



Solution Architect for Global
Bioeconomy & Cleantech Opportunities

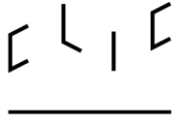


arvi
Material Value Chains

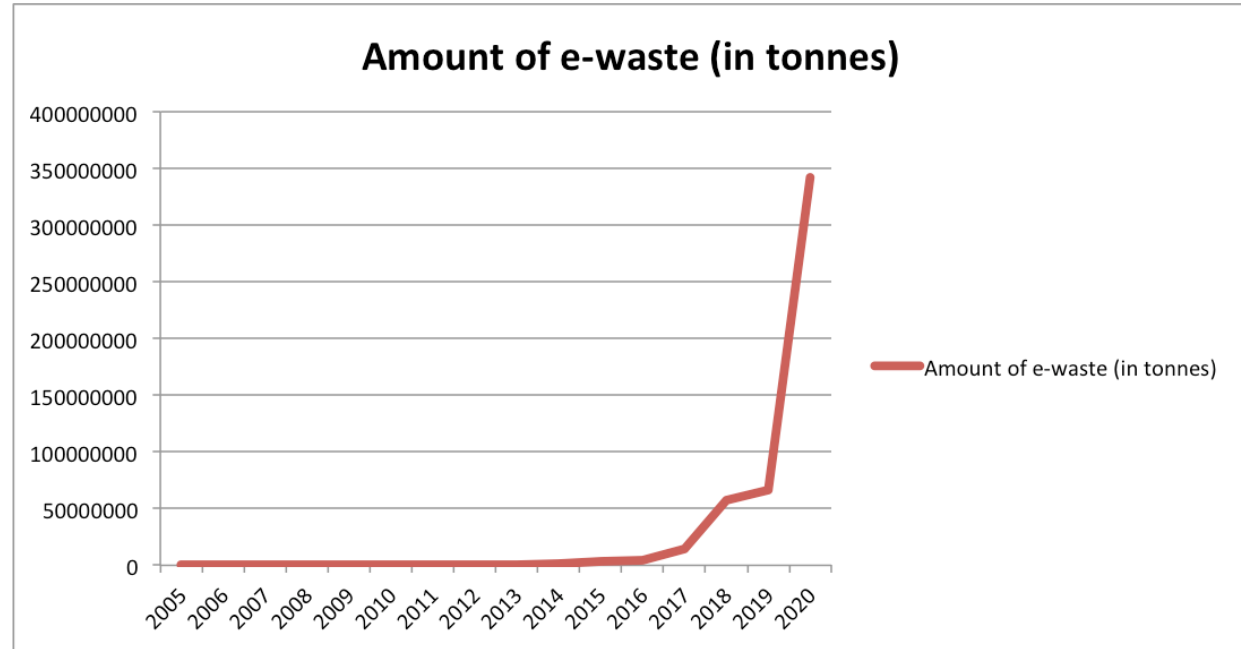
16.01.2017

Dr. Ilkka V. Kojo

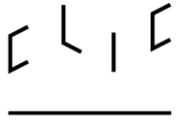
WEEE as a secondary source for metals



Amount of WEEE increasing as rapidly as the clock speed in computers...



Source: <https://povertyversuspoinson.wordpress.com/category/e-waste/>



Growth potential for mining industry; Urban mining (WEEE)

Global Sales 2010

Mobile phones (a)

1600 million units / year
 x250mgAg ≈ 400t Ag
 x 24 mg Au ≈ 38t Au
 x 9 mg Pd ≈ 14t Pd
 x 9 g Cu ≈ 14,000t Cu

1300 million Li-Ion batteries

x 3.8 gCo ≈ 6100t Co

PCs & Laptops (b)

350 Million units / year
 x1000 mg Ag ≈ 350t Ag
 x 220 mg Au ≈ 77t Au
 x 80 mg Pd ≈ 28t Pd
 x~500 g Cu ≈175,000t Cu

~180 million Li-ion batteries

x 65 g Co ≈11,700t Co

Urban Mine (a+b)

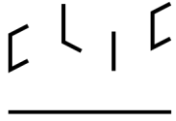
Mine production	Share
Ag: 22,200t/a	▶ 3%
Au: 2,500t/a	▶ 5%
Pd: 200t/a	▶ 21%
Cu: 16 Mt/a	▶ 1%
Co: 88,000t/a	▶ 20%

2016 Feb	Value, million €
Ag	371
Au	4 547
Pd	677
Cu	868
Co	404
	6 867

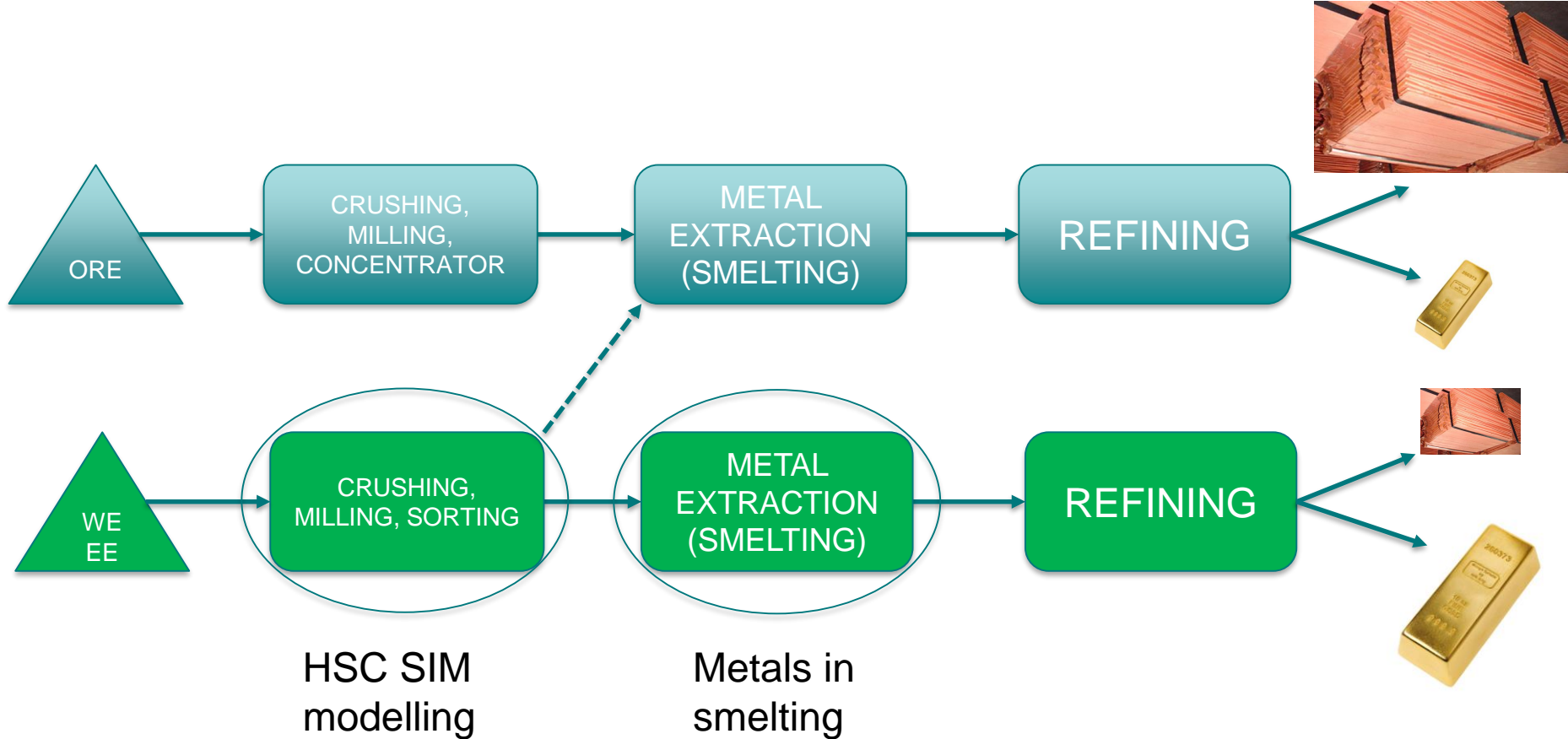
The beef is in gold!

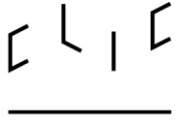
But it is not possible to recover the
beef without copper

Reuter & Van Schaik (WEEE Handbook, 2012)



Primary vs. WEEE metallurgy

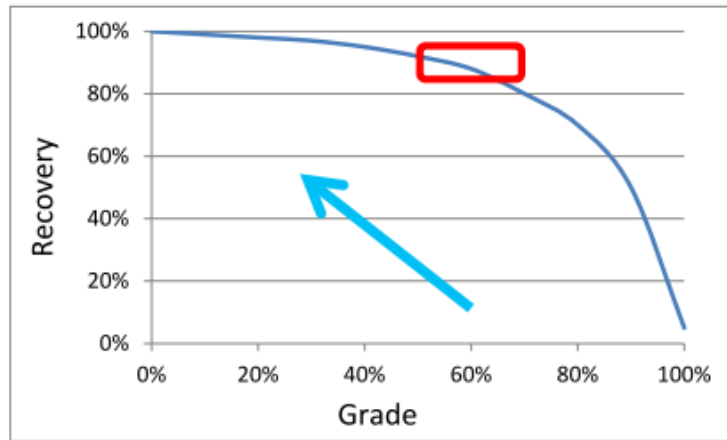




Challenge of sorting, quantity vs. quality

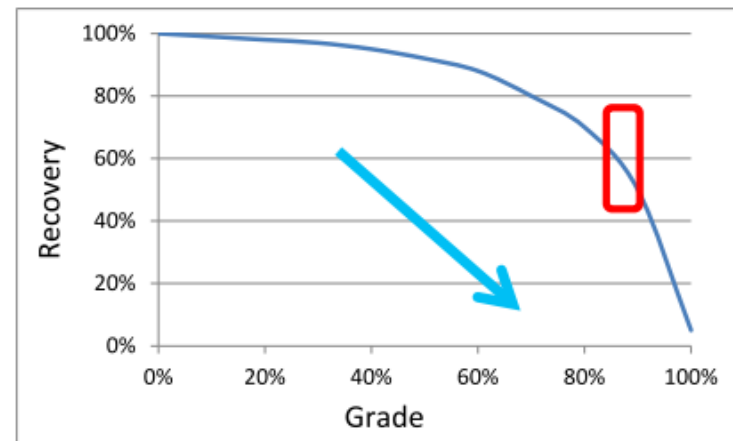
Maximize recovery

90 % recovery at 60 % purity

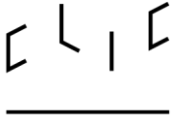


Maximize product quality

90 % purity at 60 % recovery



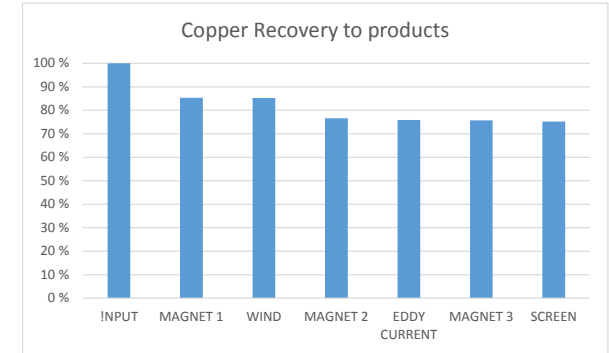
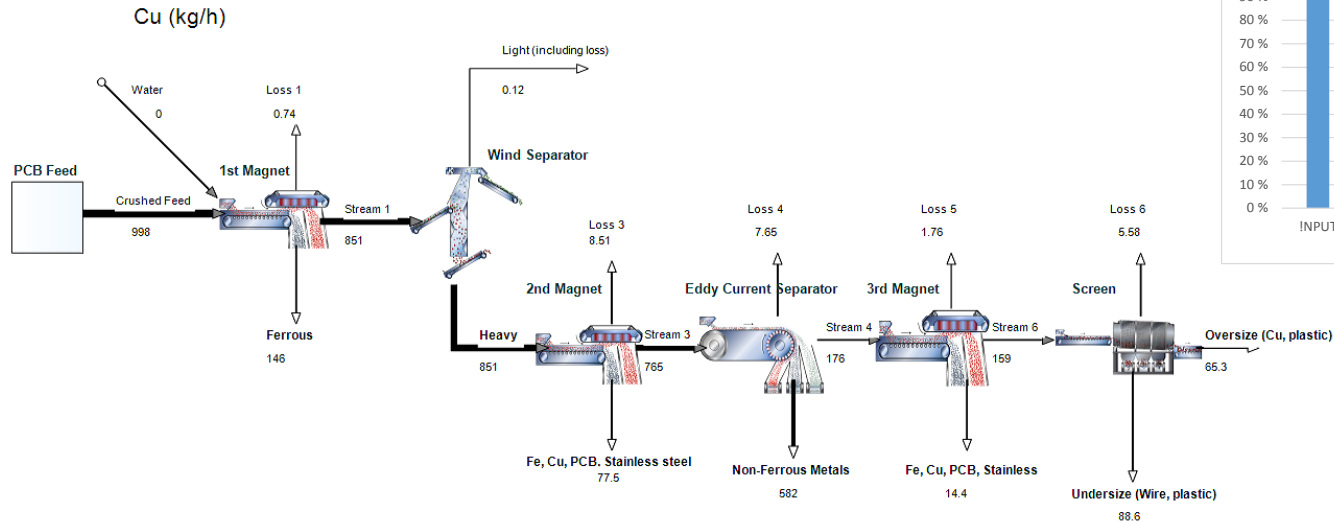
Talja, J., Metals Recycling Makes Business Sense, Metal Industry; a necessity for the circular economy
A joint seminar between Swedish and Finnish steel and metal R&D professionals, 2016-09-29 Helsinki



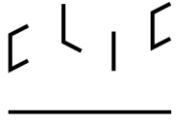
HSC SIM MODEL OF WEEE TREATMENT

Printed Circuit Board Recycling Process

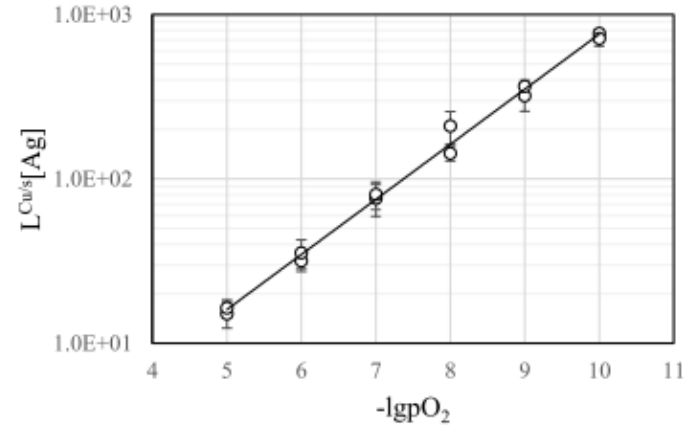
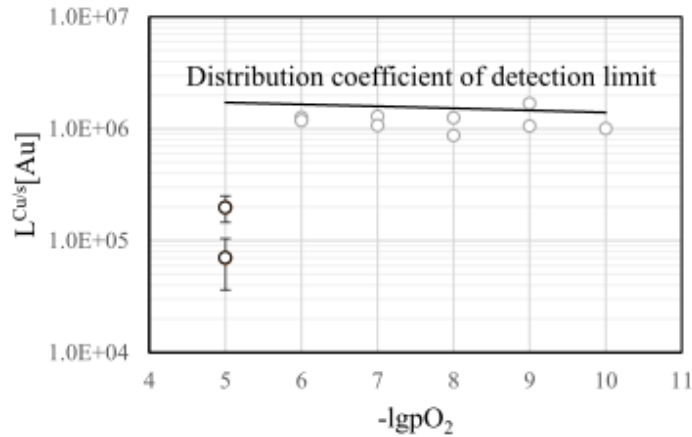
ARVI, Kuusakoski Heinola, 22.10.2015



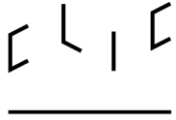
Nevalainen s., Piirilevyjen kierrätysprosessin simulointi,
LuK-tutkielma, Turun Yliopisto, Helmikuu 2016



DISTRIBUTION OF GOLD AND SILVER BETWEEN COPPER AND SLAG IN WEEE SMELTING



Katri Avarmaa, Hugh O'Brien, Pekka Taskinen, EQUILIBRIA OF GOLD AND SILVER BETWEEN MOLTEN COPPER AND $FeO \cdot X \cdot SiO_2 \cdot Al_2O_3$ SLAG IN WEEE SMELTING AT 1300 °C

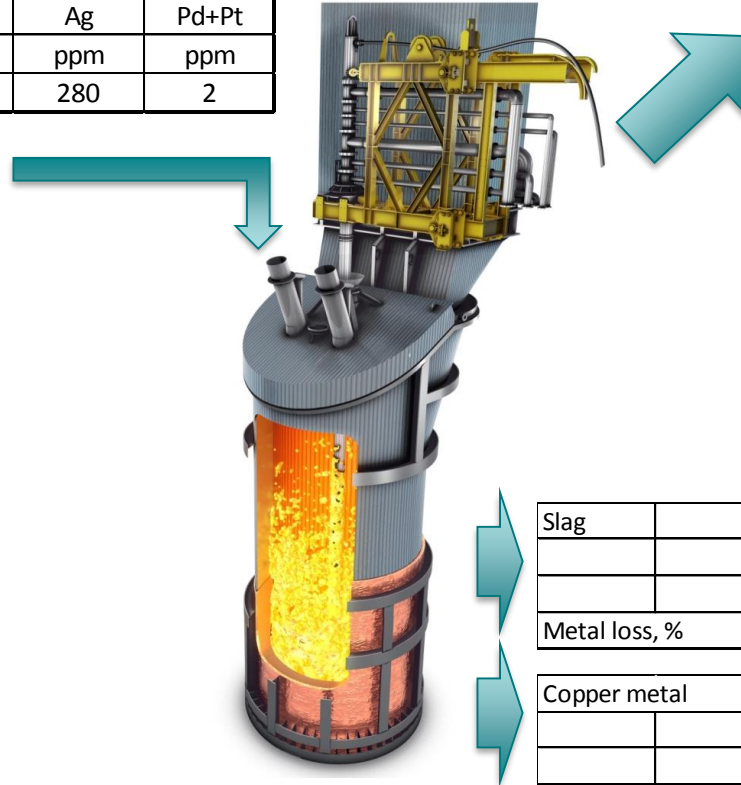


WEEE SMELTING IN A TSL FURNACE, EXAMPLE

Dust		Cu	Au	Ag	Pd+Pt
	tpy	%	ppm	ppm	ppm
	2 272	4,5	8,4	14,4	0,6
Potential treatment		0,7 %	0,5 %	0,3 %	1,2 %

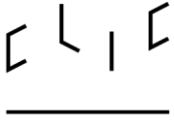
WEEE Blend	Cu	Au	Ag	Pd+Pt
	tpy	%	ppm	ppm
	47 059	31,9	79	280

Iron scrap	2 890	tpy
Coal	621	tpy



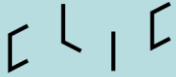
Slag		Cu	Au	Ag	Pd+Pt
	tpy	%	ppm	ppm	ppm
	21 754	0,70	0,98	14,44	0,07
Metal loss, %		1,0 %	0,6 %	2,4 %	1,3 %

Copper metal		Cu	Au	Ag	Pd+Pt
	tpy	%	ppm	ppm	ppm
	14 959	98,7	245,8	836,1	7,7
Metals Recovery, %		98,3 %	98,9 %	97,3 %	97,6 %



Conclusions

- The HSC SIM model developed in the ARVI is unique and allows simulation of WEEE sorting in order to find best (economic) alternative to the process to recover the valuables
- The model has to be calibrated case by case
- Metallurgical treatment of sorted WEEE was also calculated based on the results of thermodynamical tests and inhouse knowhow of the behaviour of the metals in pyrometallurgical treatment
- Copper is the main target to recover as it acts as a collector for other valuable metals in the smelting process
- Some of the valuables are lost in the sorting process and thus it is still a potential target for further development.



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Thank you!

Any questions?