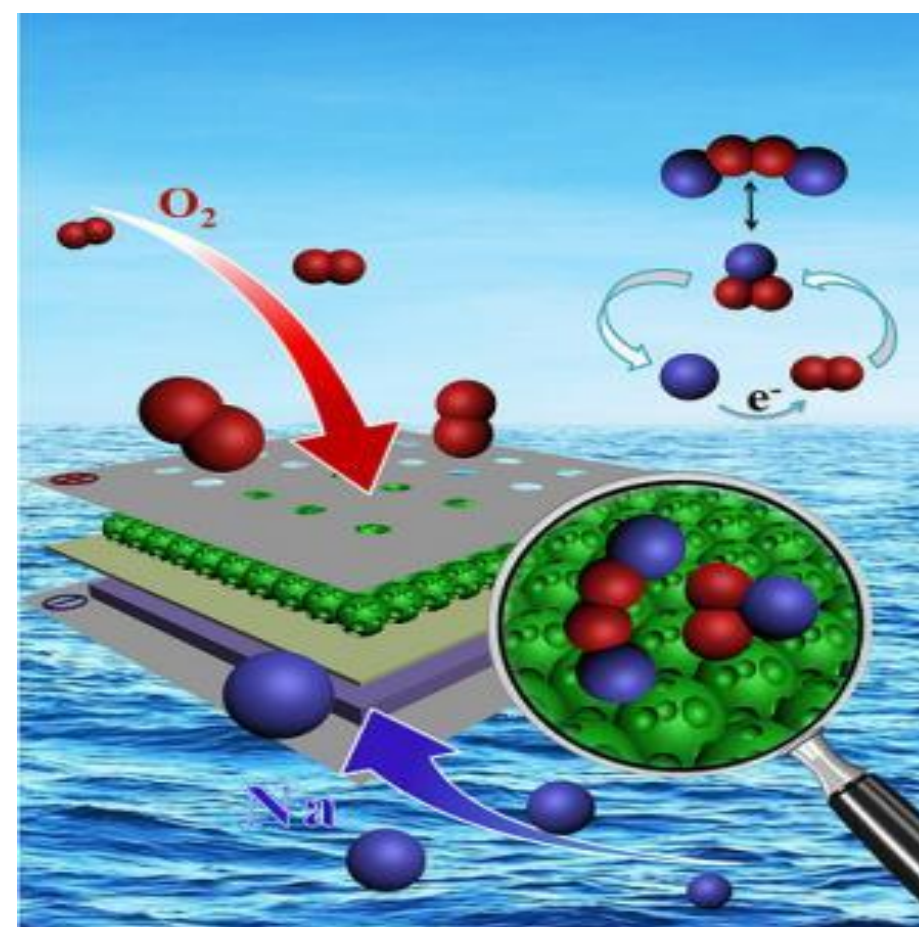


Battery New Technologies

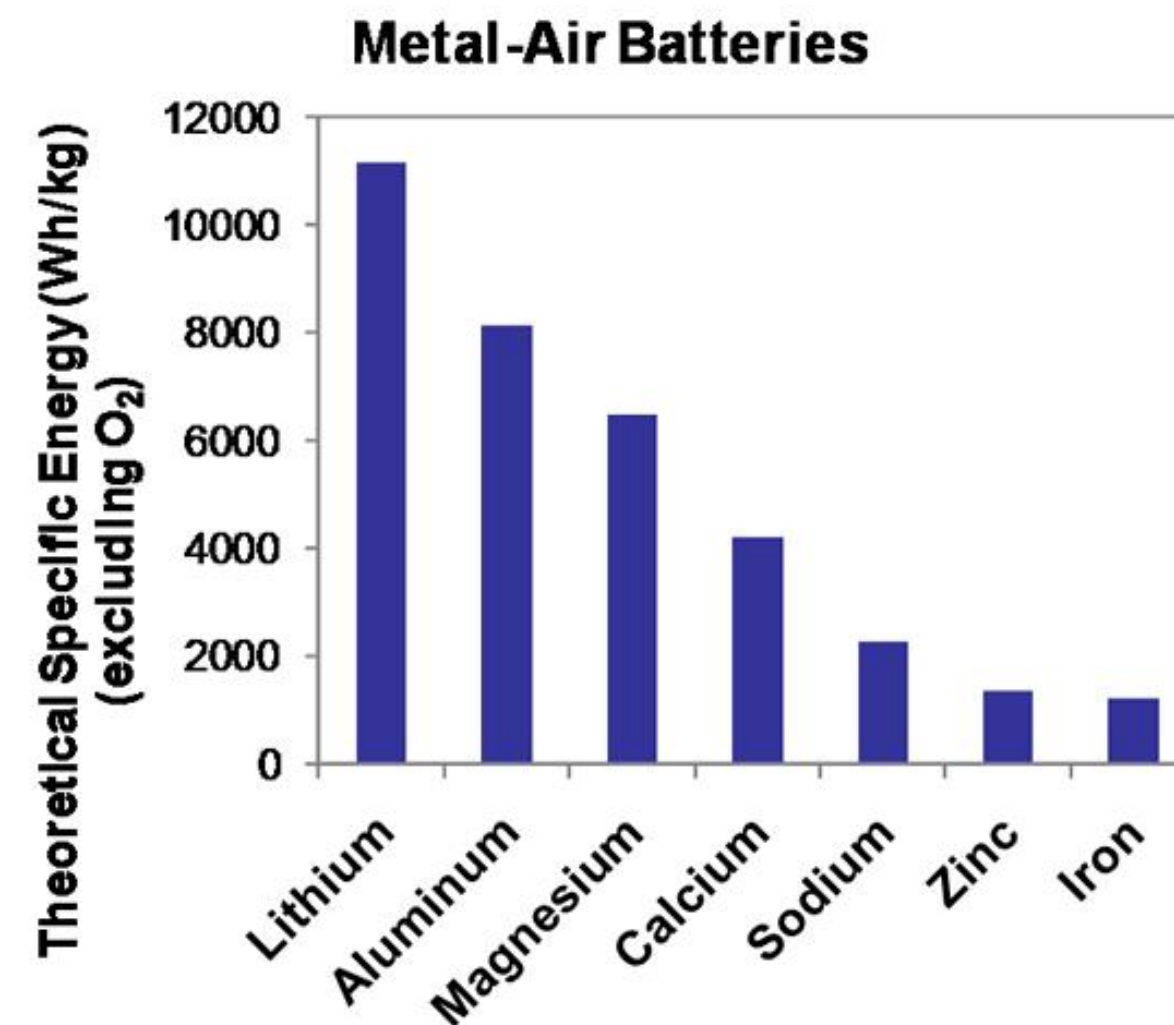
Metal air batteries:
Anode – metal oxidation
Cathode – oxygen reduction



OH^- : in aqueous Zn-air battery
 Li^+ : in non-aqueous Li-air battery
 ● : Oxygen catalysts



Na-Ar

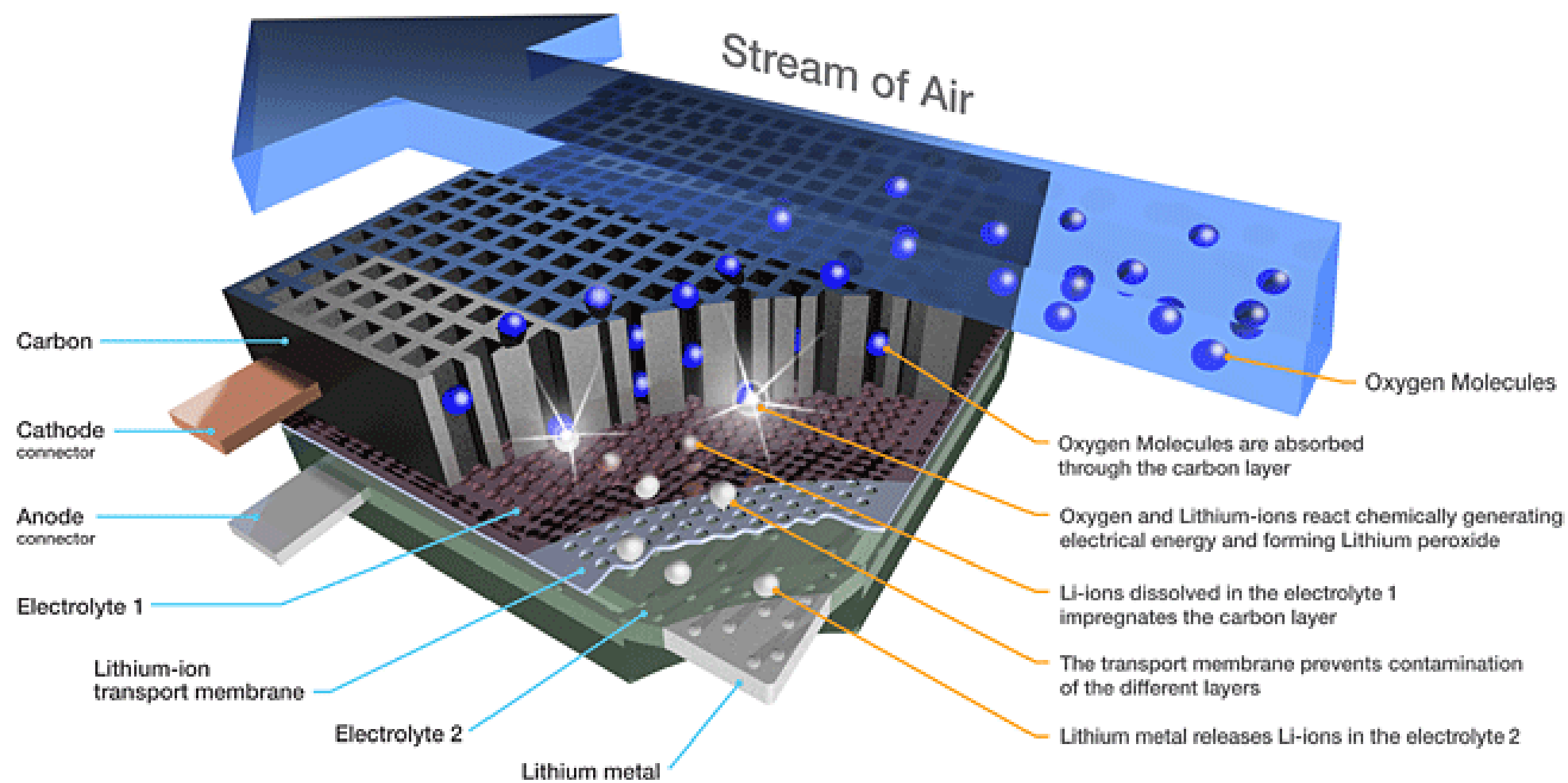


Battery New Technologies

Metal-air batteries

Battery 500

The Battery 500 technology is an open system using common air as a reagent which upon recharge releases oxygen back into the environment.



Battery New Technologies



Super caps

Ultra batteries

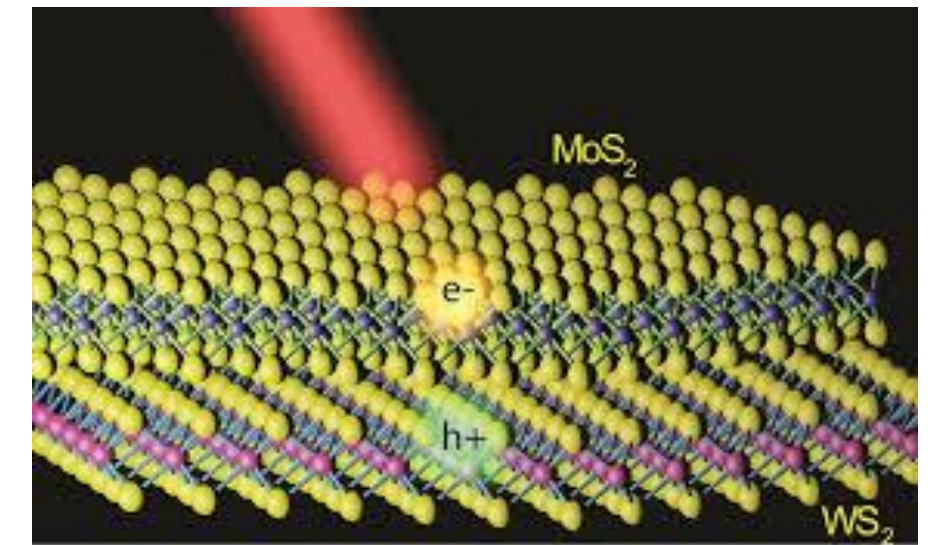
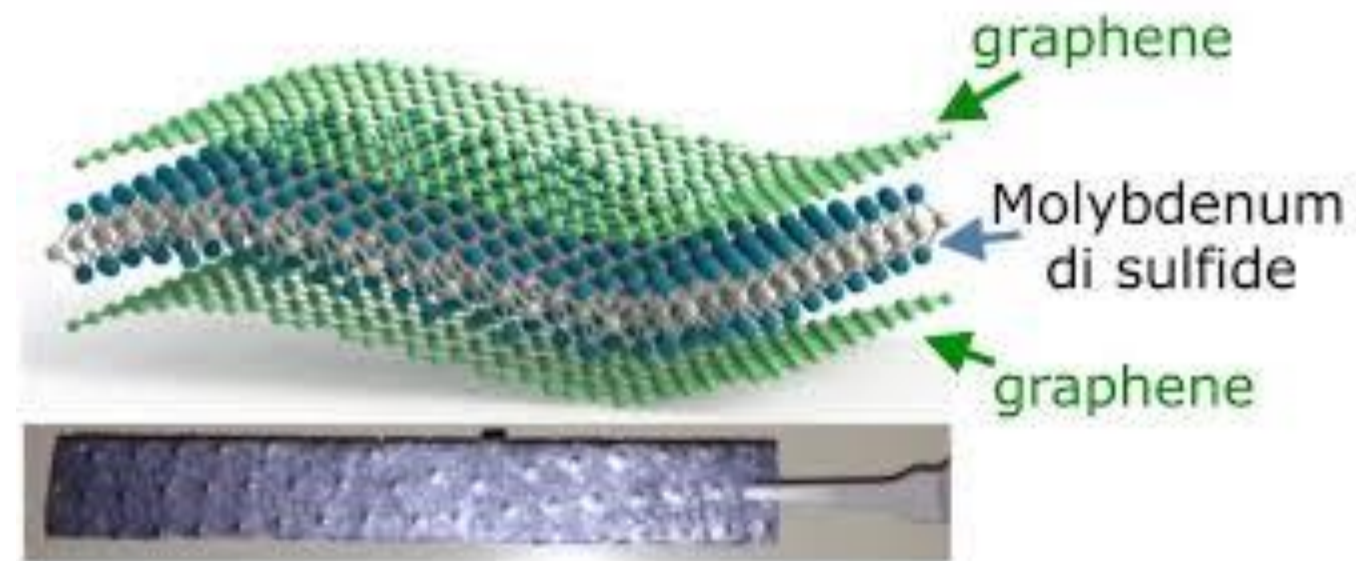
Other technologies...

Fuel Cells

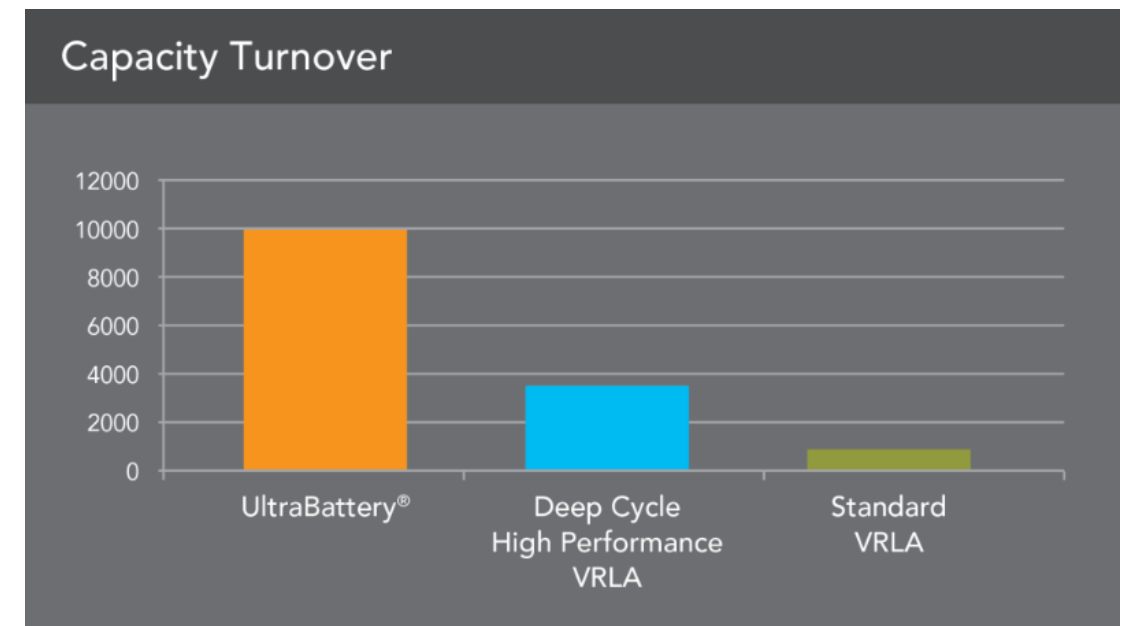
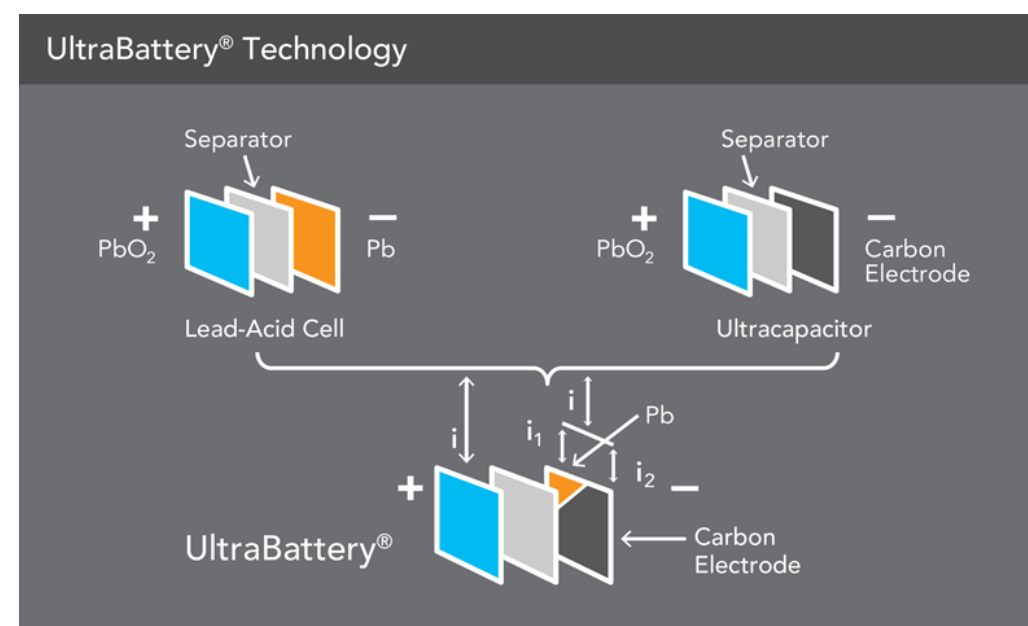
Flow batteries

Battery New Technologies

Supercapacitors

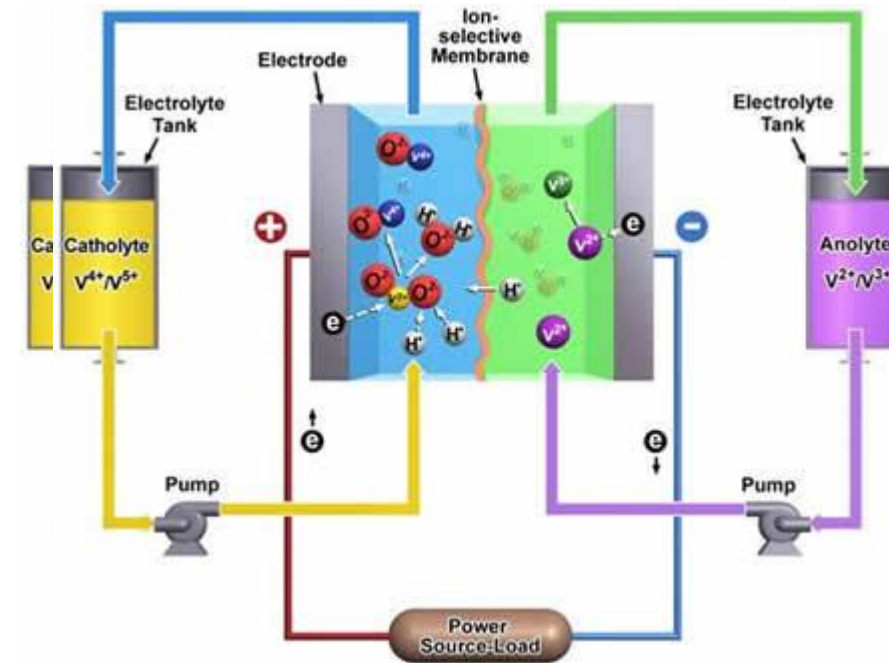
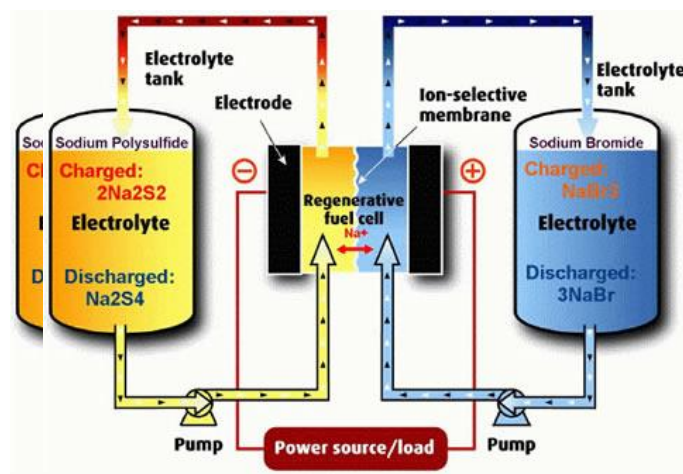


Ultra batteries

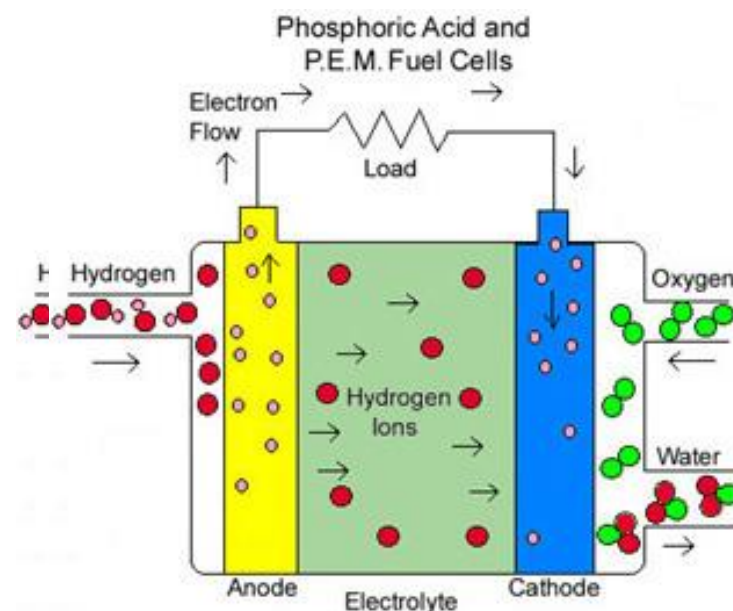


Battery New Technologies

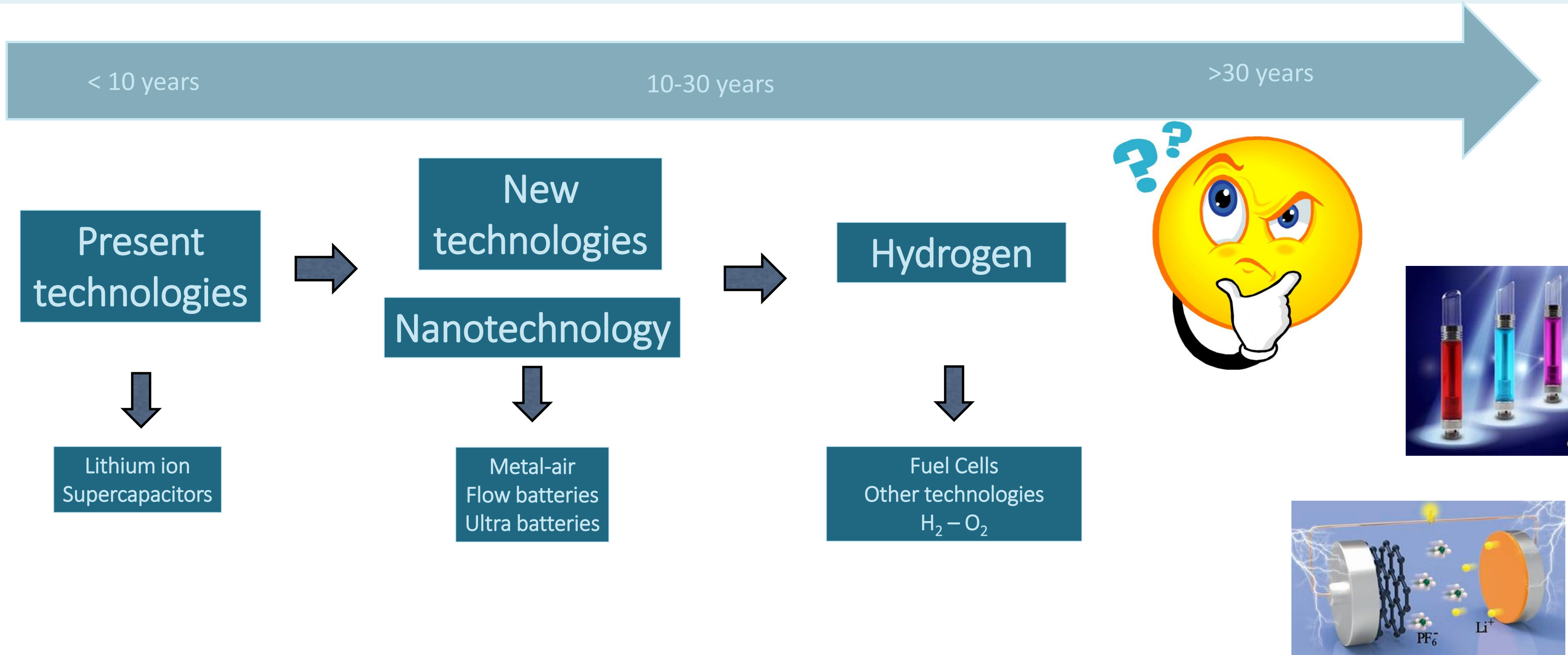
Flow Batteries



Fuel Cells



Conclusions





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B O R N I N N O V A T I V E



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THANK YOU