

Recyclage des Déchets d'équipements électrique et électronique (D3E) : Défis et innovations

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Chaire Mines Urbaines ParisTech

- Chair for Education and Research created in 2014 (5 years, 2.5 M€) and supported by ESR
- The Urban Mines Chair aims to develop research and teaching activities in the field of recycling and eco-design of WEEE.



Circular economy
Development of new models
for circular economy



Chemistry/Metals
recycling of strategic metals
from WEEE



Plastics
Sorting, compatibility and recycling of plastics

4 postdocs
8 PhDs
1 Engineer
20 interns

- **Education :**

Within the ATHENS network (<http://athensnetwork.eu/>) :

ATHENS week 2016 « WEEE and Circular economy: various actors, one emerging commitment » November 14 to 18th, 2016

ATHENS week 2017 « Circular economy and eco-design Urban Mine case » November 13-17th 2017

Master on Circular Economy with ISIGE (Department of Ecole des Mines specialized in Environment) – 1st class beginning on September 2018

- **Other events :**

Symposium « Challenges and Innovation in Recycling Processes » June 2-3th 2015 (Chimie ParisTech)

Symposium « Innovation et économie circulaire » June 5-6th 2018 (Chimie ParisTech)

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Why should we recycle e-waste ?

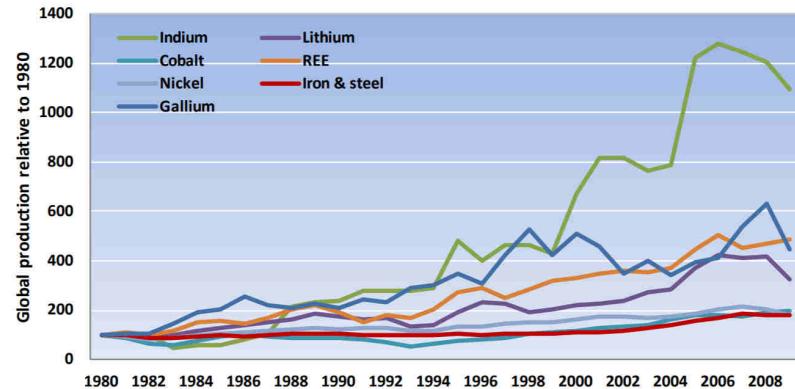
Why should we recycle?



- ***Environmental issues*** : e-waste also contains toxic and hazardous materials including mercury, lead, cadmium, beryllium, chromium, and chemical flame retardants, which have the potential to leach into our soil and water.
- ***The rise of urban mining*** : e-waste contains many valuable, recoverable materials such as Al, Cu, Au, Ag, plastics, and ferrous metals. In order to conserve natural resources and the energy needed to produce new electronic equipment from virgin resources, electronic equipment can be refurbished, reused, and recycled instead of being landfilled.

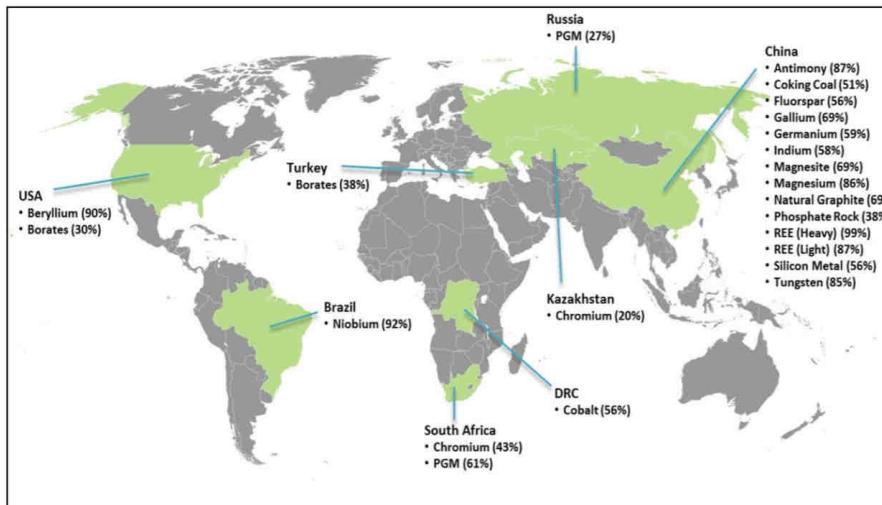
Some facts about metal production

Production of metal (1980-2009)



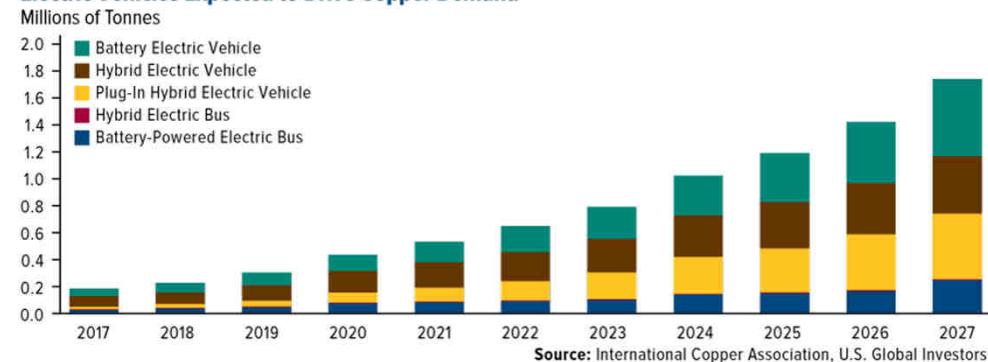
Source: USGS 2010

Where are produced metals ?



Memo 14/377 European commission, 26 May 2014
http://europa.eu/rapid/press-release_MEMO-14-377_en.htm

Electric Vehicles Expected to Drive Copper Demand



China's Rare Earth Element Export Quotas

	Export Quotas (Tonnes Rare Earth Oxides)	Annual Change
2005	65,609	-
2006	61,821	-6%
2007	59,643	-4%
2008	56,939	-5%
2009	50,145	-12%
2010	30,258	-40%
2011	30,184	-0.24%

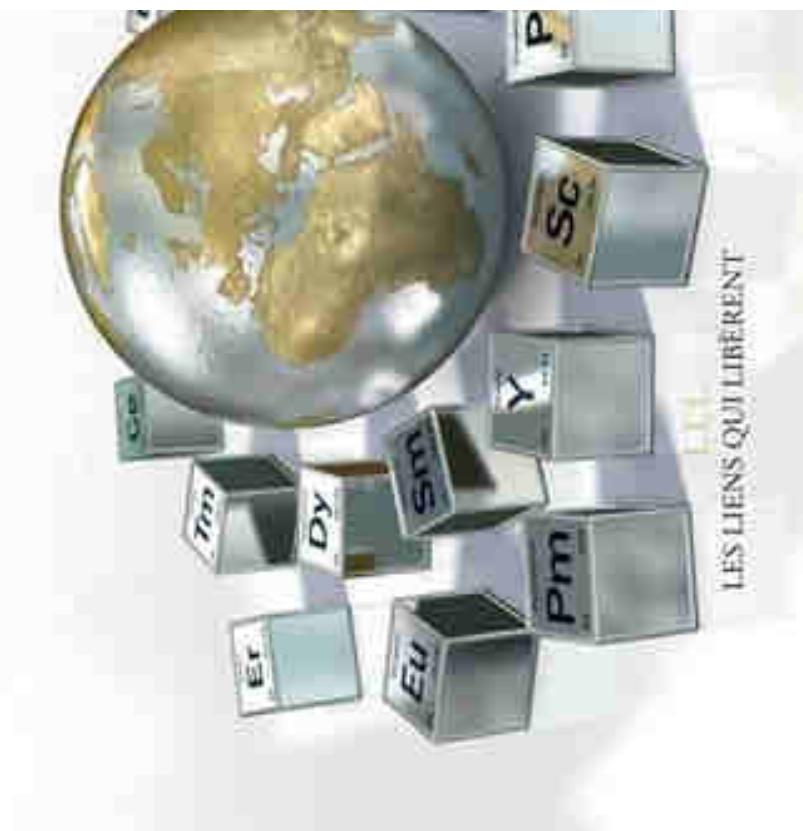
source: U.S. Department of energy critical materials strategy, December 2011

GUILLAUME PITRON

LA GUERRE DES MÉTAUX RARES

LA FACE CACHÉE DE LA TRANSITION
ÉNERGÉTIQUE ET NUMÉRIQUE

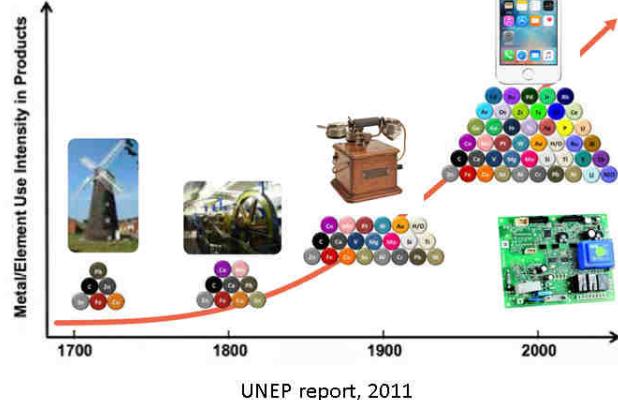
PREFACE PAR JEAN-PIERRE VIBRANNEZ



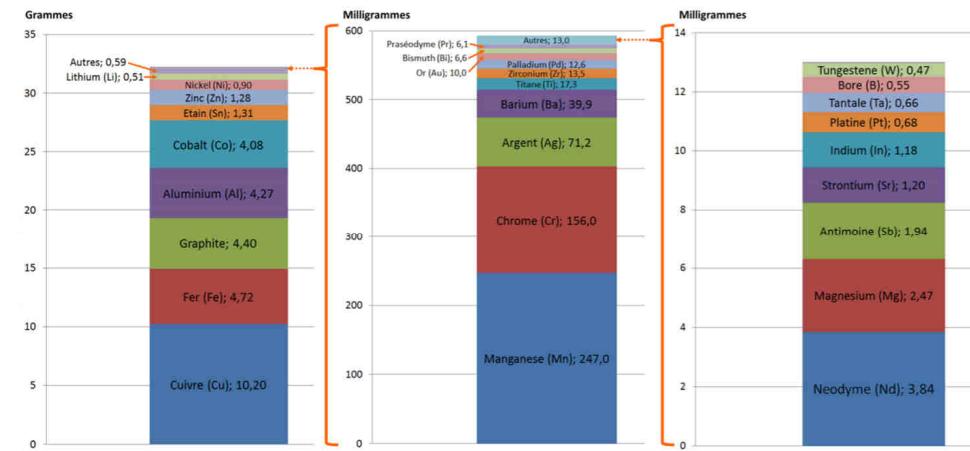
LES LIENS QUI LIBERENT

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The Urban mines



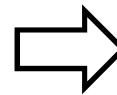
Metal composition of smartphone



Source : Orange

Metal composition of Printed Circuit Board (PCB)

Métal	Quantité par tonne	Cours du 30/06/16	Valeur
Cu	100 à 250 kg	4 200 €/t	420 € à 1 050 €
Ag	2 kg à 6 kg	0,54 €/g	1 080 € à 3 240 €
Au	200 g à 1 kg	38,2 €/g	7 640 € à 38 200 €
Pd	100 g à 300 g	19,5 €/g	1 950 € à 5 850 €
Sn	20 à 30 kg	16 100 €/t	322 € à 483 €
Ta	3 kg à 10 kg	135 €/kg	405 € à 1350 €
Autres		300 €/t	300 €
Total		12 117 à 50 473 €/t	



Traditional Mining provides
5-10 g Au /tonne of ores

Introducing Extended Producer Responsibility...

- ④ Faced with increasing amounts of waste, many governments have reviewed available policy options and concluded that **placing the responsibility for the post-consumer phase of certain goods on producers could be an option ("polluter pays" principle).**
- ④ **Extended Producer Responsibility** (EPR) is a policy approach under which **producers are given a significant responsibility – financial and/or physical – for the treatment or disposal of post-consumer products.** Assigning such responsibility could in principle provide incentives to prevent waste at the source, promote product design for the environment and support the achievement of public recycling and materials management goals.
- ④ The aim when introducing EPR schemes has been to give producers an **incentive to:**
 - help improve recycling
 - reduce landfilling
 - **and to change product design in environmentally ways,** for example by making it easier to reuse or recycle the products

Les différentes filières de recyclage en france

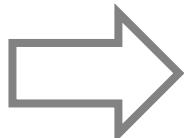
- Biodéchets
- Cadre général des filières à responsabilité élargie des producteurs
- Déchets de papiers graphiques
- Déchets des emballages ménagers
- Déchets diffus spécifiques ménagers
- Déchets du bâtiment et des travaux publics
- Déchets d'Activité de Soins à Risques Infectieux (DASRI)
- Déchets d'éléments d'ameublement (DEA)
- **Déchets d'équipements électriques et électroniques**
- Déchets professionnels issus de produits de l'agrofourniture
- Huiles usagées
- Médicaments non utilisés
- Piles et accumulateurs
- Pneumatiques usagés
- Recyclage des navires
- Textiles usagés
- Véhicules hors d'usage

Les différentes filières de recyclage en france

Filière REP	Objectif de collecte	Collecte séparée en tonnes	Taux de collecte séparée ou taux de collecte séparée apparent pour valorisation
Piles et accumulateurs portables, automobiles et industriels	Objectif de collecte des piles et accumulateurs : 25 % en 2012 et 46 % en 2016.	233 800	96 %
Équipement électriques et électroniques ménagers et professionnels	DEEE ménagers ; objectif de collecte 8 kg/hab./an en 2012, 9 en 2013 et 10 en 2014. DEEE professionnels ; objectif de collecte en 2015 de 25 % du total des mises sur le marché de 2014	471 000	36 %
Automobiles	Objectif de collecte implicite 100 %	1 241 000	59 %
Lubrifiants	Aucun objectif de collecte	208 000	92 %
Fluides frigorigènes fluorés	Aucun objectif de collecte	800	7 %
Médicaments	Objectif de collecte de + 2 % par an sur la durée d'un agrément de 6 ans à partir du 25 janvier 2010 soit + 13 % par rapport à 2008	14 300	60 %
Pneumatiques	Objectif de collecte implicite 100 %	395 000	80 %
Papiers graphiques ménagers	-	1 329 000	-
Textiles, linge de maison et chaussures ménagers	Objectif de collecte de 50 % des quantités mises en marché	150 000	-
Emballages et produits plastiques de l'agro-fourniture	Objectif de collecte de 60 à 75 % d'ici 2015	52 500	64 %
Produits phytopharmaceutiques non utilisables	Objectif de 200 tonnes éliminées par an sur l'ensemble du territoire	100	-
Cartouches d'impression bureautique	-	5 000	42 %
Mobil-homes	Aucun objectif de collecte	1 500	-
Total		4 102 000	
		Tonnages valorisés	Taux de valorisation du gisement
Emballages ménagers	Aucun objectif de collecte	3 863 000	81,12 %

Cinq éco-organismes impliqués dans la filière D3E

DEEE



OCAD3E

organisme coordonnateur de la filière DEEE

EcoLogic

agrément DEEE à l'exclusion des lampes, photovoltaïque



récylum

agrément DEEE à l'exclusion des lampes, photovoltaïque



agrément lampes, matériels professionnels

agrément photovoltaïque

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Eco-systèmes in few words



- ② Came from WEEE Directive 2002/96/CE

- ② Non profit simplified stock company, accredited by public authorities in August 2006, then in December 2009, and lastly in December 2014

- ③ 33 shareholders (WEEE manufacturers and retailers).



- ③ 1962 producer members representing 78,2% of the EEE put on market

- ③ 517 000 tons of WEEE collected in 2016 (almost 49 million units)

- ② Encouraging waste prevention and the solidarity networks

- Encouraging consumers to give back old appliances in order to re-use them, in association with Emmaüs and Envie
- Encouraging producers to eco-design new products.

The WEEE Directive main targets (1/2)

- ④ The new WEEE Directive introduces a **collection target of 45%** of electronic equipment sold that will apply from 2016 and, as a second step from 2019, a **target of 65% of equipment sold, or 85% of WEEE generated**. Member States will be able to choose which one of these two equivalent ways to measure the target they wish to report.
- ④ The new collection targets agreed will ensure that around 10 million tons, or roughly 20 kg per capita, will be separately collected from 2019 onwards.
- ④ **Retailers must collect WEEE on a "1 for 1" basis** and take back the old product when a consumer buys a new one. With the new WEEE Directive, retailers are also asked to collect small WEEE on a "**1 for 0**" basis : they must accept small WEEE (< 25 cm) even if there is no purchase.

The WEEE Directive main targets (2/2)

- ④ **Recycling targets applicable after 15 August 2015:**
 - **Large Appliances:**
 - Recovery target (energy + material): 80% → 85%
 - Recycling target (material): 75% → 80%
 - **Screens:**
 - Recovery target: 75% → 80%
 - Recycling target: 65% → 70%
 - **Small Appliances:**
 - Recovery target: 70% → 75%
 - Recycling target: 50% → 55%
- ④ The new WEEE Directive gives EU Member States the tools **to fight illegal export of waste more effectively**. Illegal shipments of WEEE disguised as legal shipments of used equipment, in order to circumvent EU waste treatment rules, are a serious problem. The new Directive will force exporters to test and provide documents on the nature of their shipments when the shipments run the risk of being waste.

e-waste flows



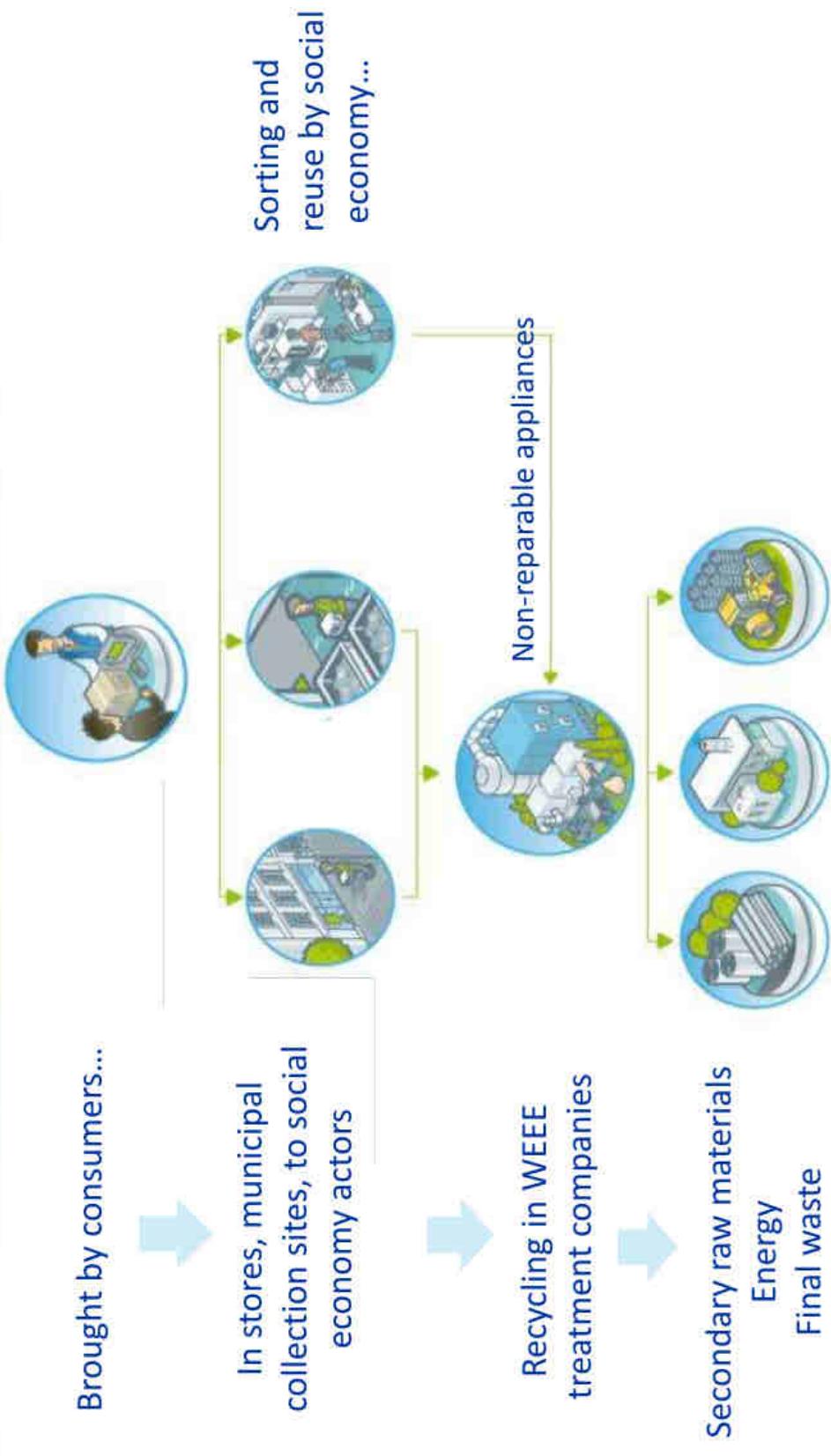
Sources: Silicon Valley Toxics Coalition; Interpol's Pollution Crime Working Group (2009)



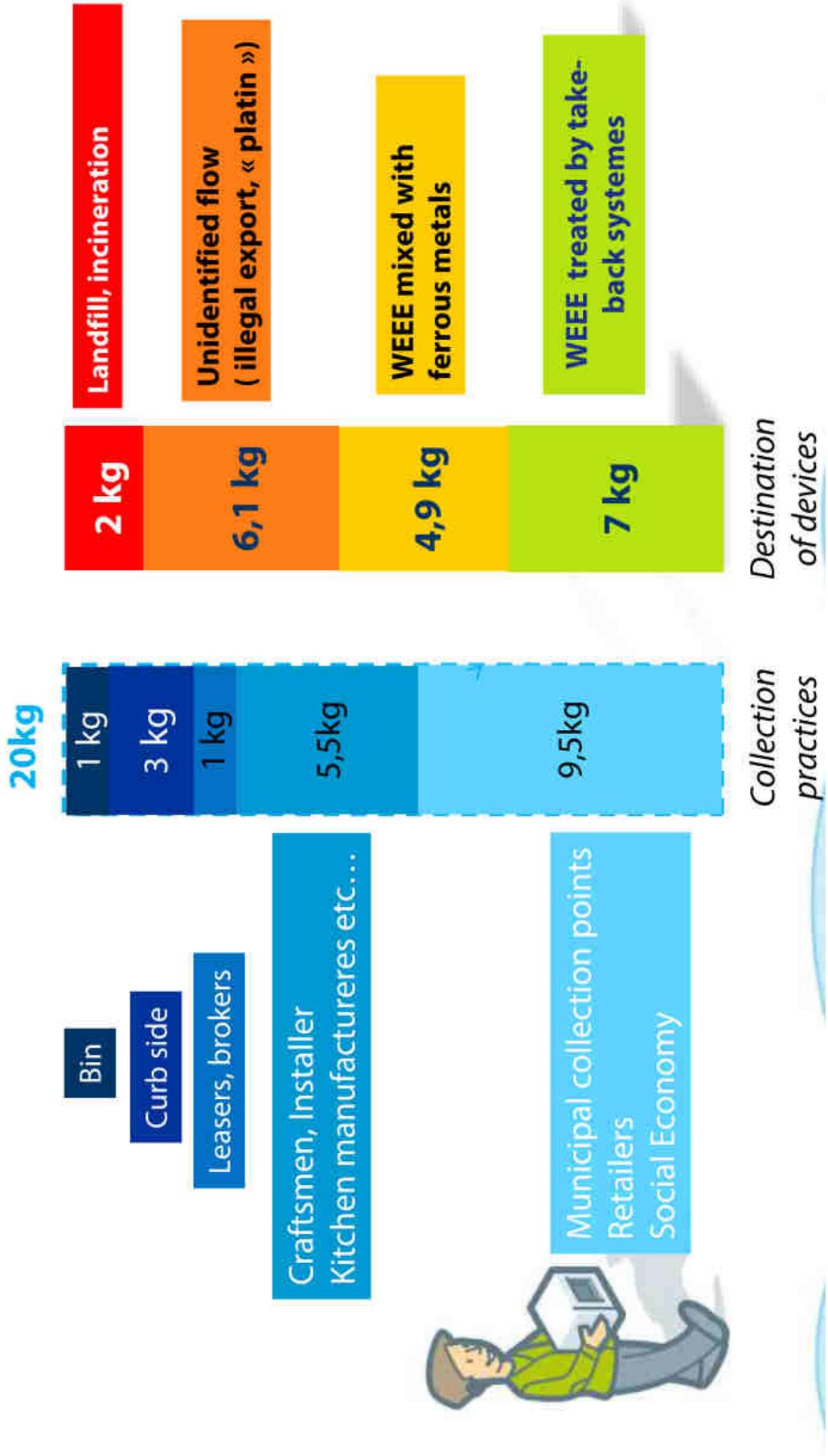
Agbogbloshie
(Ghana)

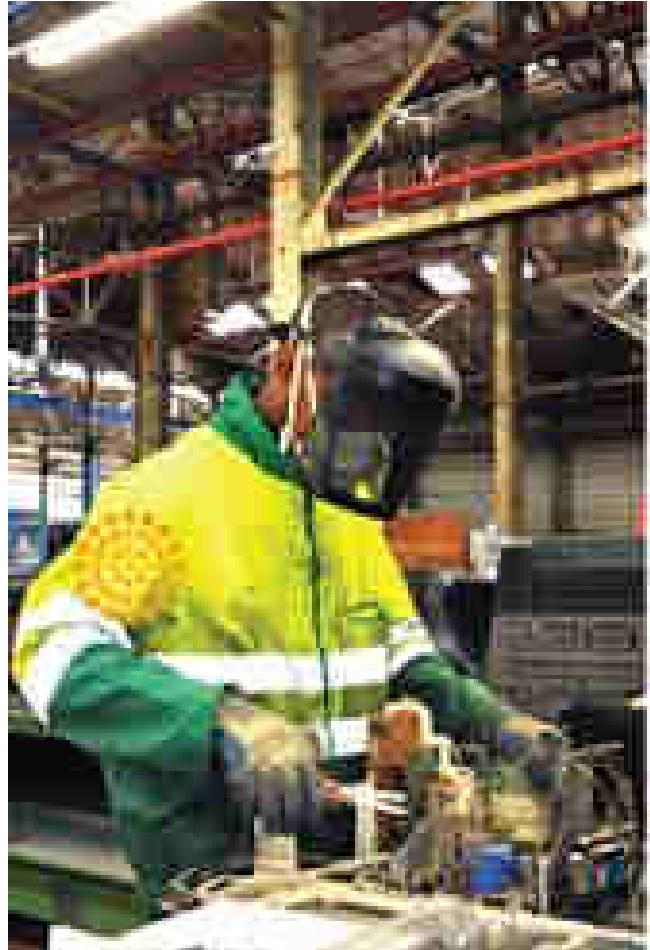


The operational route of a discarded appliance



WEEE are available from different channels*



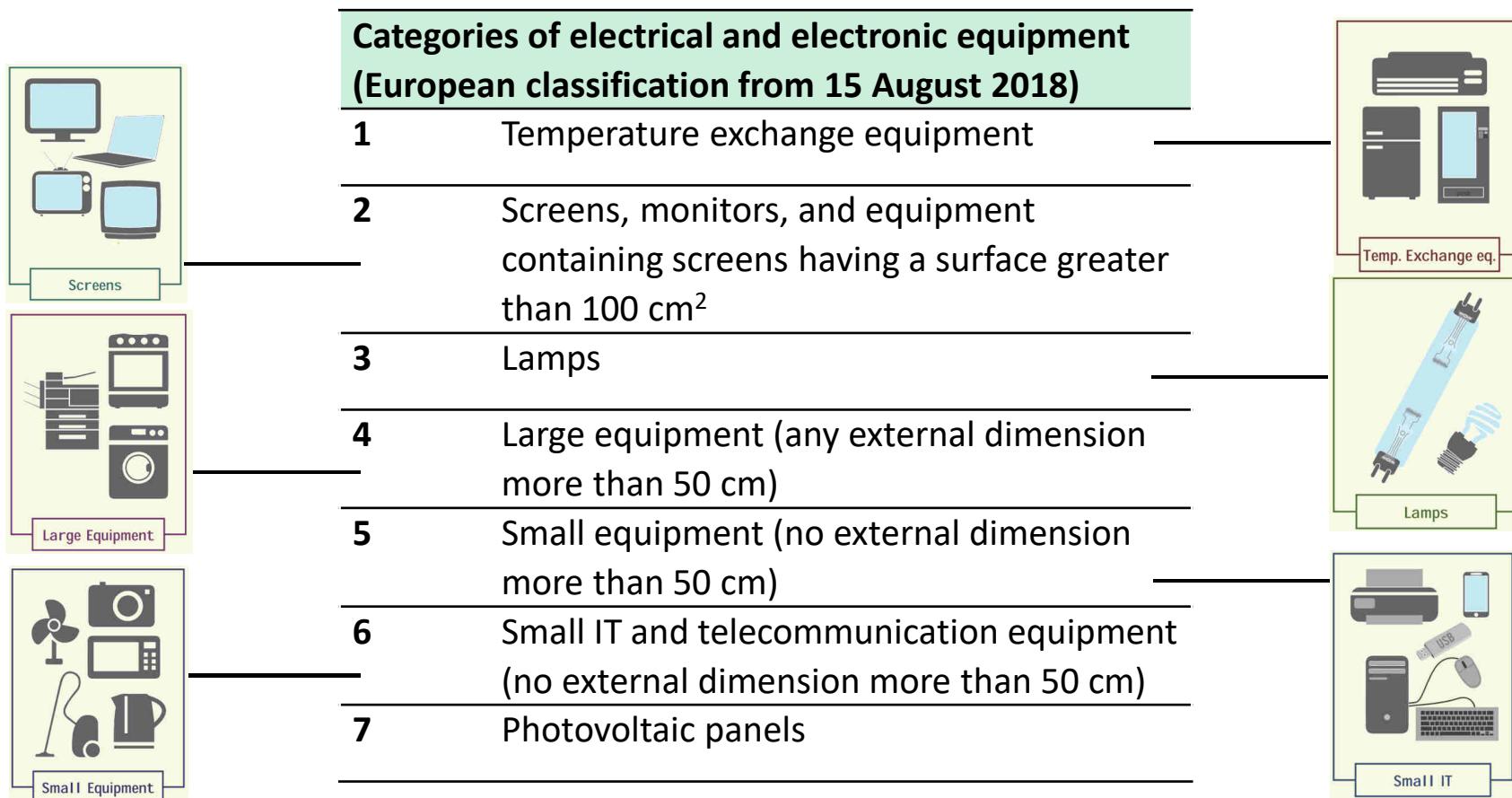


Metals and Plastics in e-waste



e-waste and metals in e-waste

What are the EEE: A great diversity in terms of use, size, content of materials, life time, etc.



The amount of WEEE generated annually world-wide was estimated at 42 million tons in 2014

Lifespan distribution of EEE

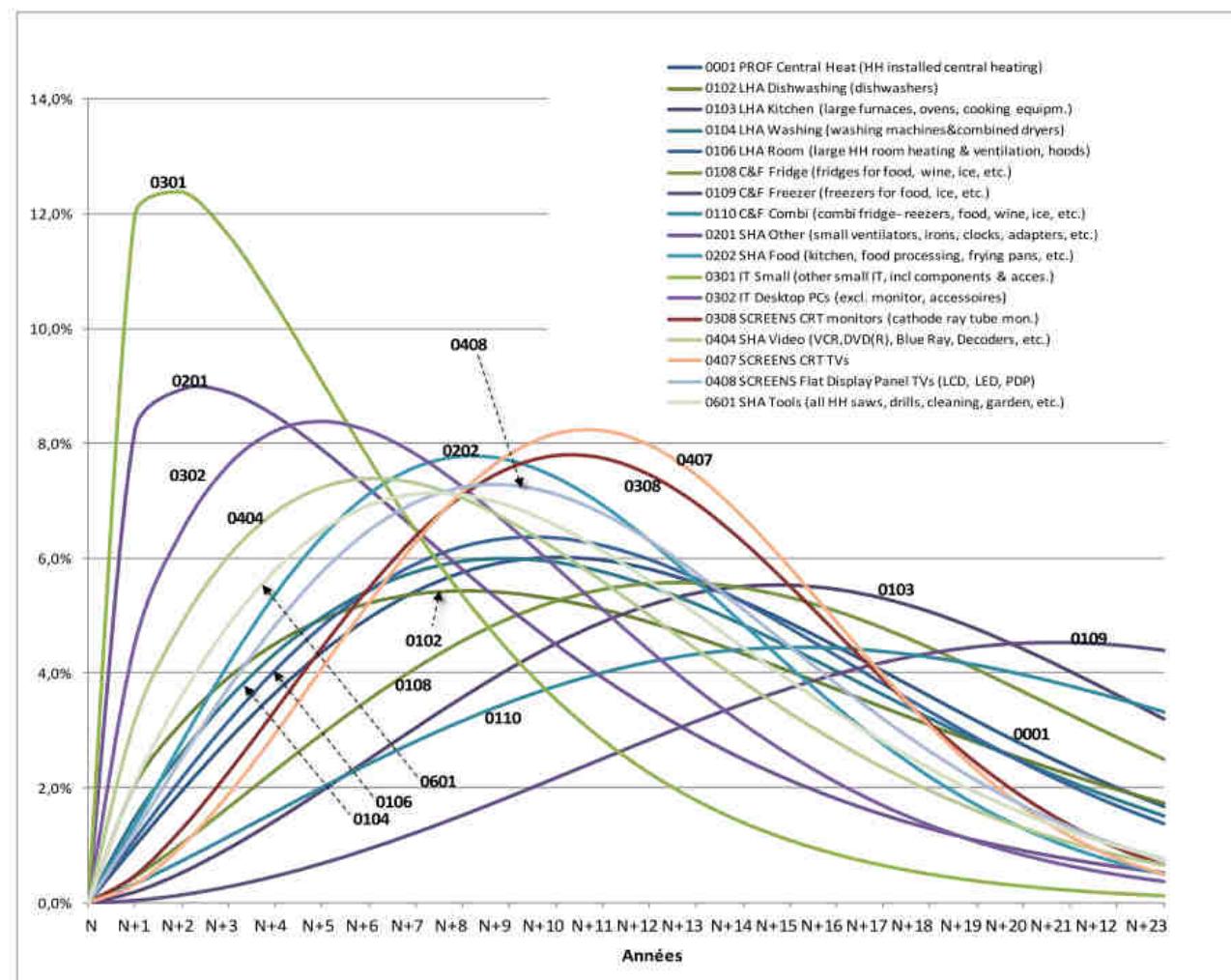


Figure 4 – Lifespan distribution for the main equipments put on the market in 2005

“STUDY ON THE QUANTIFICATION OF WASTE OF ELECTRICAL AND ELECTRONIC EQUIPMENT (WEEE) IN FRANCE”, 2013, ADEME/ OCAD3E

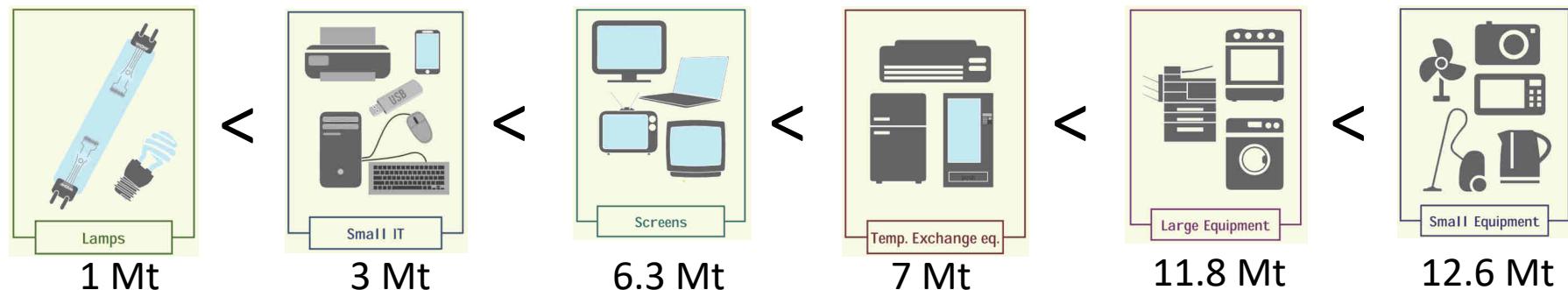
e-waste production in the world

The amount of WEEE generated annually world-wide was estimated at 42 million tons in 2014

Equivalent to 5700 Eiffel towers [in weight]



Total e-waste per category in 2014 :

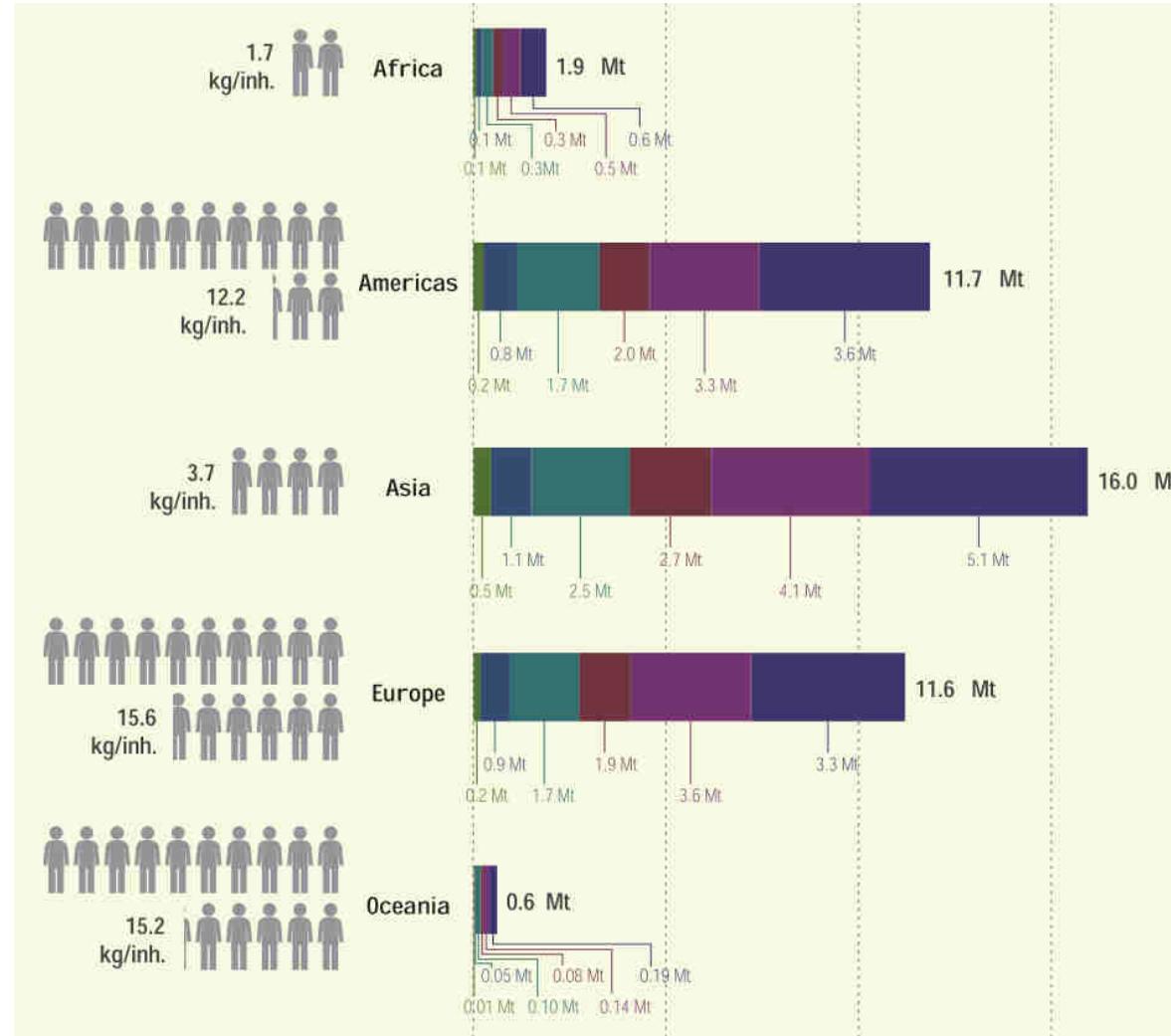


The global e-waste monitor 2014, UNU-IAS

Present state of e-waste recycling and objectives

- For end-of-life EEE, official take-back legislation is organized in a limited number of countries (mostly European countries)
- It covers only around 4 billion people (i.e., about 57% of the world population)
- So that only 6.5 Mt of the 41.8 Mt of WEEE generated in 2014 (i.e., 15% in weight) were documented and recycled with the highest standards.

e-waste production in the world



The global e-waste monitor 2014, UNU-IAS

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What is found in e-waste ?

Type of components	Quantities (%)
Au, Pd, Ag	
Cu, Sn, Ta, REE, ...	
Printed circuit boards	2.2
Mineral fraction	4.6
Residues of grinding	9.2
Ferrous metals	44.7
Non-ferrous metals	7.5
Plastics	18.3
Glass	12.2
Other	1.3

<http://www.ademe.fr> Other
rapport-annuel

-2013-

A strong potential
of recycling

What is found in e-waste ?

Material composition (% by weight) of four products



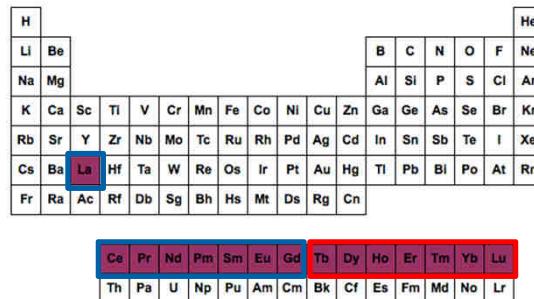
Material	Television	Washing Machine	Air conditioner	Refrigerator
Glass	57	—	—	—
Plastic	23	36	11	40
Iron	10	53	55	50
Copper	3	4	17	4
Aluminium	2	3	7	3
Other	5	4	10	3

M. Goosey, The materials of WEEE, in Waste electrical and electronic equipment (WEEE) handbook. Woodhead Publishing Limited, 2012, Chapter 7.

- From a general point of view (i.e., beyond WEEE), the recycling of metal is limited
- Certain elements are considered as critical and this should incite to recycle them (e.g., REE)

Case of REE encountered in e-waste

Rare-Earth Element



La Ce Pr Nd Pm Sm Eu Gd Tb Dy Ho Er Tm Yb Lu Y Sc

Categories	Components of EEE	Possible REEs in the stream
Products containing phosphors	Fluorescent lamps	La, Ce, Eu, Gd, Tb, Y
	LEDs	Ce, Gd, Eu, Y
	Plasma display panels	Eu, Gd, Y
	CRT screens	Ce, Nd, Sm, Eu, Tb, Y
Products containing permanent magnets	NdFeB magnets (HDDs, speakers, headphones, electric motors, etc.)	Pr, Nd, Gd, Tb, Dy
	SmCo magnets (electric motors, etc.)	Sm
Batteries	NiMH batteries	La, Ce, Pr, Nd, Y

adapted from Binnemans *et al.*, *J. Clean. Prod.*, 51, 2013, 1-22 and Tunsu *et al.*, *Hydrometallurgy*, 156, 2015, 239–58

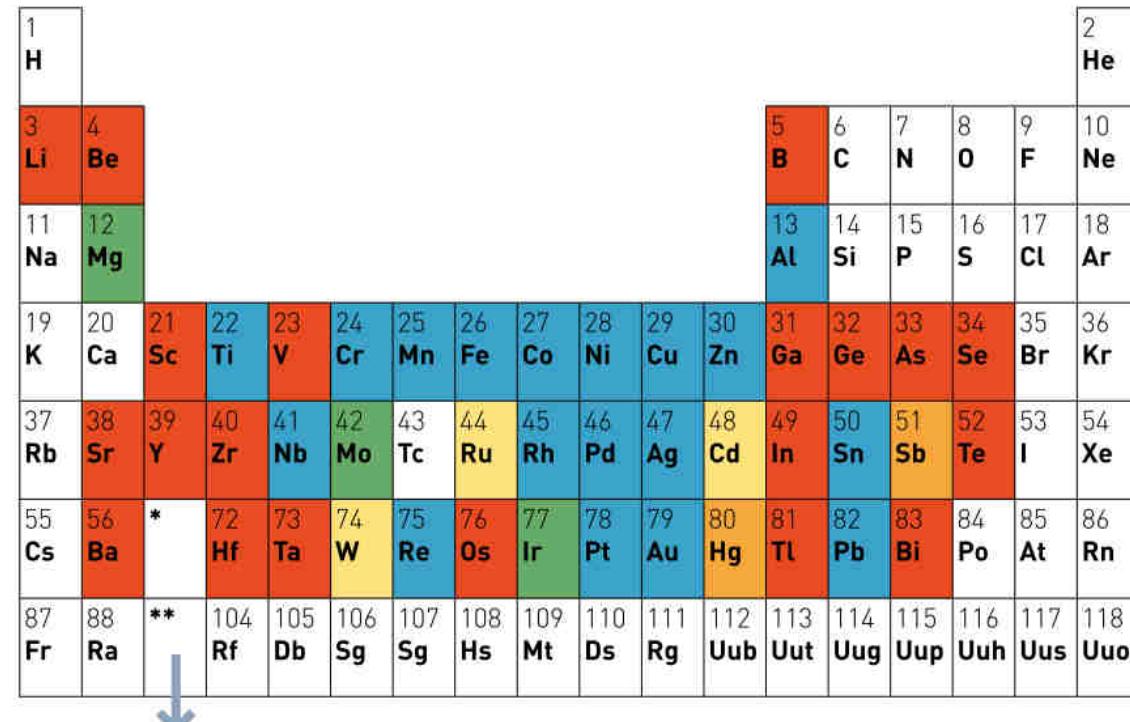
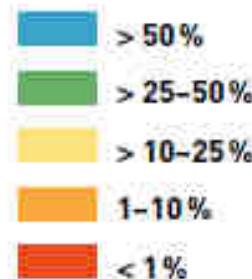
Recovery of metals

End of life – Rate Recovery (UNEP 2011)

www.unep.org/resourcepanel/Portals/24102/PDFs/Metals_Recycling_Rates_110412-1.pdf

General situation
(beyond WEEE)

Recycling %



* Lanthanides

57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
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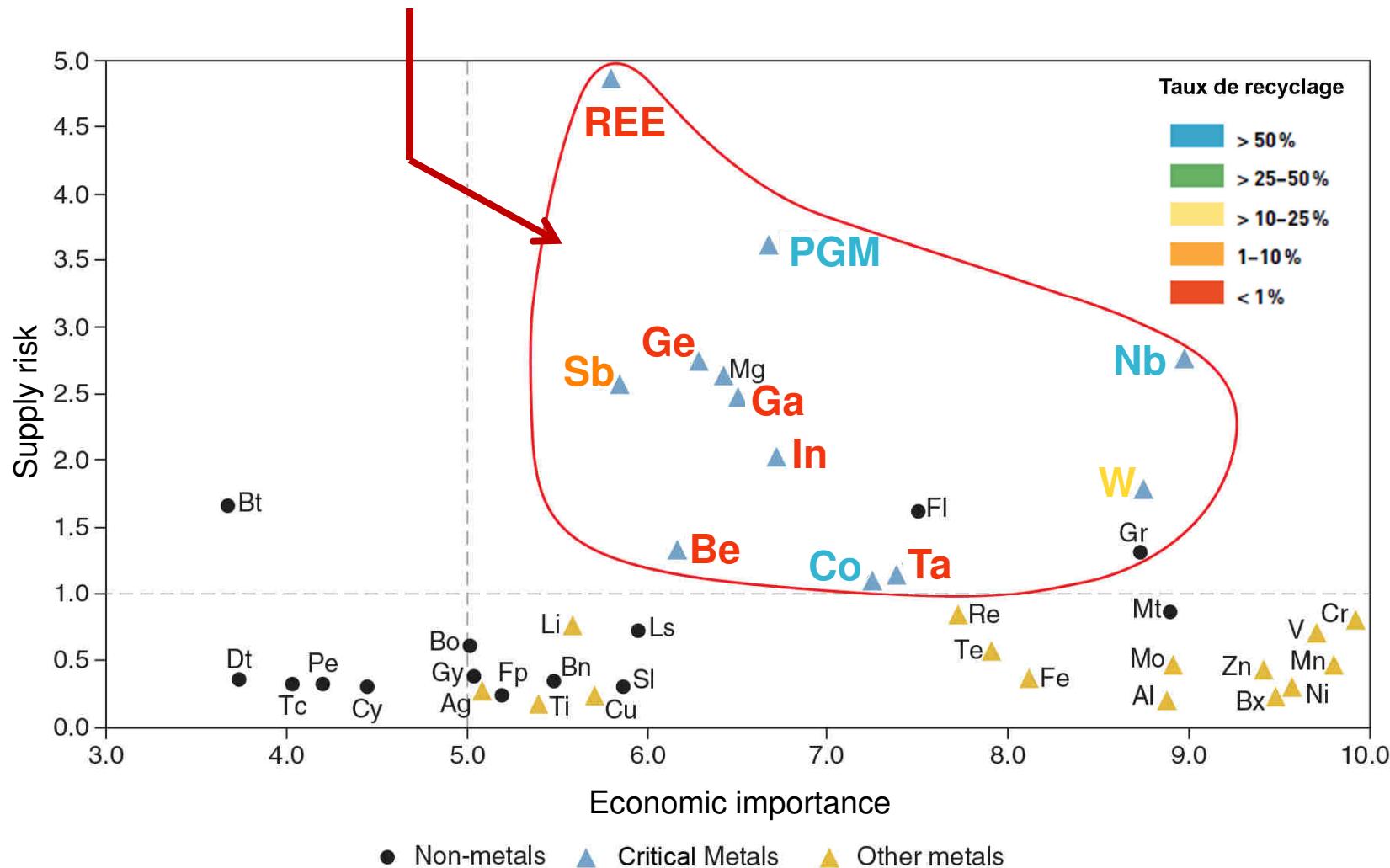
** Actinides

89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr
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A great effort is still needed

Furthermore certain elements are considered as critical



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

Uses of critical metals

Critical materials are important and are used in different area and particularly clean energy technologies (hybrid/electric car, wind turbines):

- Magnets wind turbines: neodymium, praseodymium and dysprosium, with samarium and cobalt as potential substitutes
- Phosphors for energy-efficient lighting: lanthanum, cerium, europium, terbium and yttrium
- Thin films for solar cells: Indium, gallium and tellurium
- Smartphones (lanthanum, cerium, praseodymium, neodymium, nickel, manganese, cobalt and lithium), electronic devices ...
- Rechargeable batteries

Present state of e-waste recycling and objectives

What are the targets for WEEE recycling according to the WEEE Directive 2012/19/EC ?

- From 2016, the minimum collection rate is set at 45% of the average weight of EEE put on the market over the previous three years.
- The objective increases to 65% in 2019 (or 85% of the amount of WEEE generated).

Such targets favor the recycling of main materials (plastics, ferrous metals, aluminium, copper, etc.) to the detriment of metals/elements contained in small quantities (e.g., critical elements).

The used EEE typically are treated as follows:

- Preparation/depollution (extraction of toxic substances)
- Dismantling (separation of the different components)
- Removal of PCB for futher treatment
- Shredding of the equipments
- Magnetic separation of ferrous metals
- Separation of non-ferrous metals by eddy-currents
- Separation of plastics (flottaison, optical sorting).

Such a treatment allows the separation of ferrous metals, non-ferrous metals (including copper), PCB and plastics, but the separation is rough.

Treatment of Cooling and Freezing Appliances (≈ 10 facilities in France)

- ⌚ Investment → 45 000 k€ since 2007 with a guarantee of de-pollution



Sorting and partial dismantling at reception:

- ✓ Waste (light bulb, wood, rubber)
- ✓ Glass (shelves)
- ✓ Ferrous metal (shelves), non-ferrous (wire)
- ✓ De-pollution (capacitors, mercury contactor)



« Phase 1 » de-pollution



« Phase 2 » : shredding under inert atmosphere, suction of the gas in the insulation foams

PUR foams

Others: Sorting



Ferrous metals / non-ferrous metals / plastics

Present state of e-waste recycling and objectives

- REE recovery methods are scarce, with large amounts of potential recyclable material ending up in landfills.
- **In 2011 the global average recycling rates of all REEs from end-of-life products was below 1%.**
- Main reasons for limited REE recycling relate to collection of EEE and dismantling requirements, difficult separation by conventional milling operations, matrix heterogeneity and, sometimes, low REEs content.

Treatment of flat screens

(≈ 7 facilities in France)

Example of manual dismantling : LCD flat panels

Key-step of the process: mercury backlight extraction and suction of potential leaks



Manual dismantling of the plastic housing

Electronic components
dismantling



Manual extraction of backlight tubes



Backlight mercury tubes



LCD panels



Ferrous and non-
ferrous metals

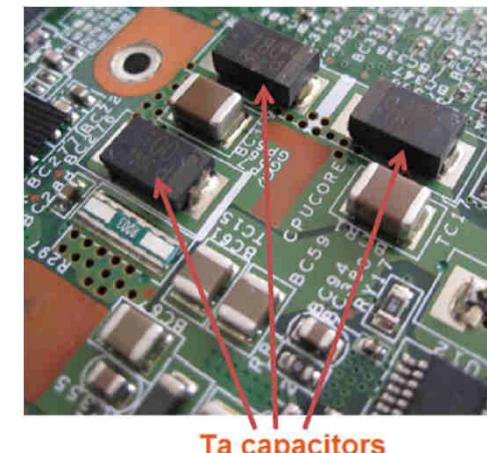
Present state of e-waste recycling (PCB treatment)

Existing recycling processes may be not efficient for the recovery of various elements !

- Typically smartphones are first processed by **pyrometallurgy**, copper plays there the role of metal collector (silver, gold, palladium), plastics contribute to energy intake, whereas glass and aluminum are found in the slag.
- Copper and precious metals (Au, Ag, Pt) are then separated by **hydrometallurgy**, their recovery rate is up to 95%.
- On the other hand, tantalum, gallium, indium, rare earths are lost in the slag

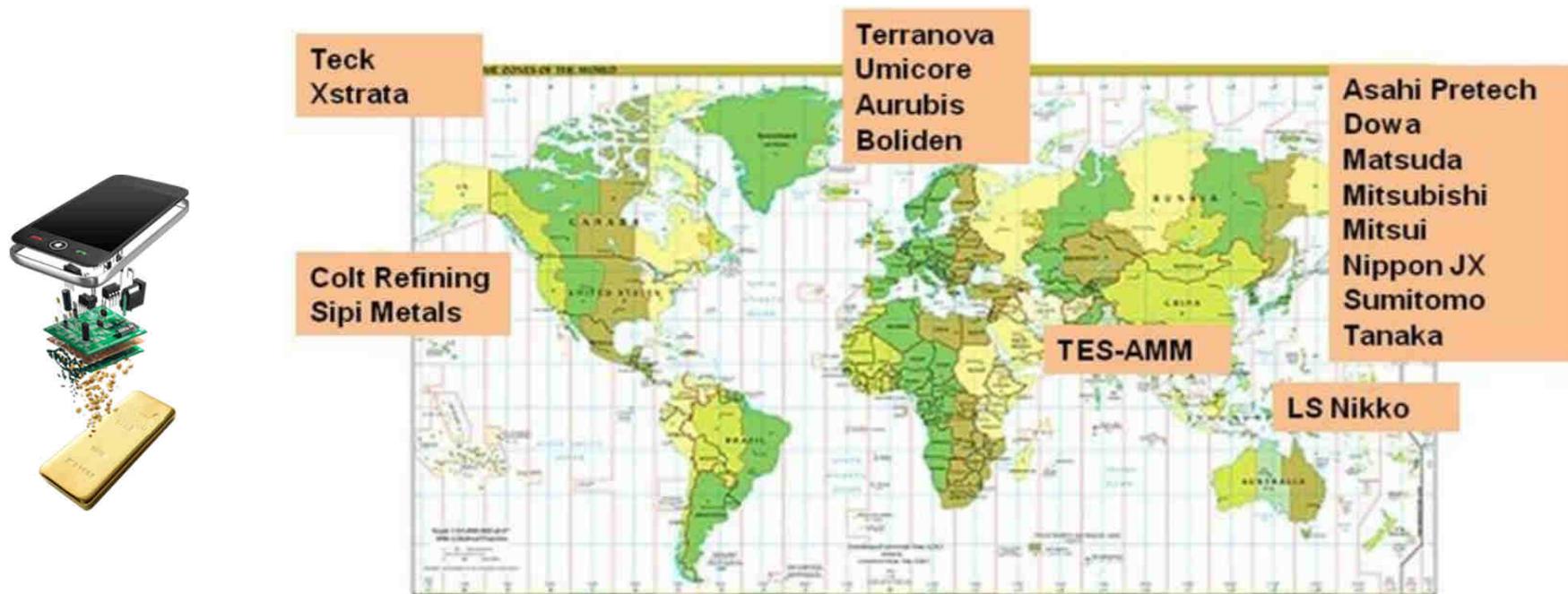


Place for innovations



<http://www.oeko.de/oekodoc/1375/2012-010-en.pdf>
(17/01/2016)

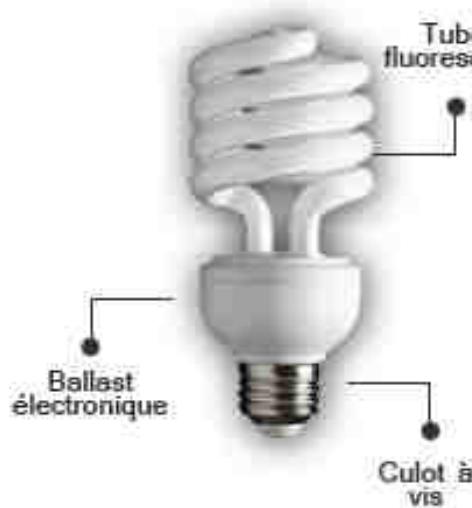
Map of precious metal smelters and hydrometallurgical processors



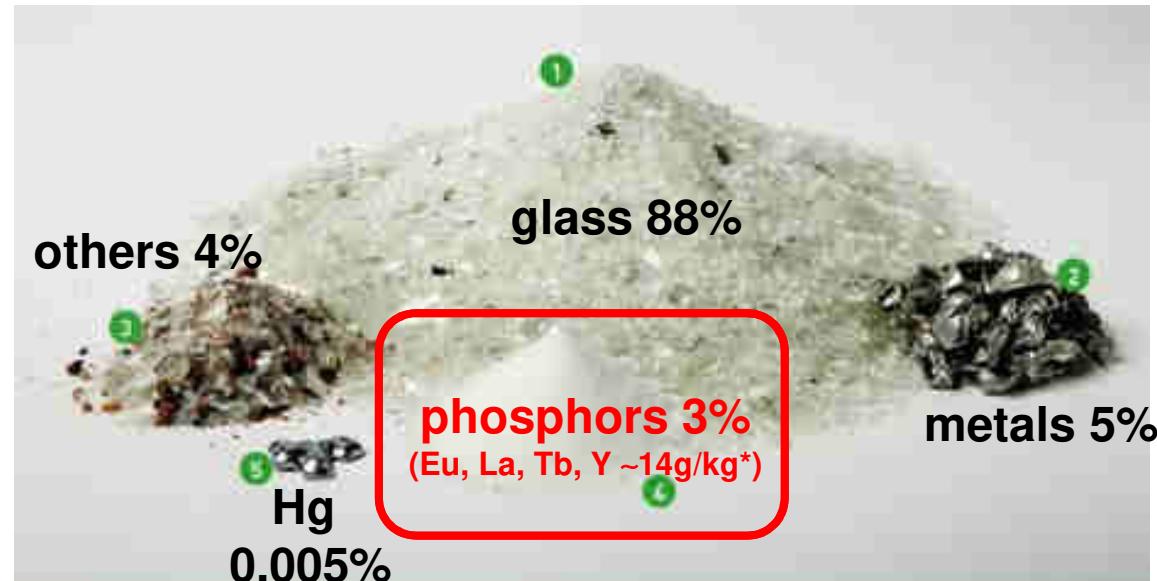
BIR (2012), Map provided by Ross Bartley of Bureau of International Recycling

Rare Earth Elements recycling from phosphors by Solvay

Even in favourable cases, the business may be not profitable as exemplified by the case of rare earth recycling from phosphors



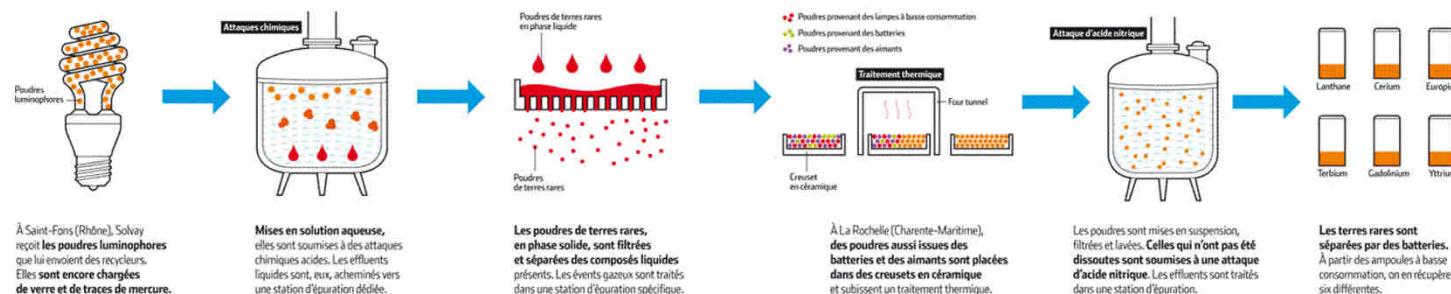
<http://www.malampe.org/comment-les-recycler/le-recyclage-des-lampes-usagées>



In spite of its know-how, Solvay has decided to close its two rare earth recycling units in France (Saint-Fons and La Rochelle)

Technological evolution among EEE : change in urban mines

UN PROCESS INÉDIT POUR EXTRAIRE LES TERRES RARES DES AMPOULES À BASSE CONSOMMATION



...due to substitution by LED – lower pressure on rare earths, etc.

Incandescent lamp



Halogen lamp



Fluorescent lamp

99% of collected lamp
0.005% Hg
Phosphors



LED lamp

1% of collected lamp
contains strategic metals



The prices of materials exhibit a certain volatility

REE. The profitability of metals recycling from WEEE is uncertain and may dramatically change in time, due to fluctuations in the market

Year	2007	2009	2011	2013
Lanthanum oxide	2.5	4.7	84.4	6.0
Cerium oxide	2.0	3.4	82.5	6.3
Neodymium oxide	23.3	12.1	188.3	56.3
Terbium oxide	445.9	283.3	1921.3	753.4
Dysprosium oxide	66.8	83.7	1184.0	429.8
Yttrium oxide	5.6	11.3	109.5	20.1

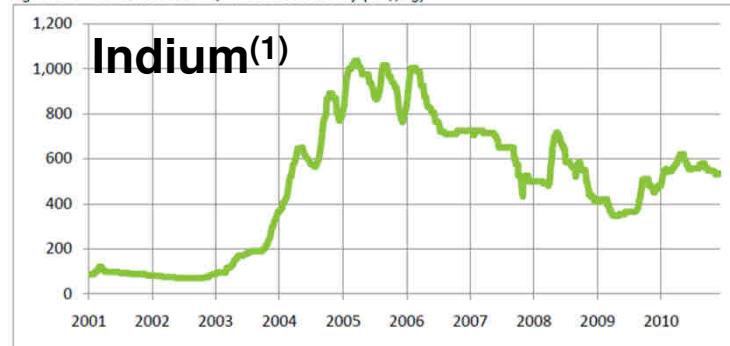
Table: Evolution of prices of selected rare earth oxides (€/kg)

Source: Arafura Resources limited (2014) – Prices in EUROS converted from US Dollars on the basis of a Chaire
0.8 USD/EUR conversion rate.

The prices of materials exhibit a certain volatility

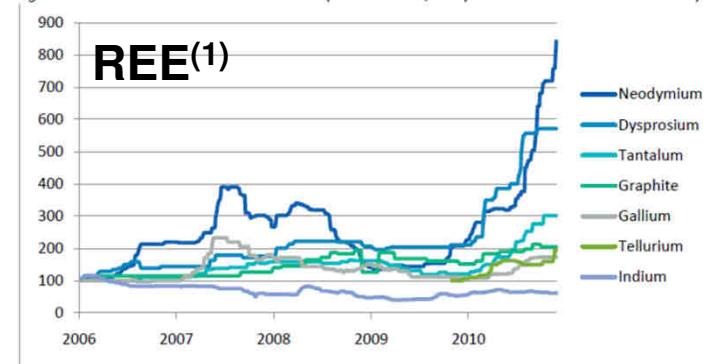
REE. The profitability of metals recycling from WEEE is uncertain and may dramatically change in time, due to fluctuations in the market

Figure 6: Indium Metal Prices, min. 99.99% Purity (US\$/kg)



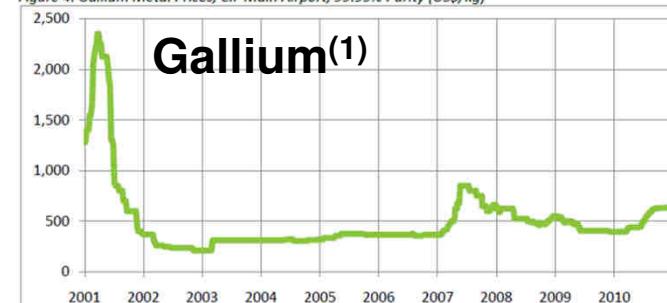
Source: Metal Pages

Figure 2: Price Trends For 6 Critical Materials (Jan 2006=100, except Tellurium where Nov 2009=100)



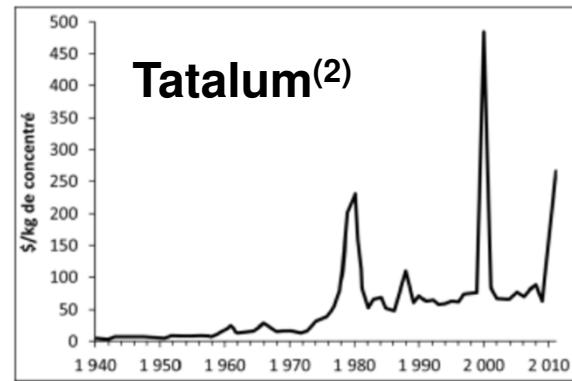
Source: Metal Pages & Industrial Minerals Magazine

Figure 4: Gallium Metal Prices, CIF Main Airport, 99.99% Purity (US\$/kg)



Source: Metal Pages

Tatalum⁽²⁾



(1) Alastair MacGregor CFA & Peter Willis. Investing in Critical Metals June 2011. Critical Metals: Rare Earths, Indium, Gallium, Tellurium, Tantalum; and Graphite

(2) Average price of tantalum concentrates between 1940 and 2011 (US Geological Survey & BRGM 2012)

Enjeux du recyclage des Plastiques

1- Garantir la dépollution et la traçabilité

Disposer de procédés tri efficace sur le territoire français répondant aux spécificités des flux de DEEE :

- ✓ Concentrer/isoler les fractions chargées en composants bromés ou polluants organiques persistants.
- ✓ Garantir la traçabilité du traitement et le devenir des fractions bromées

2- Recyclage matière et économie circulaire

Améliorer les taux de recyclage matière et de valorisation pour chaque flux pour atteindre les objectifs réglementaires toujours plus ambitieux

Contribuer au développement de l'économie circulaire en donnant accès au gisement

Disposer de matière répondant aux spécificités techniques attendues pour développer l'accompagnement des producteurs adhérents dans des projets d'intégration de plastiques recyclés dans leurs nouveaux équipements

Contexte réglementaire et normatif lié à l'utilisation des plastiques dans les D3E

La norme NF EN 60335-1 impose aux équipements électriques et électroniques la résistance au feu et en spécifie les caractéristiques

Beaucoup de Retardateurs de Flamme sont constitués de dérivés contenant du brome (nocif pour l'environnement et la santé): les Retardateurs de flamme Bromés ou RFB

La directive DEEE 2012/19/UE exige que les plastiques contenant des RFB soient extraits

La norme EN 50625-1 précise qu'il faut séparer les plastiques qui contiennent du brome des plastiques non bromé afin de respecter le seuil normatif de 2000ppm de brome dans la fraction non bromée afin que cette fraction puisse être orientée vers le recyclage

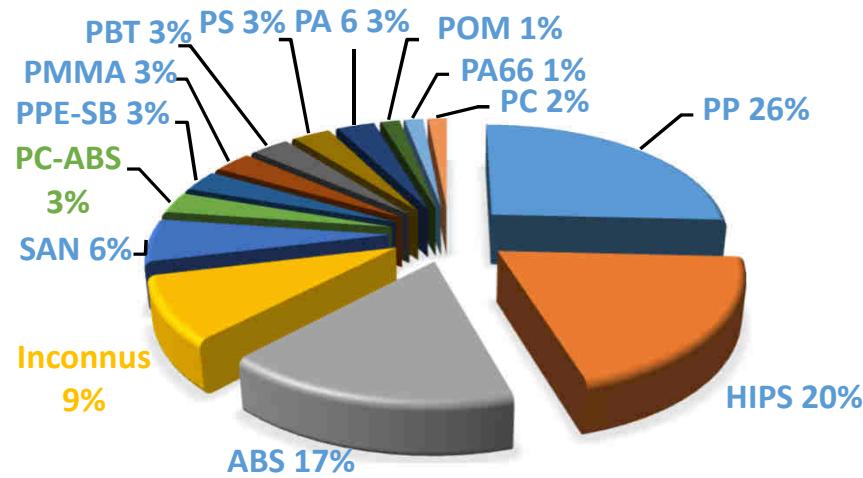
A ce jour les flux de DEEE concernés par une problématique de brome : PAM, Ecrans CRT, Ecrans plat

→ Séparer où et comment ? Dans les unités de tri des plastiques, par flottation ou tri optique

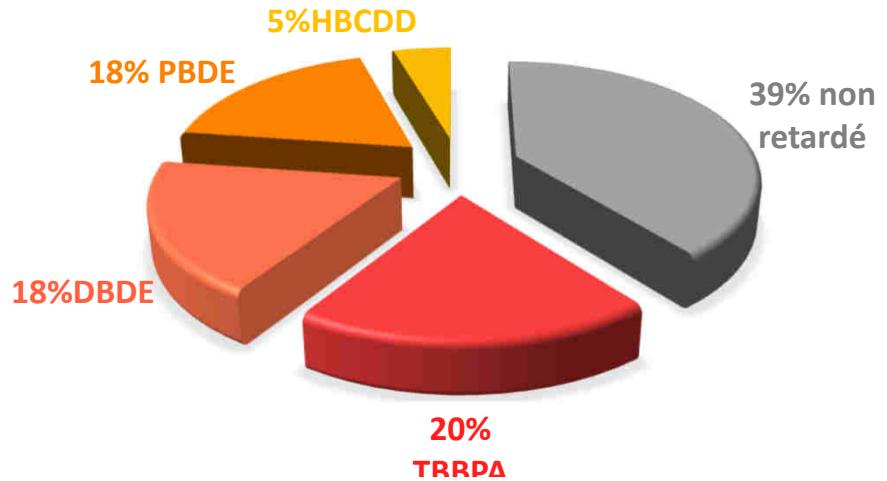
* PPM : partie par million

Plastiques dans les Petit Appareils en Mélange (PAM)

Caractérisation des matériaux par spectroscopie IR :



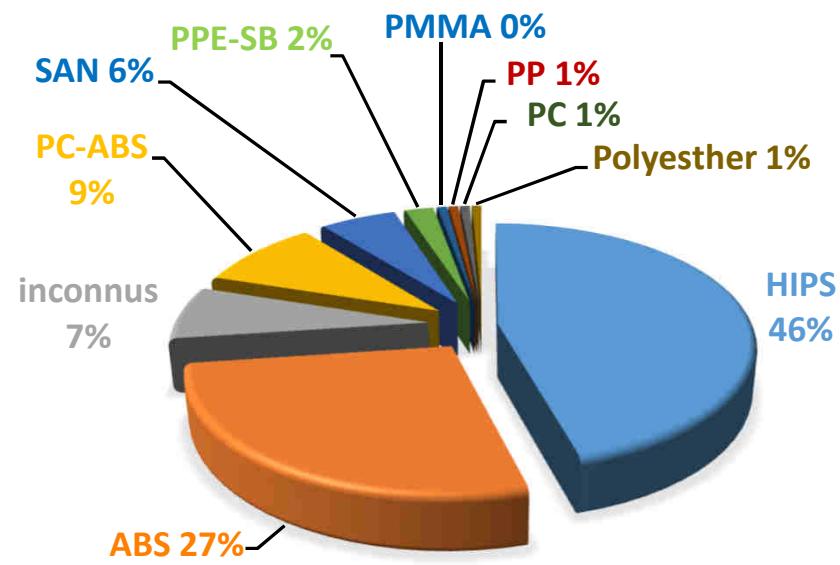
Caractérisation des additifs :



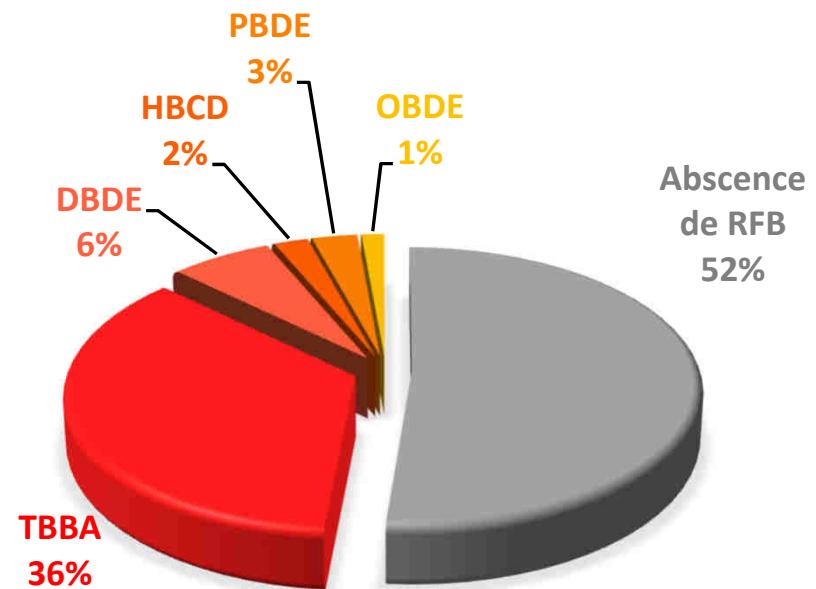
Les plastiques de PAM sont caractérisés par une très grande hétérogénéité de matières. Le tri des plastiques minoritaires n'est pas économiquement viable.

Plastiques dans les écrans CRT

Caractérisation des matériaux par spectroscopie MIR



Caractérisation des additifs :



Re-use of materials : create new markets (e.g. plastics)



⑦ 30%



⑦ 30%



⑦ 25 - 47%



⑦ 13%

Mines Urbaines



Exemples of innovation

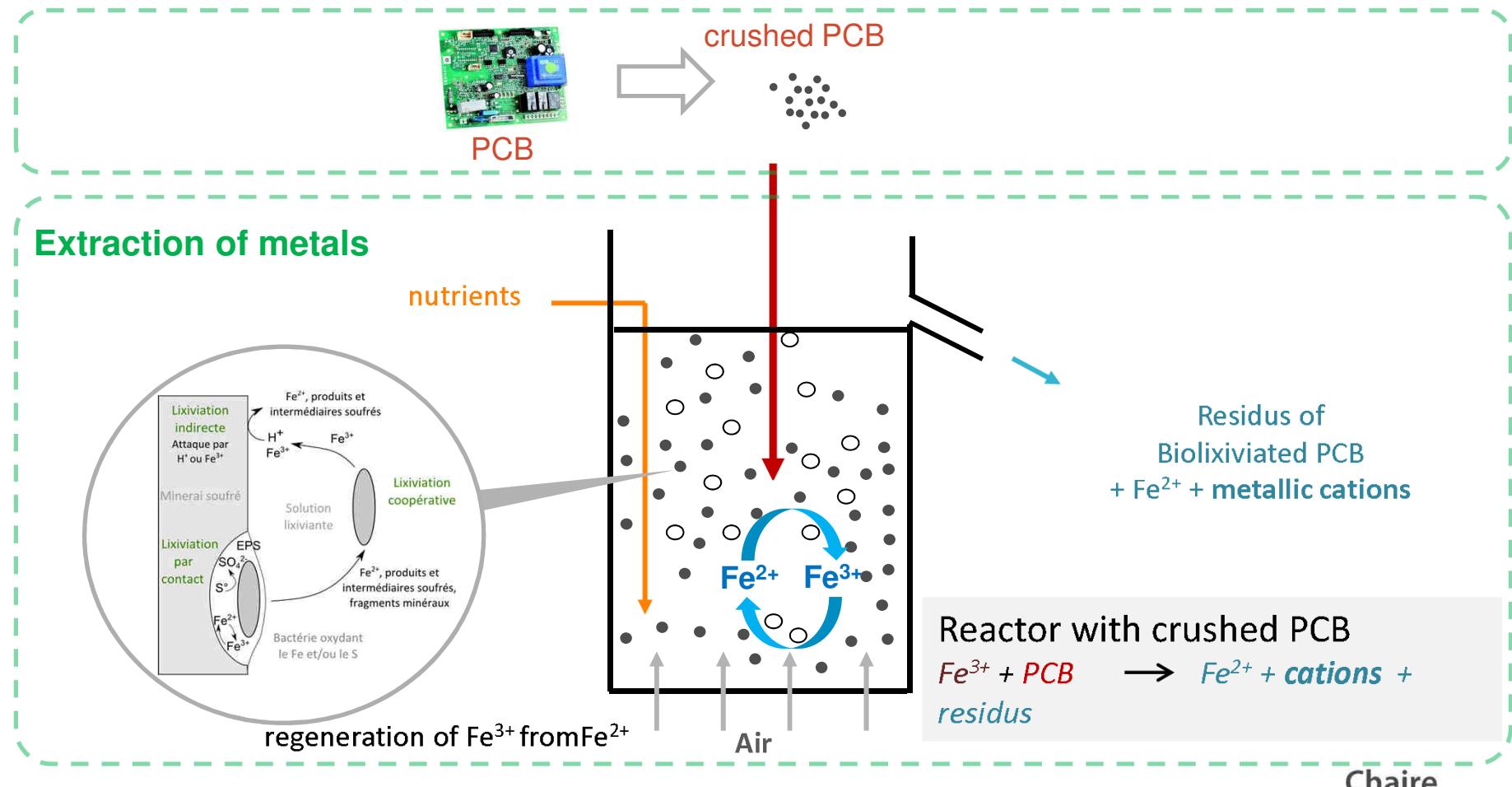


Biolixivation of Printed Circuit Board

(A.Hubeau, Chimie ParisTech/BRGM)

Principle :

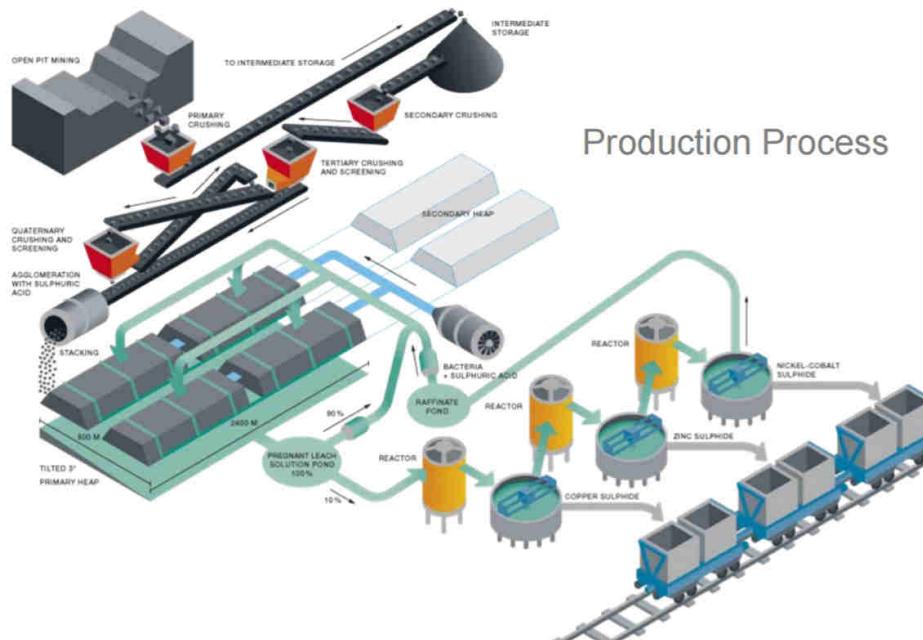
Objective : recovery of Cu – Sn – Pb – Ni – Co – (Ta – In – Ga)



Biolixivation des minéraux

Biolixivation en tas

Biolixivation en tas sur le site de Talvivaara (Finlande).



Biolixivation en bioréacteur

Biolixivation de la pyrite sur le site de Kasese (Ouganda).

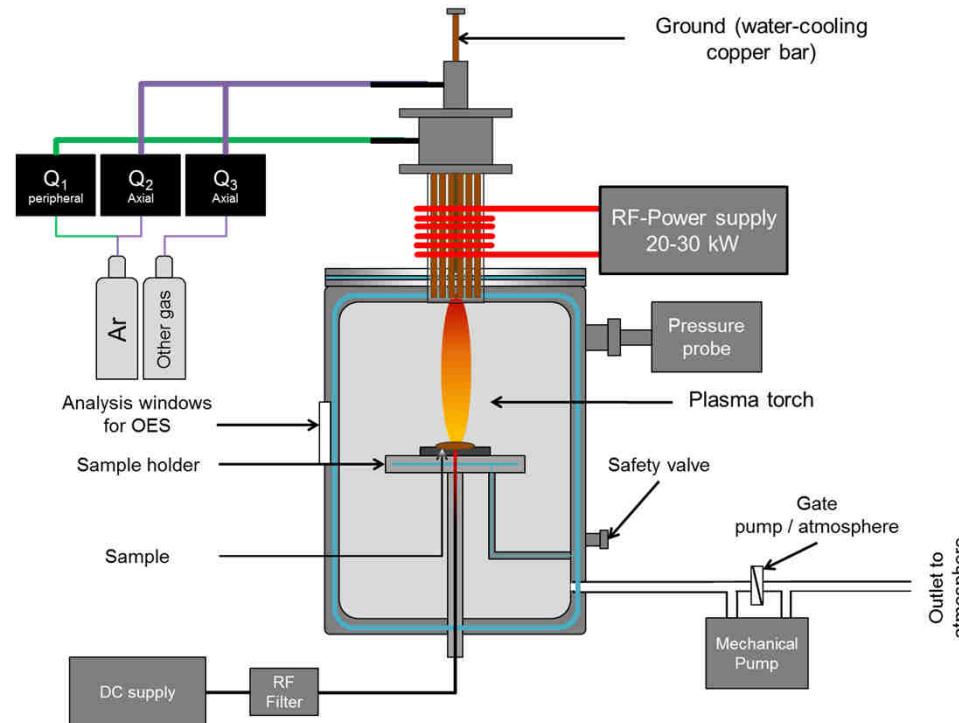


90 tonnes/an de Cobalt

Selective recovery of strategic metals by thermal Plasma (J. Cramer, Chimie ParisTech)

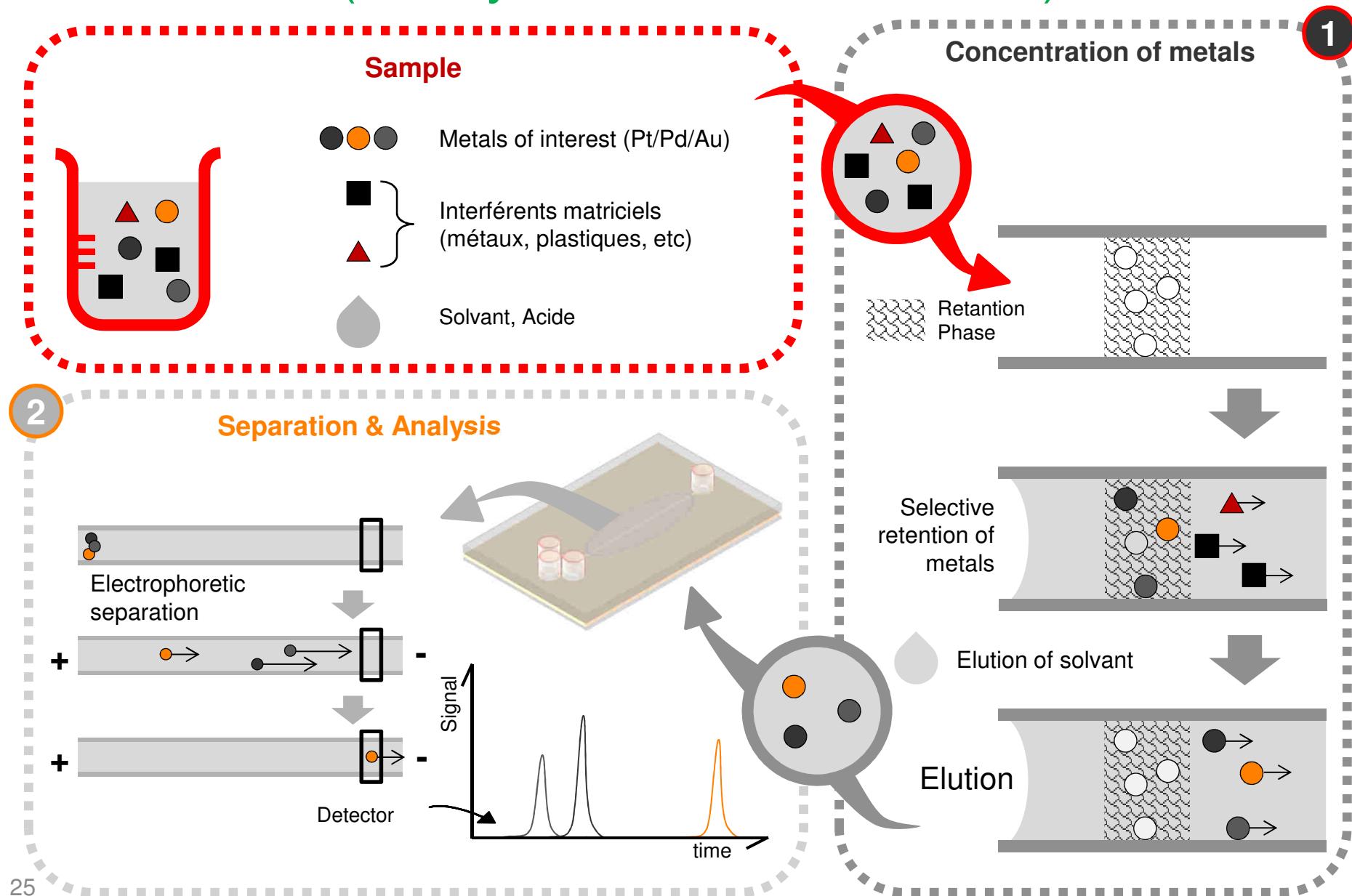
Objectif : Selective extraction of critical metal from WEEE

Recovery of Cu – Sn – Ta – In – Pd – Ag



Analysis of metals in solution

(J. Guyon, Chimie ParisTech)



Exemples : robots for disassembling operations

Apple

Advances in robotics make disassembling operations cheaper



Liam is a robot with 29 arms which can disassemble 350 iPhones per hour (1.2 million per year)

<http://www.extremetech.com/mobile/225337-apple-unveils-29-armed-robot-designed-to-disassemble-old-iphones>
https://images.apple.com/environment/pdf/Apple_Environmental_Responsibility_Report_2017.pdf

Hitachi

Hitachi has developed a machinery to separate and collect rare earth magnets from hard disc drive:

For HDD's a drum type unit spins to shake and prang the HDD's continuously, which loosens screws and disassembles the HDD's into their structural components.

100 Units/hour with the developed machinery compared to 12 Units/hour manually

<http://www.hitachi.com/New/cnews/101206.pdf>

New products

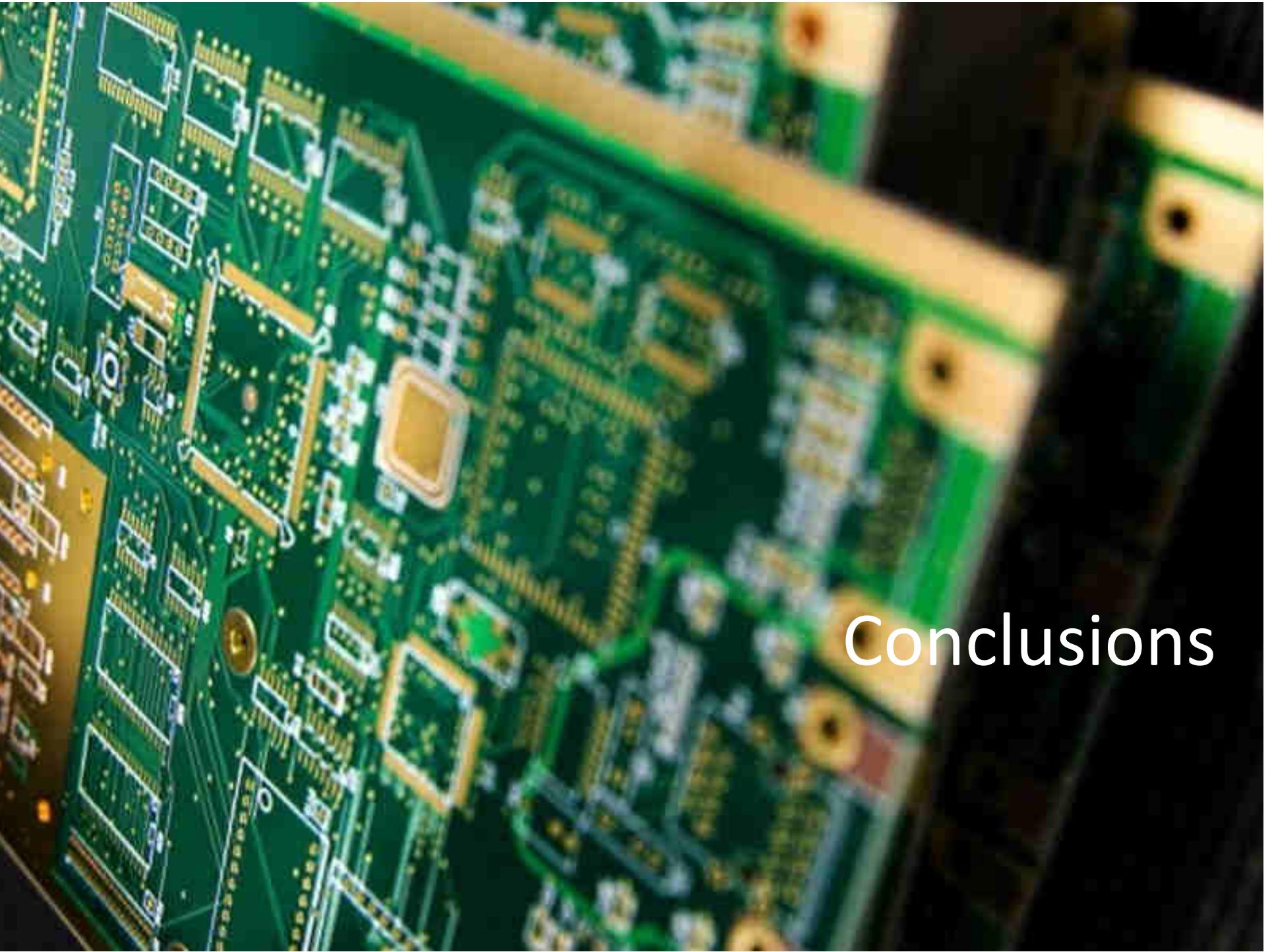


Coolrec 

Filament for 3D printer, made from
recycled refrigerator PS.

Nouveaux modèles économiques : Eurecook (SEB)





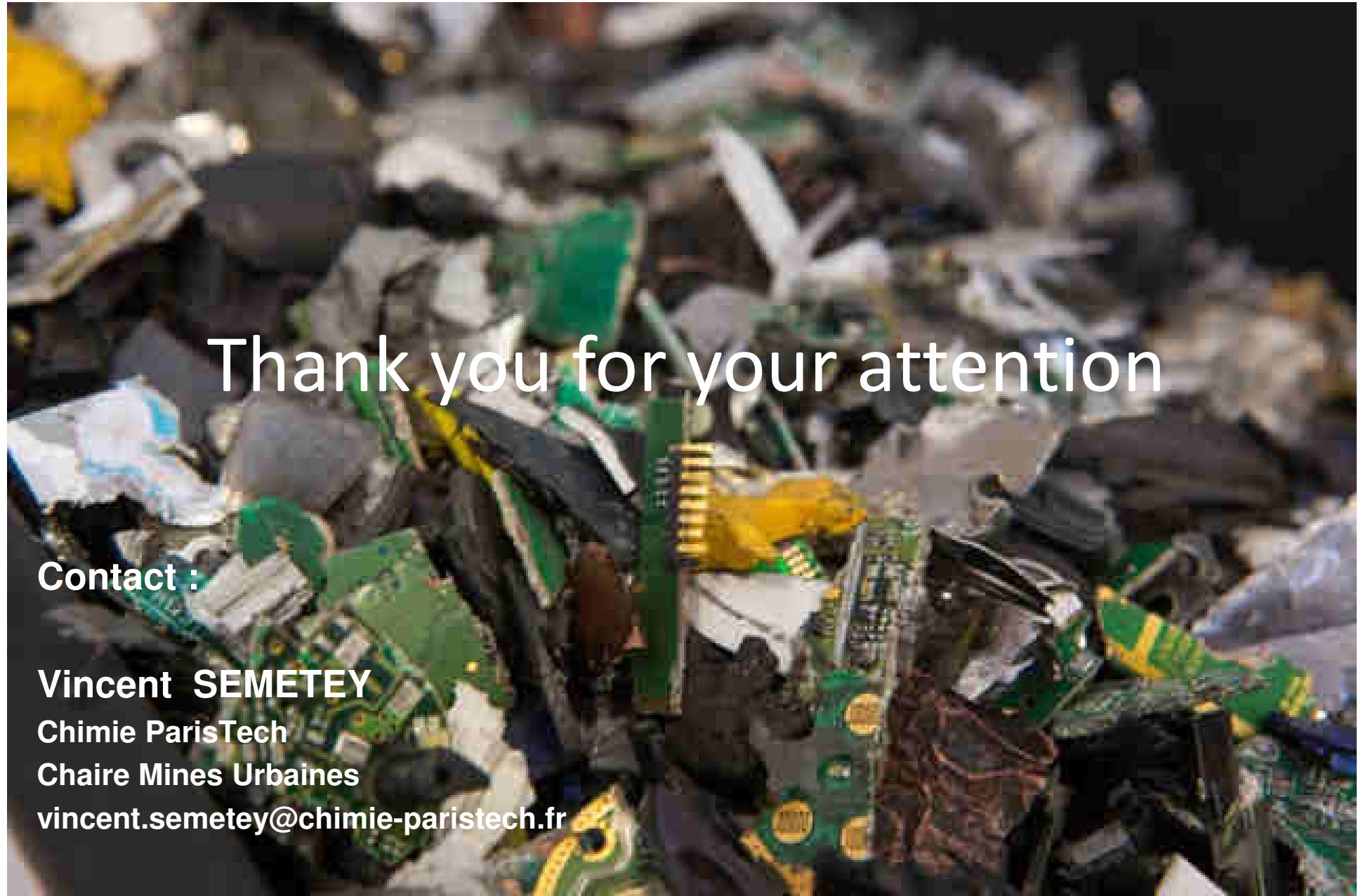
Conclusions

Conclusions

- Presently metals such as iron, copper, gold, palladium are rather well recycled from WEEE.
- On the other hand, metal such as gallium, indium, REE, tantalum are lost during recycling of electronic equipments such as mobile phones
- Metals/Plastics recycling can significantly contribute to metal/Plastic resources, but will not replace virgin mining
- Only the resale value and the potentially criticality may incite to recycle minority elements, but not the regulation!

Coming challenges

- Improve the collection of EEE – User involvement (e.g., < 15% mobile phones recycled!)
- Re-use of raw materials / Create Urban Mines
- Advanced and leading recycling industry, innovations and jobs
- Improve and support eco-design



Thank you for your attention

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WEEE Recycling

Research, Development, and Policies

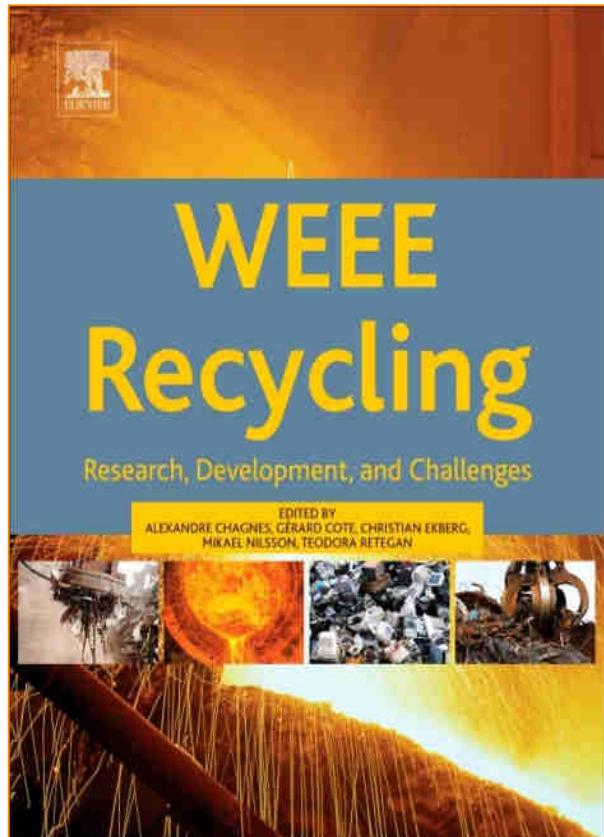
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