Closing Material Loops in the Extended Value Chain

Recycling of Critical Resources – Upgrade Introduction

Perrine Chancerel
Vera Susanne Rotter

Joint International Congress and Exhibition
EGG ELECTRONICS GOES GREEN 2012+
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TAKING GREEN TO THE NEXT LEVEL

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Closing Material Loops in the Extended Value Chain

Agenda

– 13.30 **Recycling of Critical Resources** –Introduction Vera Susanne Rotter … Technische Universität Berlin, Germany

– 14.00 **Recycling of Critical Metals from End-of-Life Electronics** Andreas Manhart, Matthias Buchert, Daniel Bleher, Detlef Pingel … Öko-Institut, Germany

– 14.30 **Opportunities and Limits of WEEE Recycling – Recommendations to Product Design from a Recyclers Perspective** Markus Reuter … Outotec Oyj, Espoo, Finland

Break

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– 16.30 **Towards a Comprehensive Recovery System for Critical Metals** – The Swiss Approach Patrick A. Wäger, Rolf Widmer, Fabian Blaser, Esther Müller, Anna Stamp … Swiss Federal Laboratories for Materials Science and Technology (Empa), Switzerland

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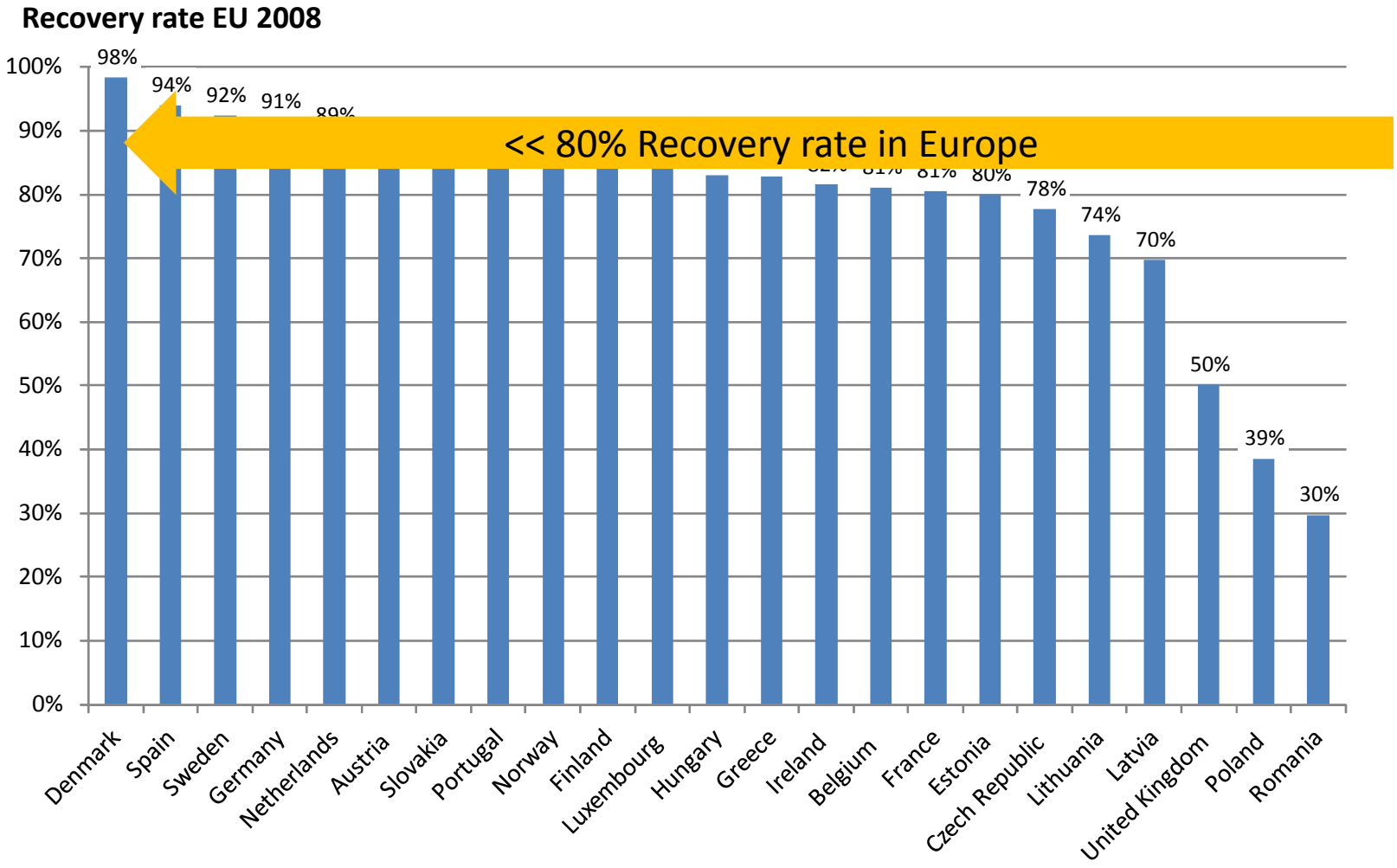
Closing Material Loops in the Extended Value Chain?



Data Eurostat
http://epp.eurostat.ec.europa.eu/portal/page/portal/waste/key_waste_streams/waste_electrical_electronic_equipment_weee

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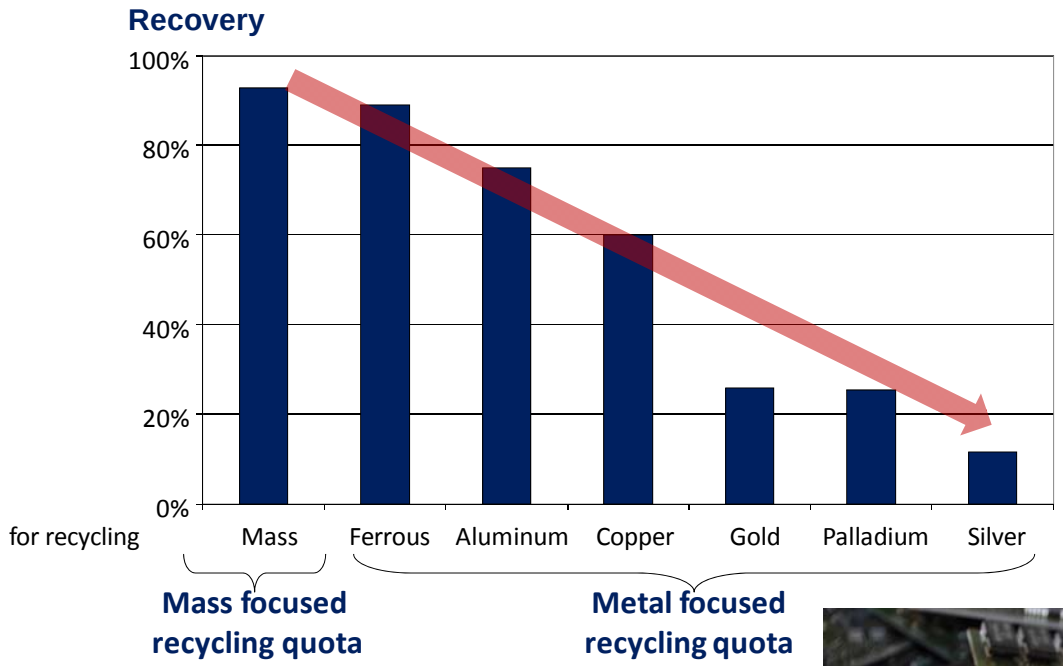
Closing Material Loops in the Extended Value Chain?

Metal specific recovery rates at the pre-processing level



Chancerel, P.; Meskers, C.; Hagelueken, C.; Rotter, V. S.
Assessment of metal flows during pre-processing of waste electrical and electronic equipment focusing on precious metals. Journal of Industrial Ecology Volume 13, Issue 5, October 2009, Pages: 791-810

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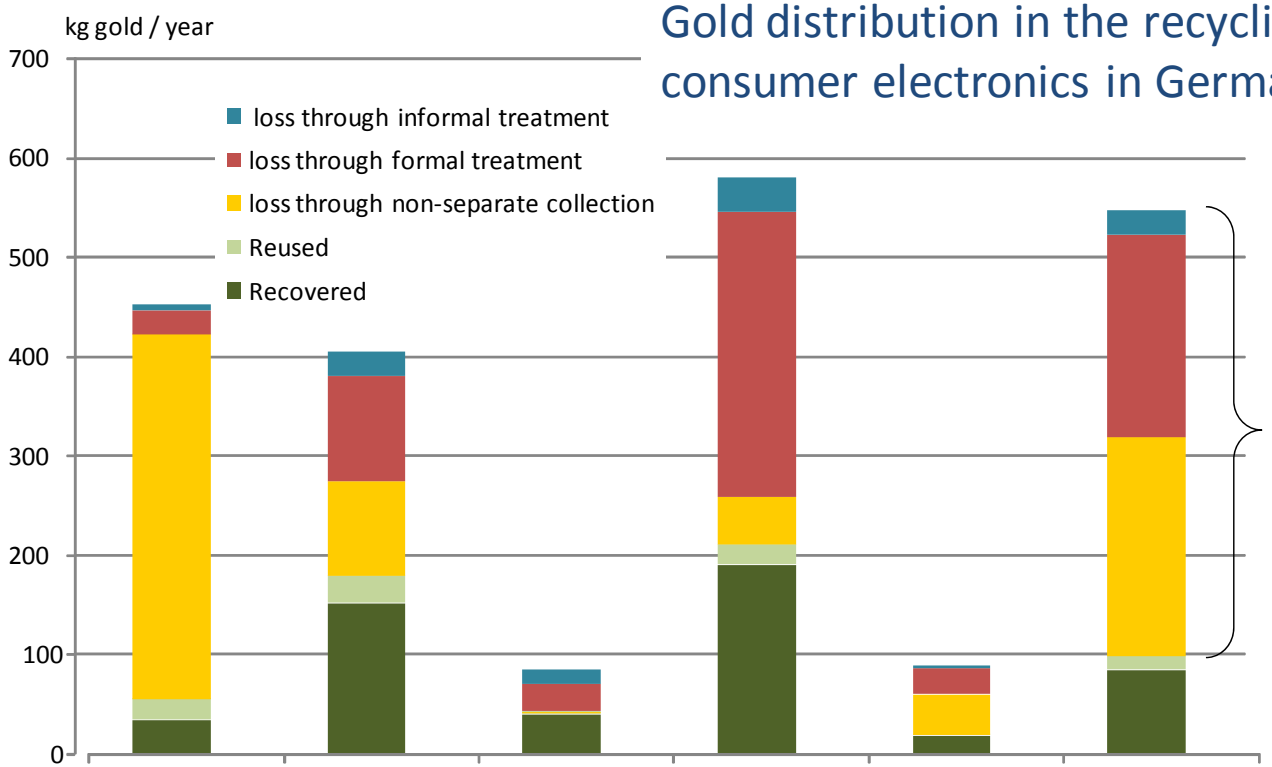
Losses along the WEEE recycling chain

Gold distribution in the recycling of post-consumer electronics in Germany in 2007



	Mobile phones	Desktop personal computer	CRT monitor	Large high-grade equipment	Small high-grade equipment	Low-grade equipment
Gold potential (kg)	451	404	84	580	88	546
Gold losses (%)	88%	56%	51%	64%	79%	82%
Waste generation (t)	1300	13110	136978	48787	1431	197998

1. Trace elements have lower recovery rates
2. Formal treatment and pre-processing contribute hugely to the losses of gold

Chancerel, P., 2009 Substance flow analysis of the recycling of small waste electrical and electronic equipment. Dissertation an der TU Berlin

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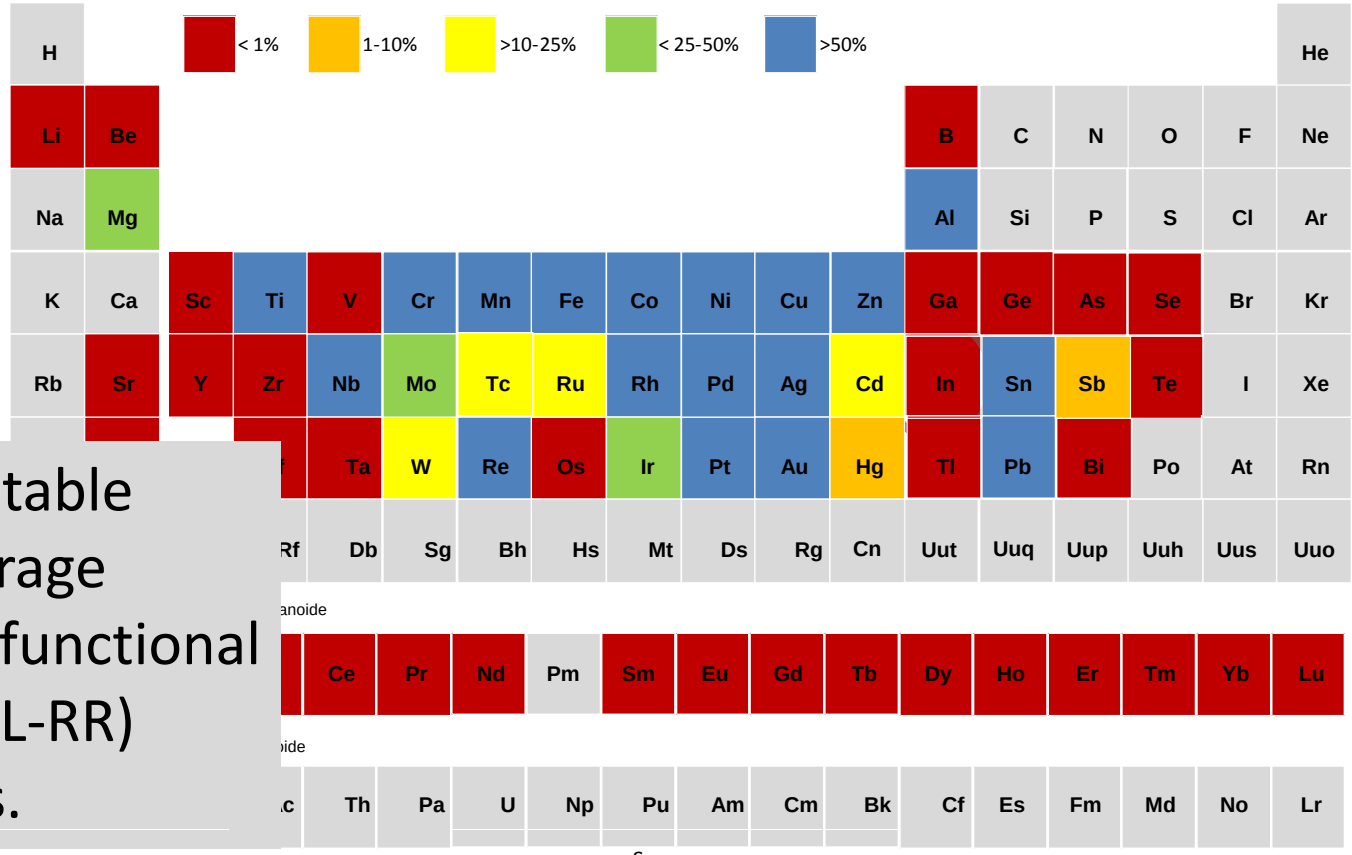
Status of metal recovery

The Recycling of Metals: A Status Report. Second report of the Global Metal Flows group of the UNEP's International Panel on Sustainable Resource Management.



The periodic table of global average end-of-life functional recycling (EOL-RR) for 59 metals.

Source:
Graedel, T. E., Allwood, J.; Birat, J.-P.; Buchert, M.; Hagelüken, C.; Reck , B. K.; Sibley, S. F. and Sonnemann G. What Do We Know About Metal Recycling Rates?. Journal of Industrial Ecology, 15 (3), 2011 pp 355–366,

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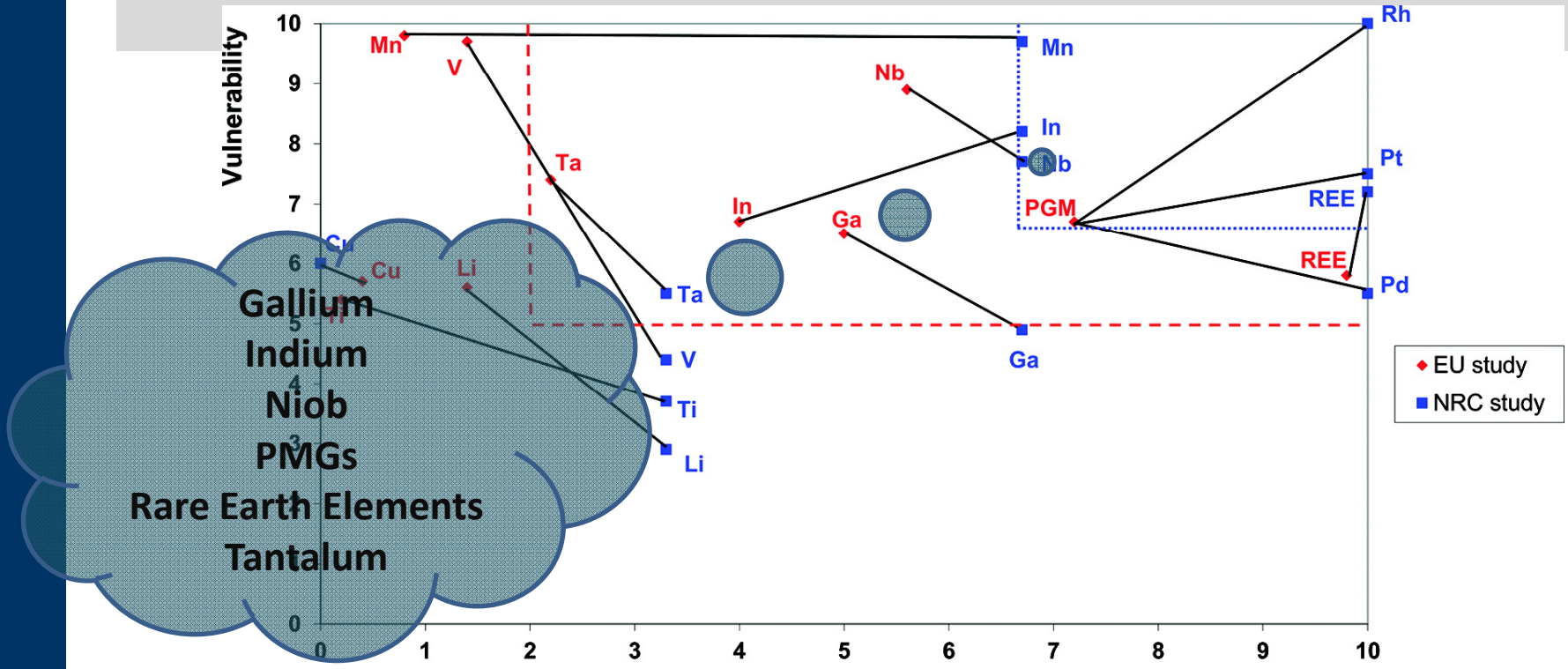
Critical Metals

National Research Council (NRC), Committee on Critical Mineral Impacts on the US Economy. Minerals, Critical Minerals, and the U.S. Economy; The National Academies Press: Washington, DC, 2008.

European Commission. *The Raw Material Initiative – Meeting our Critical Needs for Growth and Jobs in Europe*; Staff Working Document SEC(2008)2741 {COM(2008) 699}; Brussels, Belgium, 2008.



Source Lorenz Erdmann and Thomas E. Graedel **Criticality of Non-Fuel Minerals: A Review of Major Approaches and Analyses**
Environmental Science & Technology **2011** *45* (18), 7620-7630

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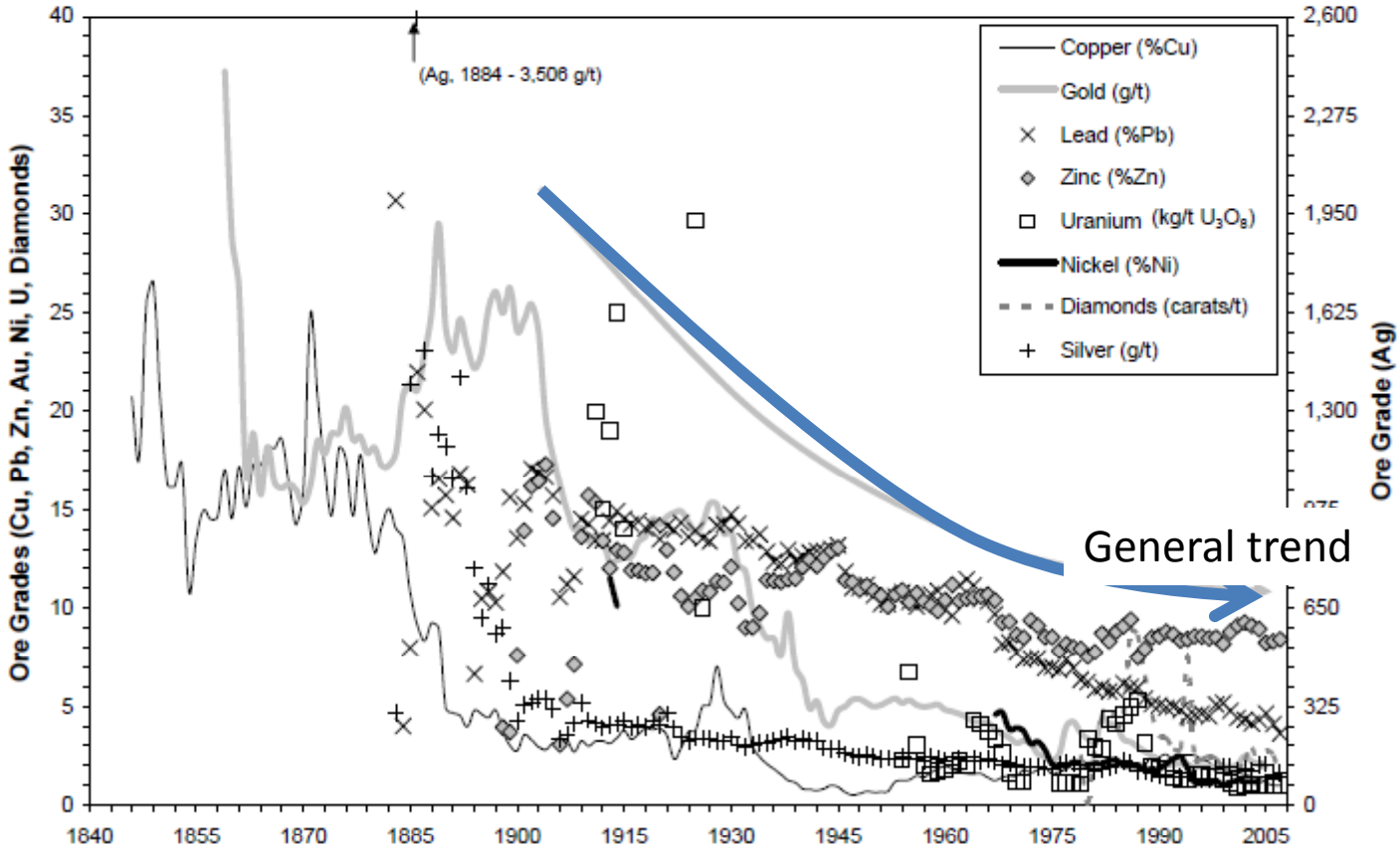
Reduction of primary ore grades



Combined Average Ore Grades in Australia Over Time for Base and Precious Metals

Source: G.M. Mudd, Sustainability of Mining in Australia, Research Report No. RR5, Monash Univ., 2007.

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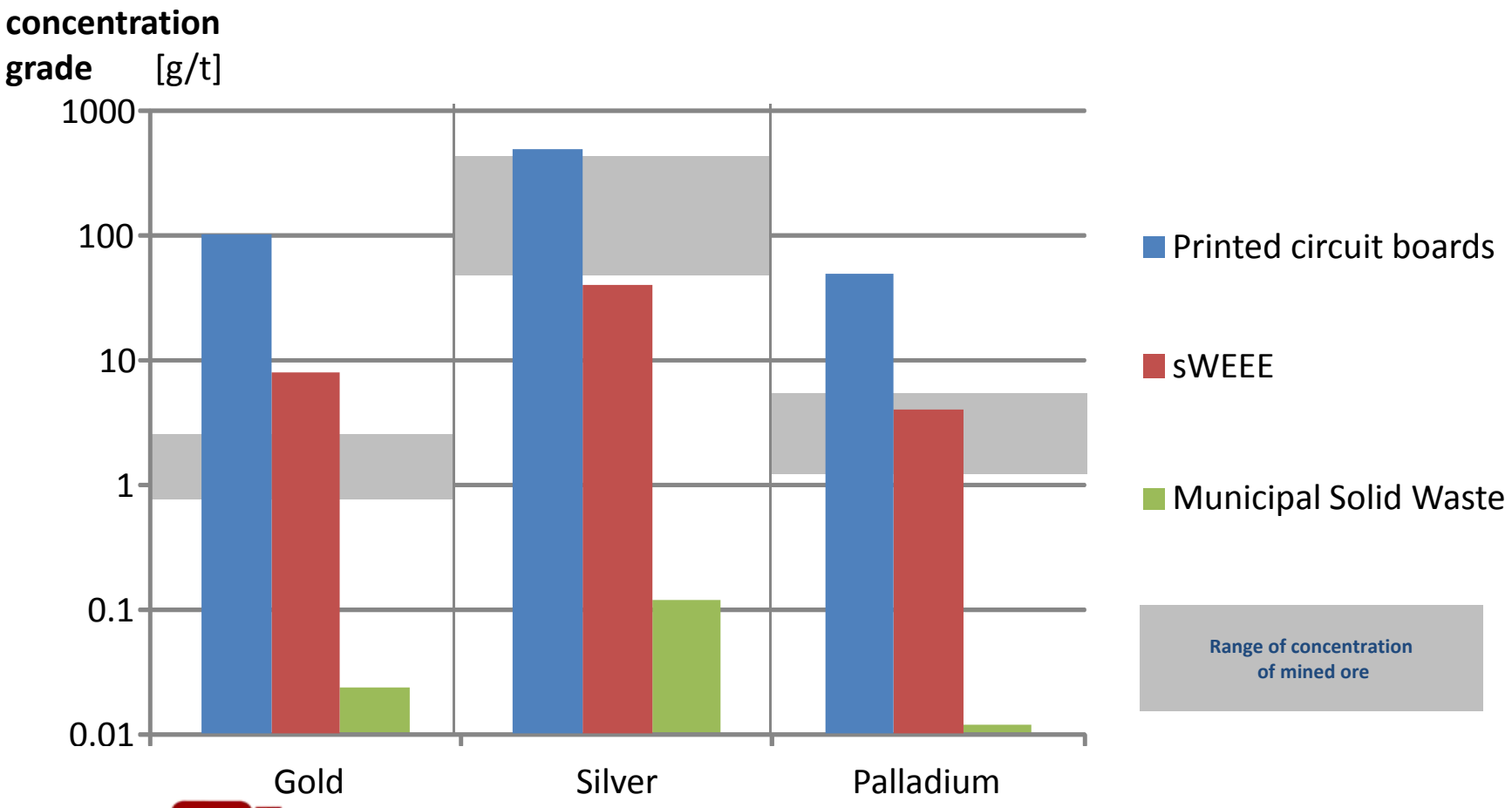
Quality of “urban ores”

Strategic relevant metals are concentrated in components and get dissipated through waste management



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Case Study: Recovery of metals from end-of-life mobile phones

Goal: To quantify and assess the flows of nine trace metals associated with end-of-life (EOL) mobile phones in Germany in 2007 in the whole recycling chain

Scope: Nine metals – silver (Ag), gold (Au), palladium (Pd), nickel (Ni), bismuth (Bi), tin (Sn), antimony (Sb), indium (In) and tantalum (Ta)

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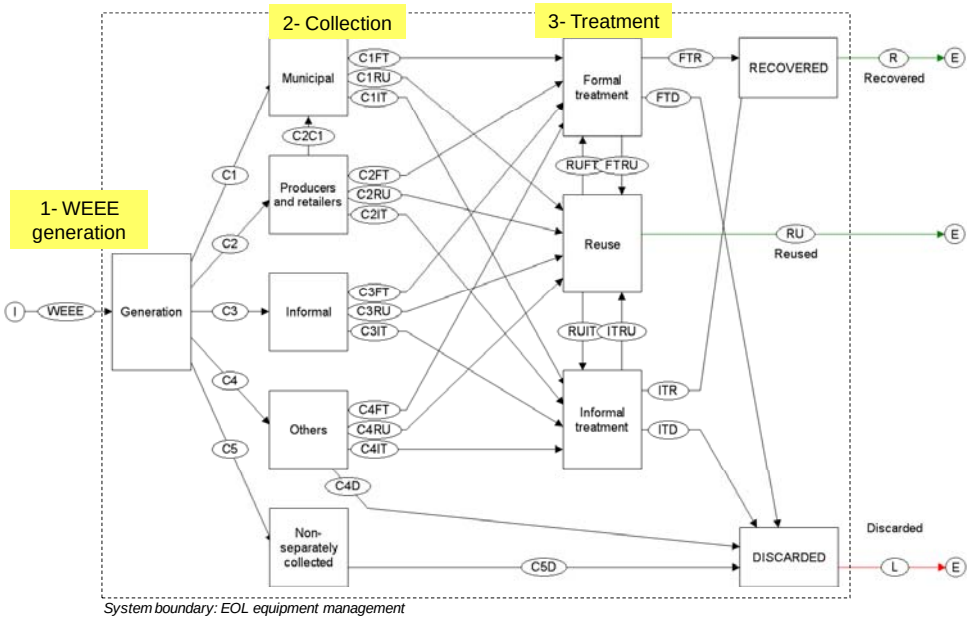
Case Study: Recovery of metals from end-of-life mobile phones



System boundary: EOL equipment management

Element	Unit	Concentration[1]
Al	%	3
Cu	%	14
Fe	%	7
Ag	ppm	3630
Au	ppm	347
Co	ppm	145
Ni	ppm	15000
Pd	ppm	150
Sb	ppm	1000
Sn	ppm	10000
Bi	ppm	300
Ta	ppm	40
In	ppm	20

Subsystem	Required information	Assumption[2]
Generation	Average lifetime	6 years
	Theoretical generation of EOL mobile phones	2278 tonnes
Collection	Separately collected EOL mobile phones	229 tonnes
	Non-separately collected EOL mobile phones	979 tonnes

[1] Data sources: Hagelüken & Meskers 2008; Reller &al. 2009; Huisman 2004; DDTSC 2004; Nokia 2009; UNEP 2006

[2] Chancerel 2010

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Case Study: Recovery of metals from end-of-life mobile phones

Recovery rates achieved in 2007 by the pre- and end-processing technologies

Metal	Distribution D_{PP} over the pre-processing technologies[1]			Recovery rates achieved by formal pre-processing[2]		Recovery rates achieved by formal end-processing[3]	Recovery rates achieved by informal pre- and end-processing[4]
	No PP	Manual	Mech.	Manual	Mech.		
Ag/Silver				90%	11%	99%	0%
Au/Gold				90%	26%	98%	13%
Pd/Palladium				90%	26%	99%	0%
Ni/Nickel	for all metals			90%	25%	83%	0%
Bi/Bismuth	60%	10%	30%	90%	10%	65%	0%
Sn/Tin				90%	39%	52%	0%
Sb/Antimony				90%	12%	47%	0%
In/Indium				90%	10%	10%	0%
Ta/Tantalum				?	?	0%	0%

(PP= pre-processing; Mech.= Mechanical)

[1] Chancerel et al. 2011
[2] Chancerel et al. 2011; Chancerel et al. 2009; Meskers & Hagelüken 2009
[3] Deubzer 2007
[4] Keller 2006

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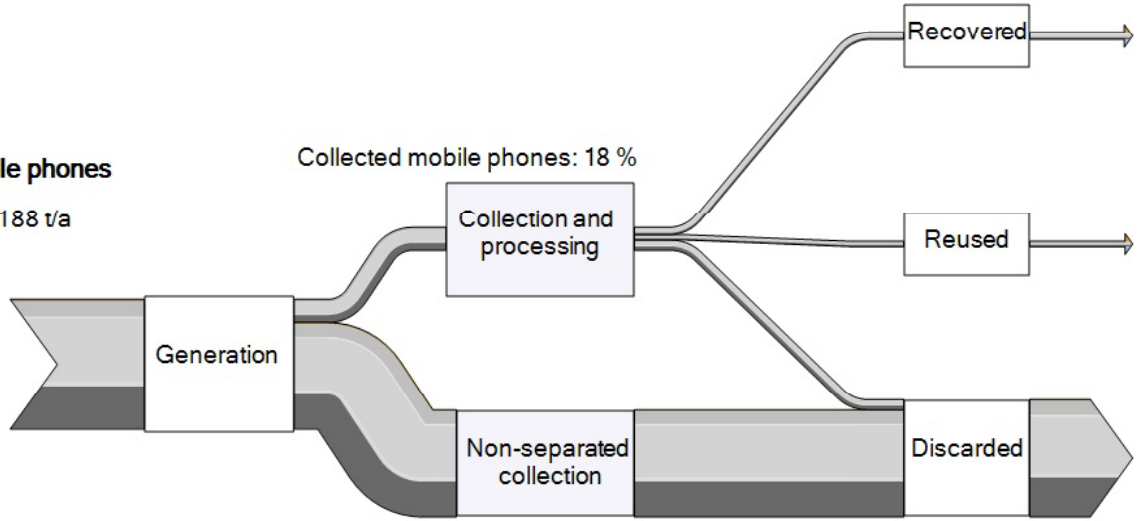
Case Study: Recovery of metals from end-of-life mobile phones

Flows of trace metals:

Generated EOL mobile phones

Mobile phones: 1289 ± 188 t/a

Au: 447 ± 66 kg/a
Pd: 193 ± 29 kg/a
Ag: 4680 ± 714 kg/a
Bi: 387 ± 66 kg/a
In: 26 ± 7 kg/a
Ni: 19341 ± 2952 kg/a
Sb: 1289 ± 220 kg/a
Sn: 12894 ± 1969 kg/a
Ta: 52 ± 14 kg/a
(Input=100%)



Recovered metals

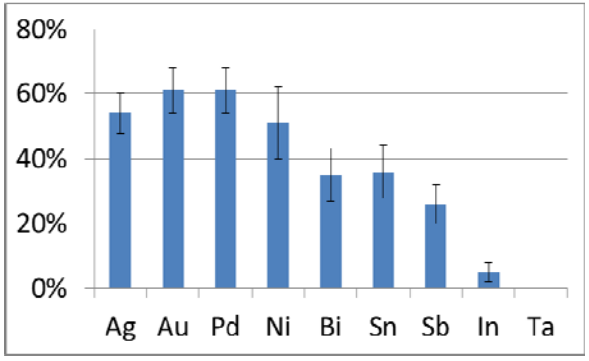
Au: 8 %
Pd: 8 %
Ag: 7 %
Bi: 4 %
In: 1 %
Ni: 6 %
Sb: 3 %
Sn: 4 %
Ta: 0 %

Reused mobile phones: 4 %

Discarded metals

Au: 88 %
Pd: 88 %
Ag: 89 %
Bi: 91 %
In: 95 %
Ni: 89 %
Sb: 93 %
Sn: 91 %
Ta: 96 %

Overall recovery rates achieved by end-processing:



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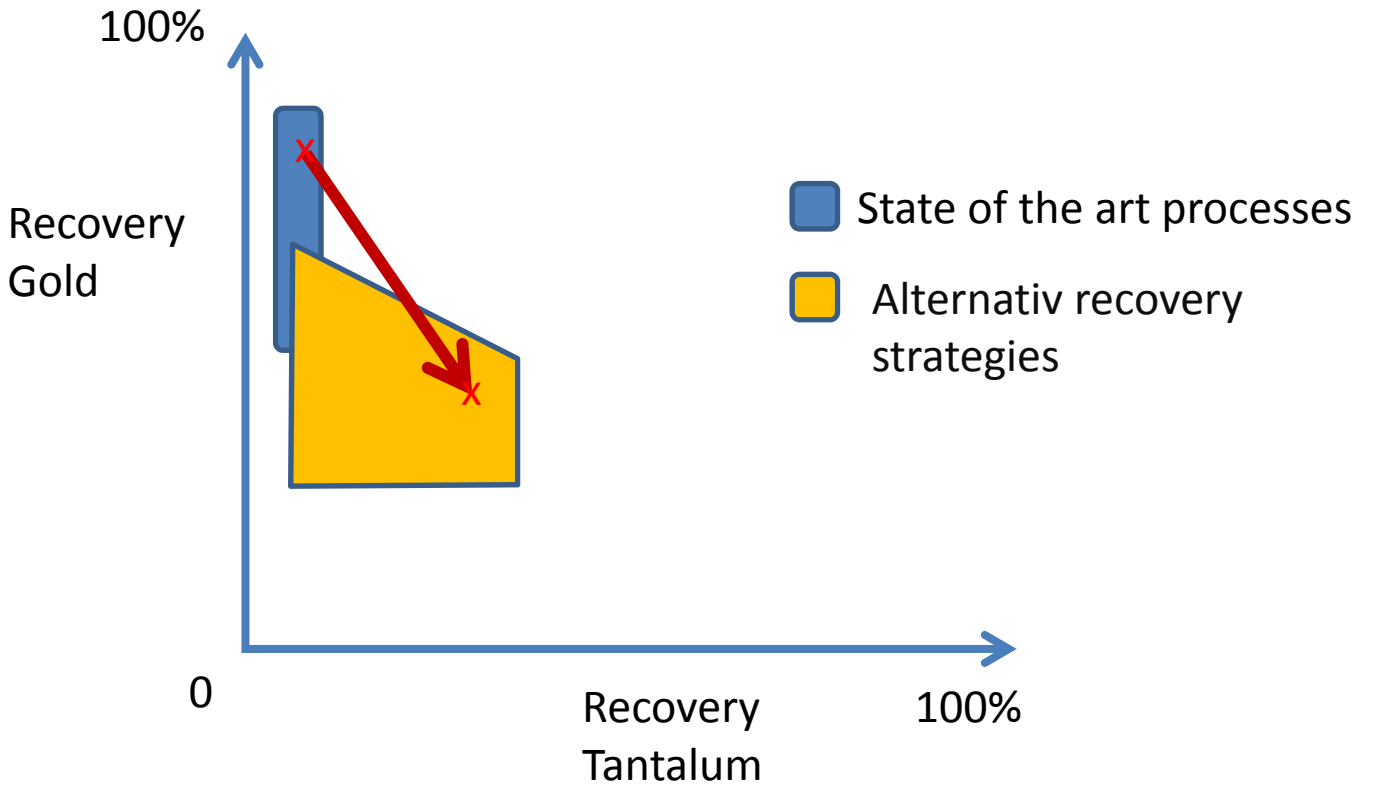
Closing Material Loops in the Extended Value Chain

Closing loops requires multi-criteria decission making



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Integrierte Ansätze zur Rückgewinnung von Spurenmetallen und zur Verbesserung der Wertschöpfung aus Elektro- und Elektronikaltgeräten

Improved valorization and integrated recovery of trace metals in Waste Electronic and Electric Equipment (WEEE)

Project duration: Aug 2012-Jul 2015

GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung

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LASU Technische Universität Berlin

UPgrade Objectives

"Upgrading" material flows along the recycling chain does not aim at a 100% recovery but is the result of an interdisciplinary decision making and optimization along the extended value chain.

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UPgrade Consortium

Project partners

Associated partners

Scientific coordination

Work packages

WP 1 Identification of metal potentials in WEEE

WP 2 System analysis and optimization of the WEEE recycling chain

WP 3 Characterization and optimization of upgrading processes along the WEEE recycling chain

WP 4 Definition of „Design for Recycling“ recommendations

WP 5 Stakeholder Dialogues „Weee recover Metals“

Results and Deliverables

New upgading and separation technologies for enhanced recycling of WEEE targeting at trace metals

- Inventory of trace metals in WEEE
- Practical handbook for experimental Substance Flow Analysis
- Best Practice handbook for Recyclers
- Practical DfR handbook for product designers
- Stakeholder Dialogues „Weee recover Metals“ (Workshops, Newsletter, Publications)

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Discussion questions

1) Are supply risks of „critical metals“ critical for the EEE industry?
2) Do we know enough about critical metals in EEE? If no, which information are missing?
3) Can design for recycling solve the problem?
4) Is our recycling infrastructure sufficient for enhanced recycling of critical metals?
5) What are appropriate decission support tools?
6) How should stakeholders collaborate?

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