RECUPYL exploite la mine Urbaine®

Déchets et Développement Durable

La réincarnation des métaux

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Les 4 défis du 21em siècle

1. Changement Climatique
2. Energie : "pic" du pétrole
3. Ressources en eaux
4. Ressources minérales

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2

Les réponses

1. Changement Climatique → baisse des émissions CO_2
2. Energie → baisse part énergie fossile
3. Eaux → économie and recyclage
4. Ressources minérales → substitution et RECYCLAGE

3

"Durabilité" des ressources stratégiques

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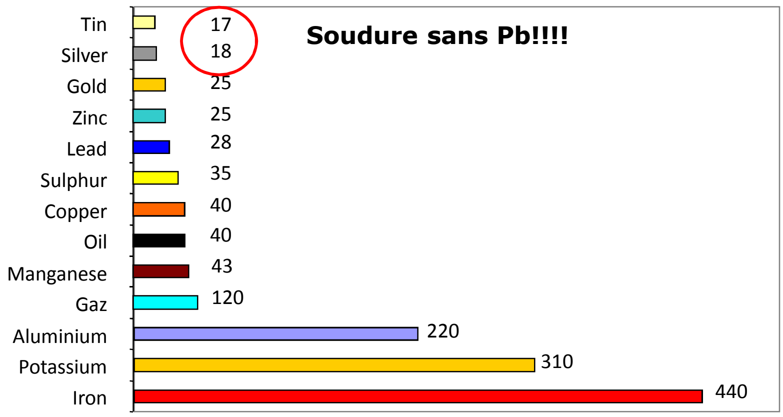
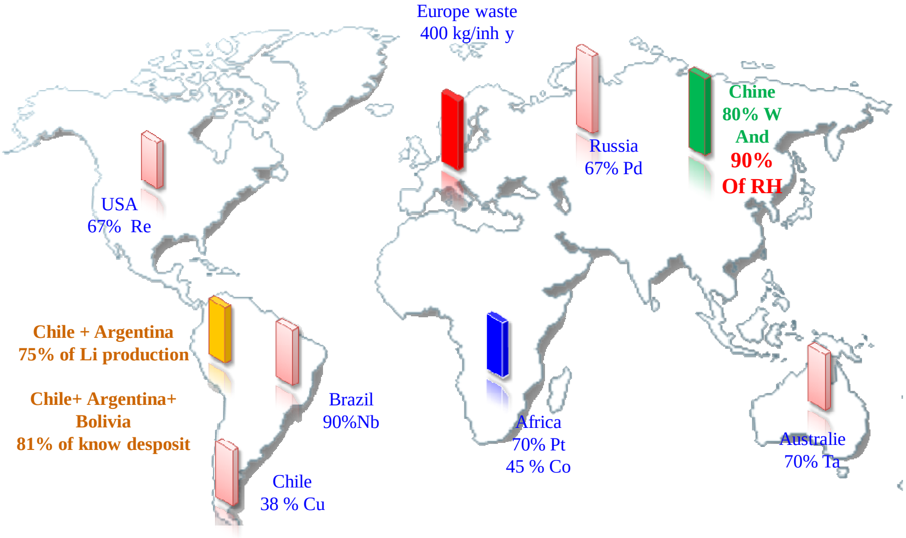
Nombre d'années de disponibilté



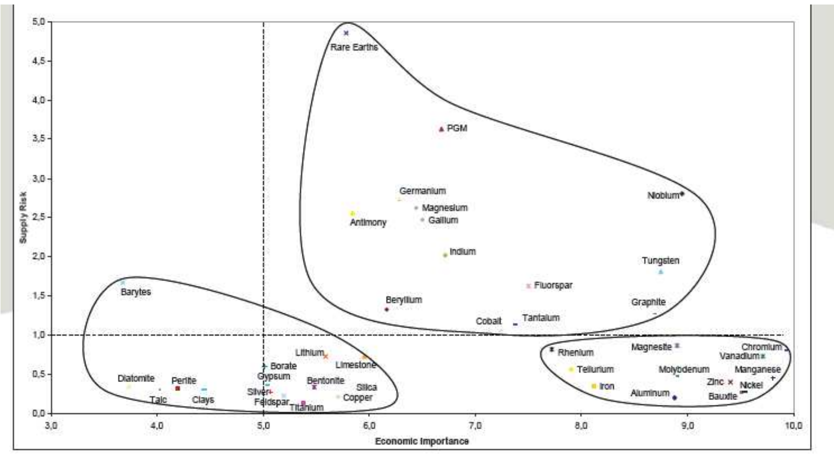
Sources OMPM 2007

Aspect Géopolitique
Concentration des ressources stratégiques



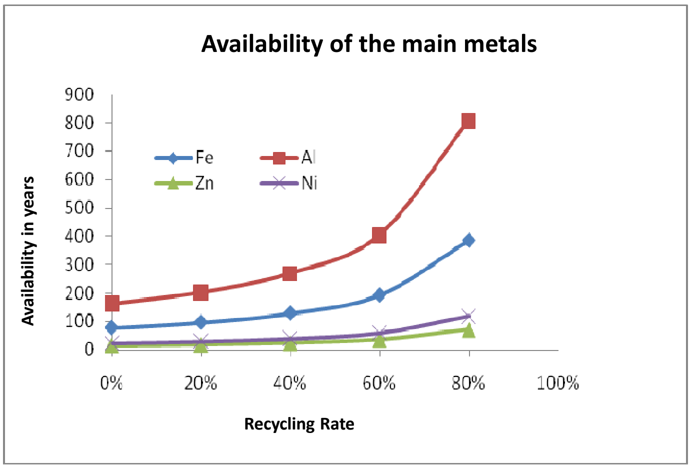
Situation européenne

Classification of the 14 critical metals for EC (Madrid report July 2010)



The "Raw Materials Initiative": a new challenge for the EU recycling industry" DG Industry and enterprise (Brussels , September 15, 2010)

Durabilité des ressources métalliques



La solution est autour de nous

De l'ancienne mine ...

... À la mine "urbaine"

Quelques exemples de mines « urbaines »

Ba , Pb, Y, Eu

In, Sn , Ag

Au, Ag, Pd, Co

Electrical and hybrid cars
RH, Li, Co-Mn-Ni

Pour cela nécessité ABSOLUE d'organiser un cycle de vie pour tout PRODUIT

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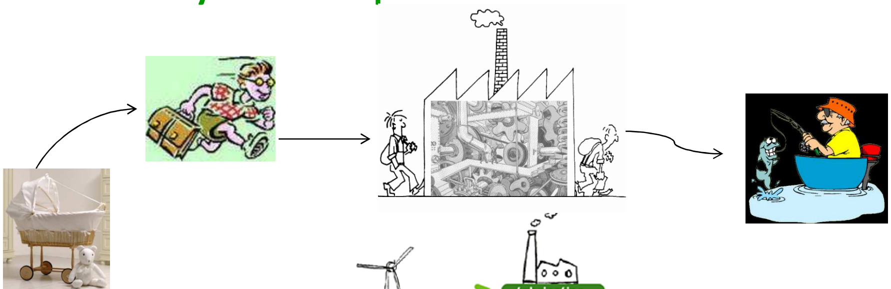

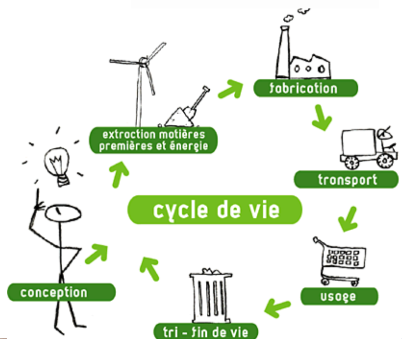

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Segment des piles et batteries

Evolution des batteries

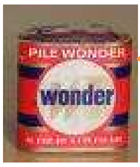
1890

1930

2005

1998

Evolution de la composition



From …..
natural Binders
Paper, coal
And mercury
additive

To….. PTEFE,
Graphite,
Plastic, steel
And .. mercury Free
But other additives

From …..
Rubber,
wood
And lignite

To …..
PP,
PE, PVC
And baryum
sulfate

Évolution de la chimie des piles et batteries depuis 130 ans!

En permanence de nouveaux métaux

1880
- Zn-MnO2
- Pb-PbO2

1940
- Zn-MnO2
- Pb-PbO2
- Ni-Cd
- Zn-HgO
- Zn-air

1980
- Zn-MnO2
- Pb-PbO2
- Ni-Cd
- Zn-HgO
- Zn-air
- Ni-MHx
- Zn-Ag2O
- Li-MnO2
- Li-SOCl2
- Li-CFx
- Li-FeS2
- Ni-Fe

2000
- Zn-MnO2
- Pb-PbO2
- Ni-Cd
- Zn-HgO
- Zn-air
- Ni-MHx
- Zn-Ag2O
- Li-MnO2
- Li-SOCl$_2$
- Li-CF$_x$
- Li-FeS$_2$
- Ni-Fe
- Li-CoO$_x$

2010
- Zn-MnO2
- Pb-PbO2
- Ni-Cd
- Zn-HgO
- Zn-air
- Ni-MHx
- Zn-Ag2O
- Li-MnO2
- Li-SOCl2
- Li-CFx
- Li-FeS2
- Ni-Fe
- Li-Li CoO$_x$
- Li-LiNiO$_2$
- Li-Li Mn2O4
- Li-(V$_6$O$_{13}$)
- Li-Li FePO4
- Li-M-N-C
- Li(Si)- Sx

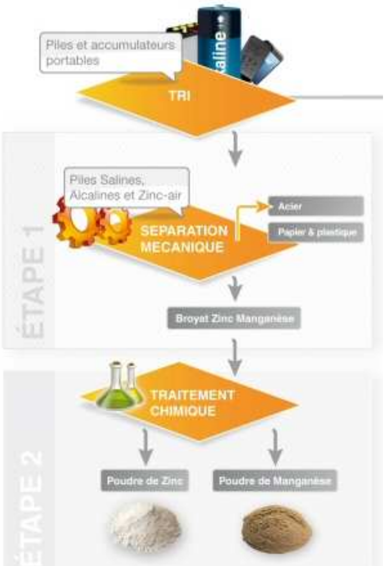
Evolution de la consommation

1960

1990= 1960 +

2010= 1990 +

Recyclage des piles alcalines et salines
résoudre un problème, préserver une ressource



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Recyclage des piles alcalines et salines



Europe = 120 000 T/an

18 000 acier

24 000 T Zinc

20 000 manganèse

Réincarnation en……..

bordures d'autoroute
Acier galvanisé

Acier dur au Mn

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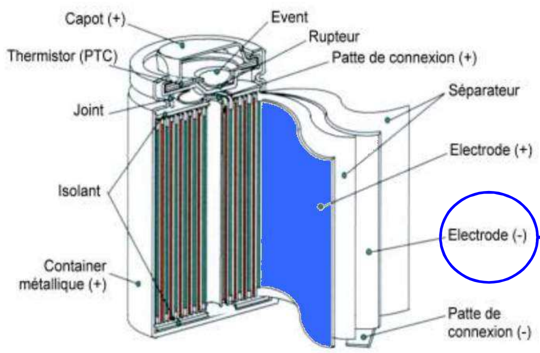
Segment des batteries lithium ion

les batteries Li-ion un segment très riche et très dynamique

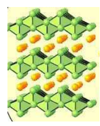
Anode	Separator	Electrolyte	Cathode	Stoichiometry
graphite	polyolefin	carbonates and lithium salt	lithiate cobalt-oxide	$LiCoO_2$
graphite	polyolefin	carbonates and lithium salt	lithiated nickel-cobalt-aluminum-oxide	$LiNi_{0.8}Co_{0.15}Al_{0.05}O_2$
graphite	polyolefin	carbonates and lithium salt	lithiated nickel-manganese cobalt oxide	$LiNi_xCo_zMn_yO_2$
amorphous carbon	ceramic-coated polyolefin	carbonates, lithium salt, and polymer	lithiated manganese-oxide	$LiMn_2O_4$
amorphous carbon	polyolefin	carbonates and lithium salt	lithiated manganese-oxide	$LiMn_2O_4$
lithium-titanate	polyolefin	carbonates, lithium salt, and polymer	lithiated manganese-oxide	$LiMn_2O_4$
graphite	polyolefin	carbonates and lithium salt	lithiated iron-phosphate	$LiFePO_4$

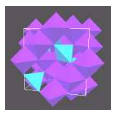
Le lithium présent dans tous les systèmes

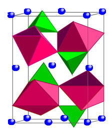
Tendance de cathodes



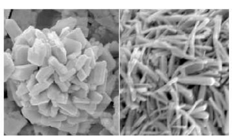
- •LiCoO2
- •LiMn2O4
- •LiFePO4
- •LiMPO4
- •LiNCA
- •LiNCM





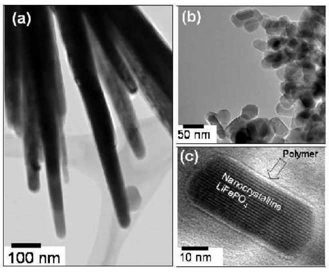


Évolution vers les nanomatériaux

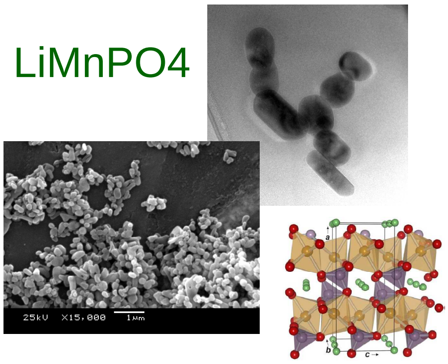


Matériaux avancés

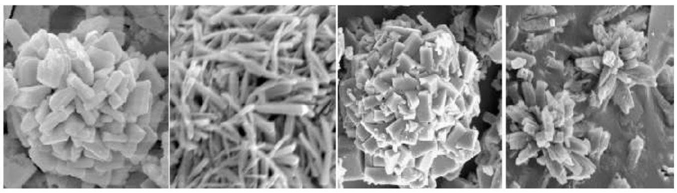
LiFePO4



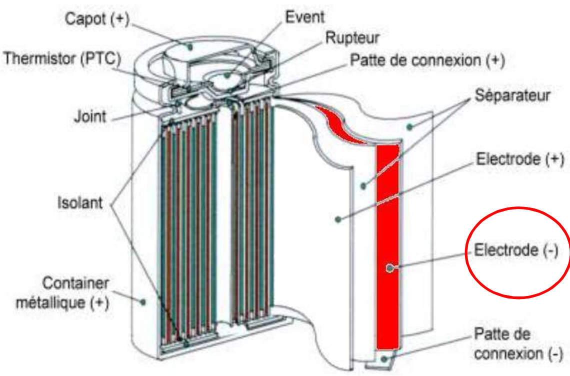
LiMnPO4



$LiMn_{0.5}Fe_{0.5}PO_4$ — $LiMnPO_4$ — $LiMn_{0.33}Ni_{0.33}Co_{0.33}PO_4$ — $LiMn_{0.5}Mg_{0.5}PO_4$

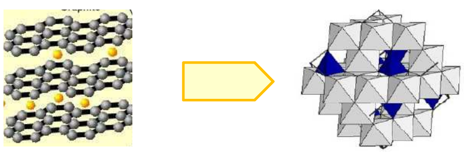


Tendance des anodes

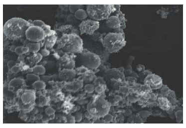
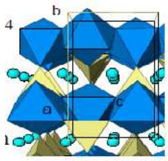


- Graphite
- Silicon based anode
- SiO2 based anode
- Tin base anode
- Titanium based anode

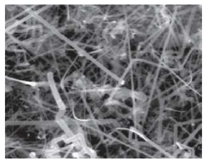
Évolution de matériaux 2D aux matériaux 3D



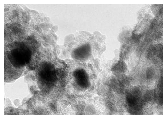
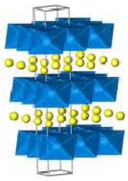
Matériaux avancés pour anodes

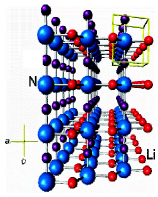
CuSn anode



Nano silicon anode

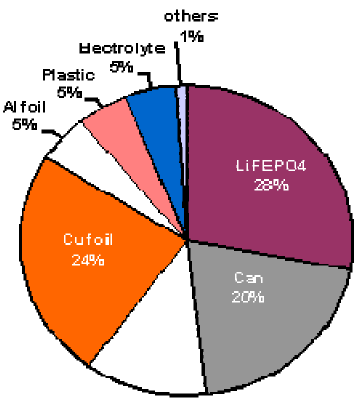
Carbon-tin anode



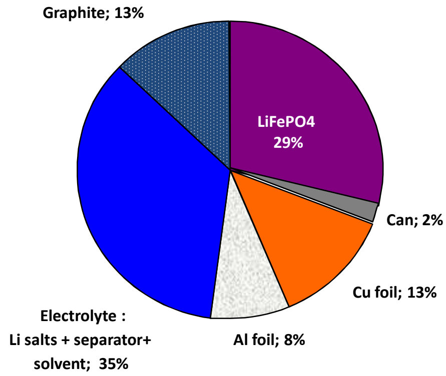
Li-Ti-Ni anode

equation de recyclage et conservation de ressources
Example de batteries lithium ion à base de LiFePO4

Weight composition



"cost" composition



Cibler tous les composants

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La durabilité de ce segment passe par la maîtrise du lithium

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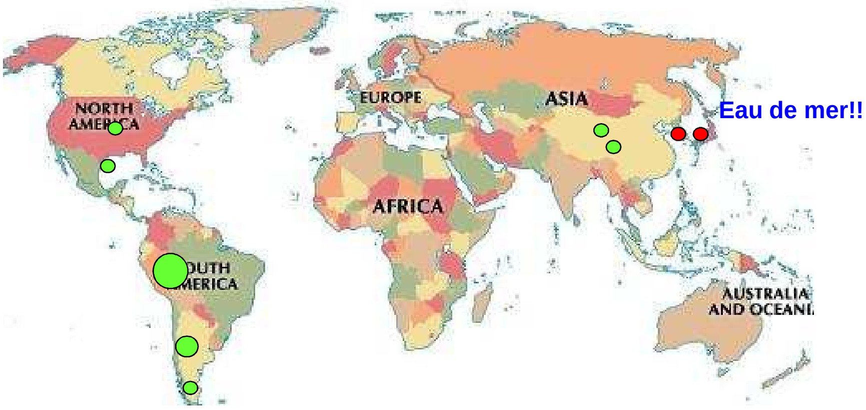
Demande / offres ???

Ressources Limitée? **Difficulté d'accès**



Ressources naturelles en Lithium

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Salar de Uyuni (Bolovia)
0.025%

Salar de Atocama (Chile)
0.14%

Silver peak Nevada
0,023 %

To be concentrated until 6%

And separate Na; K; Mg and ca

needs from 3 to 6 months par campagne

Average Li in batteries
3.5 %

continuous Process from 100 to 1000 kg/h

Example :
Durabilité des ressources en lithium de l'ancienne mine à la mine "urbaine"

Pour produire
1 Tonne de Li
On a besoin de…

250 T de mienrai (spodumène)

ou

750 T de saumure

28 T de batterie Li-ion portable

113g Li /kWh

Ou **de** batteries EV

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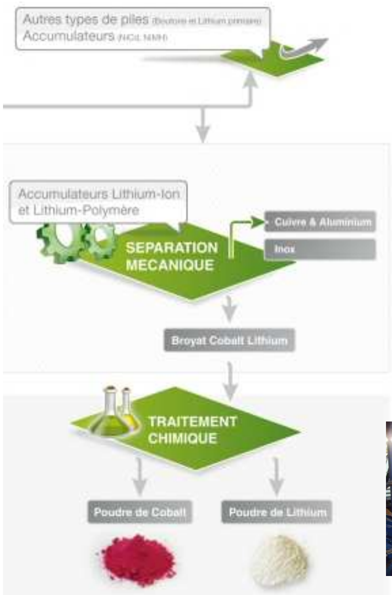
Recyclage des batteries lithium ion

Quelle voie ?

Au cours du recyclage ne pas « annuler » l'économie de CO_2 du VE et HEV

Recyclage des batteries lithium ion

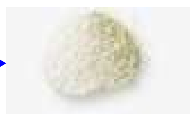


Réincarnation des métaux en …..

Acier inox

Sels de cobalt

Carbonate de Li



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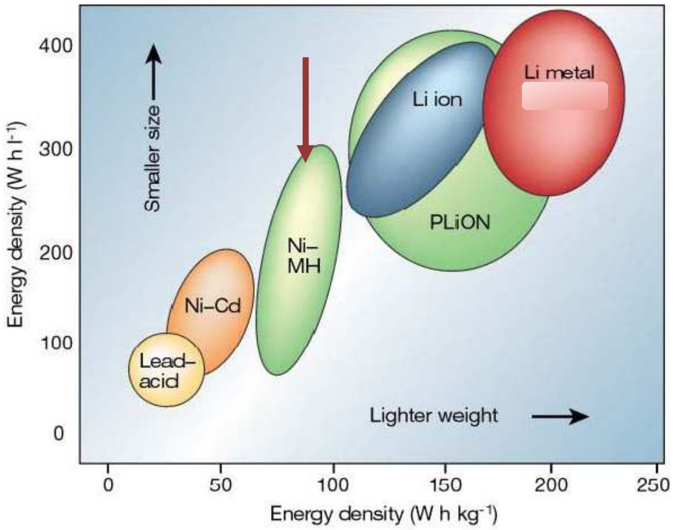
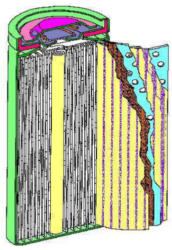
Battery nickel métal hydrure
(anode à base de Terres Rares)

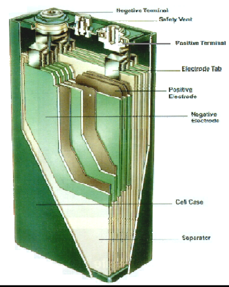
Quelle place pour la batterie Ni-MH?



Composition massique de batteries Ni-MH (moyenne prismatiques et cylindriques)

	AB5	AB2
Cathode	23-29%	28-31%
Anode	31-35%	30-33%
Separator, plastics and additives	9-13%	15-20%
Steel jacket	14-22%	19-21%

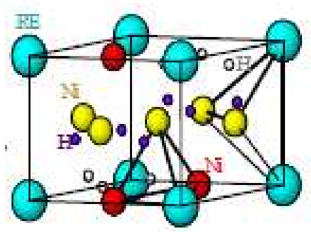




Electrode hydrure

Anode of Mish metals

It is an intergrowth of Ni-RE with free position for H

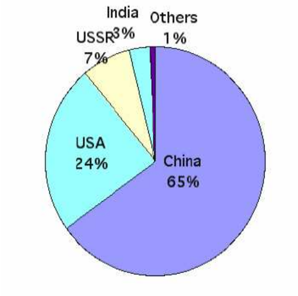


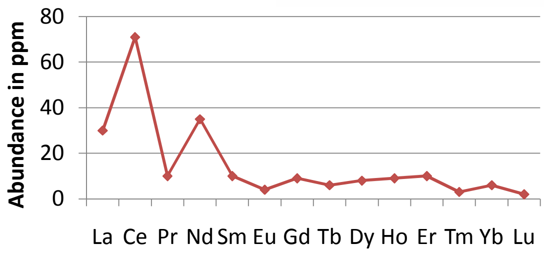
- RE
- Nickel position 1,
- Nickel position ½
- H2 insered

Average composition

A_xB_y anode	Components
AB_5	A, La, Ce, Nd, Pr B: Ni, Co, Mn, Al
AB_2	A: La, Ti B: Pr, Ni (+Nd, Co, Fe, Mn)

Terres Rares : les sources principales sont la monazite et la xenotime





Terres Rares…vraiment rares …sauf en Chine!!!!! 88% de la production mondiale

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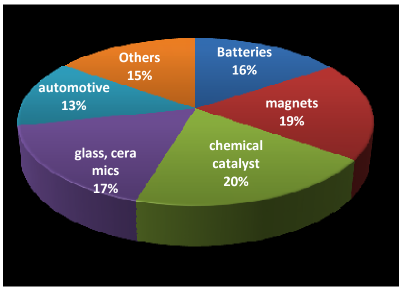
The richest in Bayar Obo Mine (Inner Mongolia)
View Google earth

Monazite deposit
with 2.8 % of RE

Urban Mine

Negative Electrode (3 brands)	La, Ce, Nd, Pr	90 à 150 kg/T of batteries

Utilisation des Terres Rares



Ex. **Wind turbine**
1MW need 500 to 800 kg
of Neodyme
(NdB magnet)

Application	Magnets	NiMH batteries	Catalysis	Display and optic	Glass Additives
Metals	Nd, Pr, Dy, Tb, Sm	La, Ce, Pr, Nd	Ce, La, Nd La, Ce, Pr, Nd	Eu, Y, Tb, La, Dy, Ce, Pr, Gd ,	Ce, La, Nd, Er, Gd, Yb

Terres Rares et batteries

Batteries Ni MH pour véhicule hybride
de 12 à 15 kg de TR par batterie

En plus du besoin pour le portable et l'outillage

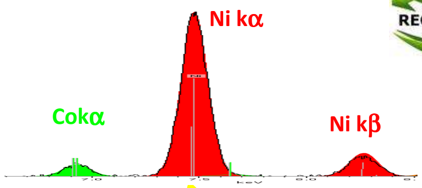
Réincarnation des fractions de la batterie Ni-MH

100 kg of batteries

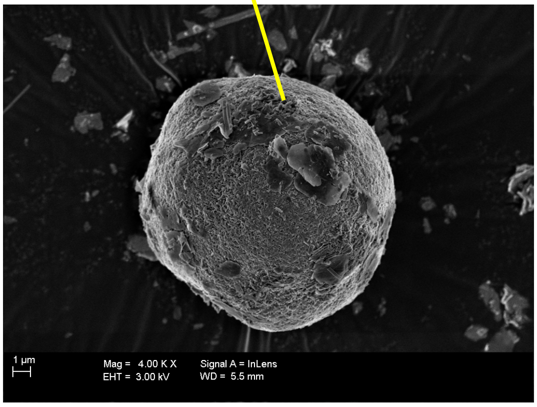
- Ni concentrate 38-42%
- Anode powder 25-31%
- Stainless steel 15-18%
- Mixed plastics 8-12%



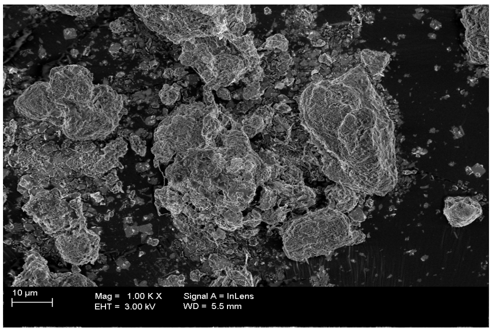

Fraction magnétique



EDS analysis

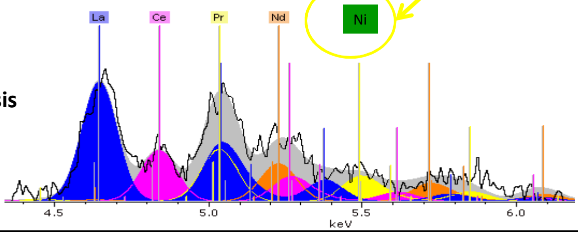


Fraction de composé « hydrures »



Composite Ni-Terres Rares

and EDS analysis



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Un autre segment d'énergie une autre sources de métaux: Les Piles à Combustibles

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TECHNOLOGIES

Type		Working Temp. [°C]	Temp.	Primer Gas	Oxidants	Electrical Efficiency [%]
Alkane Fuel Cell	**AFC**	60-90	Low Temp. FC	pure Hydrogen	pure Oxygen	40-45
Polymer Electrolyte Membrane Fuel Cell	**PEMFC**	50-90	Low Temp. FC	Hydrogen	Oxygen, Air	35-40
Direct Methanol Fuel Cell	**DMFC**	80-130	Low Temp. FC	Methanol	Oxygen, Air	25-35
Phosphor Acid Fuel Cell	**PAFC**	160-220	Middle Temp. FC	Hydrogen	Air	38-42
Molten Carbonate Fuel Cell	**MCFC**	550-650	High Temp. FC	Natural Gas, Biogas, Coal Gas,	Air	45-55
Solid Oxide Fuel Cell	**SOFC**	800-1000	High Temp. FC	Natural Gas, Biogas, Coal Gas	Air	40-60

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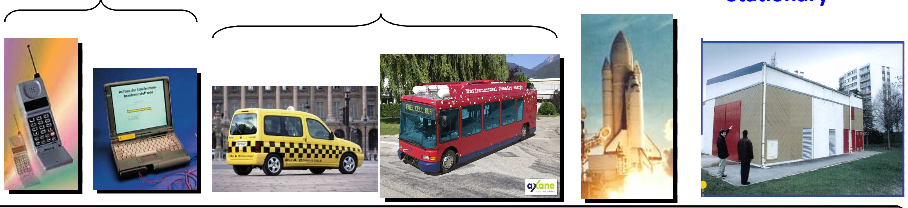
Un champ d'application varié

portable

Transportation

Spatial

Stationary



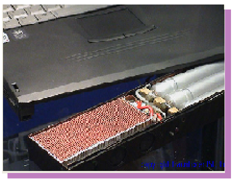
10 W — 100W — 1 kW — 10 kW — 100kW — 1 MW

Segment portable en accélération

- **NEC/Fujitsu**

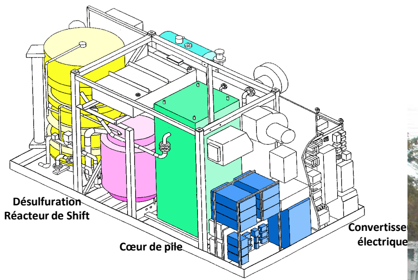

•**PANASONIC**

SIEMENS

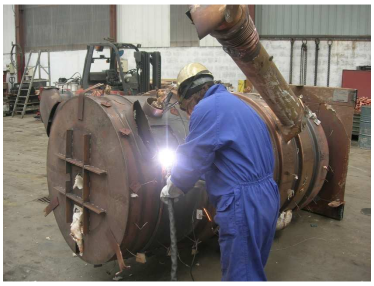



Première expérience européenne pour RECUPYL:
Démantèlement de la 1er pile à combustible de 200 kW
Arrivée en fin de vie (station essai GDF-EDF de Chelles)

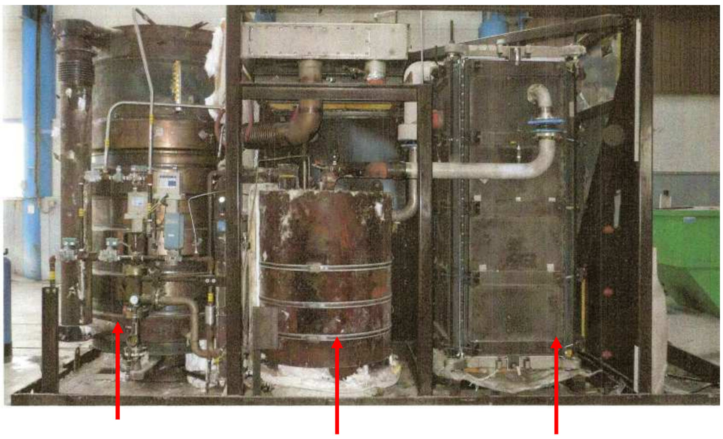
RECUPYL



démantèlement



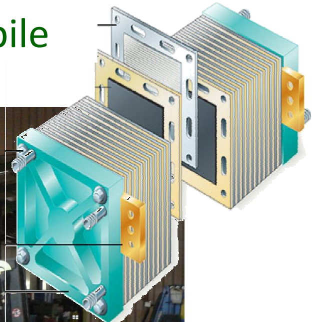
démantèlement



Réforming desulfurator Heart of cell

Récupération intégrale des Composants électriques

Traitement du cœur de pile



Bilan massique et taux de recyclage

Item	concentration	gross mass	Net recovered
Carbon steel	100%	12720	12720
Stainless steel	100%	2642	2642
catalyst 1		360	
Zinc	41.1%		148
Cuivre	37.8%		136
Residue	11.0%		
Catalyst 2		90	
Zn	72.0%		63
Alumina	1.0%		
Ni	27.0%		24
electrode+ Graphite	0.05%	1974	0.987
electrolyte waste	0.00%	210	
electronic waste	77%	2560	1980
Packaging	0.0%	1100	
	Total weight kg	21656	17714

Taux de recyclage de 88%

RECUPYL

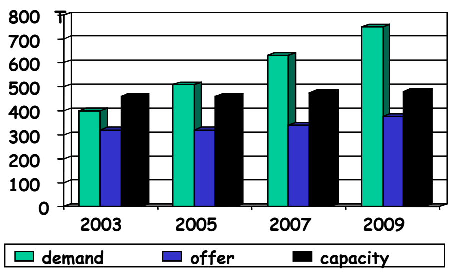
Cellules photovoltaiques

Recyclage des Panneaux Photovoltaiques

Valorisation de l'Indium

RECUPYL SA

Si la technologie à l'indium émergeait, la situation serait encore plus Problématiques qu'elle n'est actuellement avec l'approvisionnement d es LCD



En conclusion
On peut dire …

Il est possible de réincarner les métaux

mais on peut aussi dire …

Si les anciens alchimistes

Tentaient de changer le plomb en or

…………les nouveaux "alchimistes"

Changent les déchets en or !!!