



Metallurgy – Key to Recycling

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Outotec

Sustainable use of Earth's natural resources

Outotec in Brief

- **Sales EUR 2,078 million (2012)**
 - Over 5,745 national patents or applications, 630 patent families and 70 trademarks
- **Ranked Globally 12th most sustainable corporation**
 - <http://corporateknights.com/report/9th-annual-global-100>
 - **Knowledge in the processing of >60 elements**
- **>130 Non-ferrous smelters (58 Flash, 56 TSLs, 17 Kaldo)**
 - 2013 Flash Milestones (Tongling>400,000tpa & Fanchenguang>400,000tpa)
 - ca. 50% Cu , >30% Sn in TSL , close to 40% PGM matte converting
 - Ca. 70% Cu in China through Outotec
- **650 sulfuric acid plants**
 - World's largest metallurgical based, Zambia and largest in Ma'aden
- **Minerals Processing / Hydrometallurgy**
 - 1100 grinding mills (28MW worlds' largest saving around 15% energy)
 - >10000 flotation units (reaching 500m³)
 - 1800 thickeners / >3500 filters
- **Ironmaking and Ferroalloys**
 - 20 pelletizing and sintering plants for chromites (ferroalloys),
 - 13 ferroalloy smelters
 - 340 iron ore sintering plants / 93 iron ore pelletizing plants
- **Light metals / Roasting / Waste to Energy**
 - 290 fluidized bed roasting plants / alumina calcining



Grinding mills
LKAB Sweden



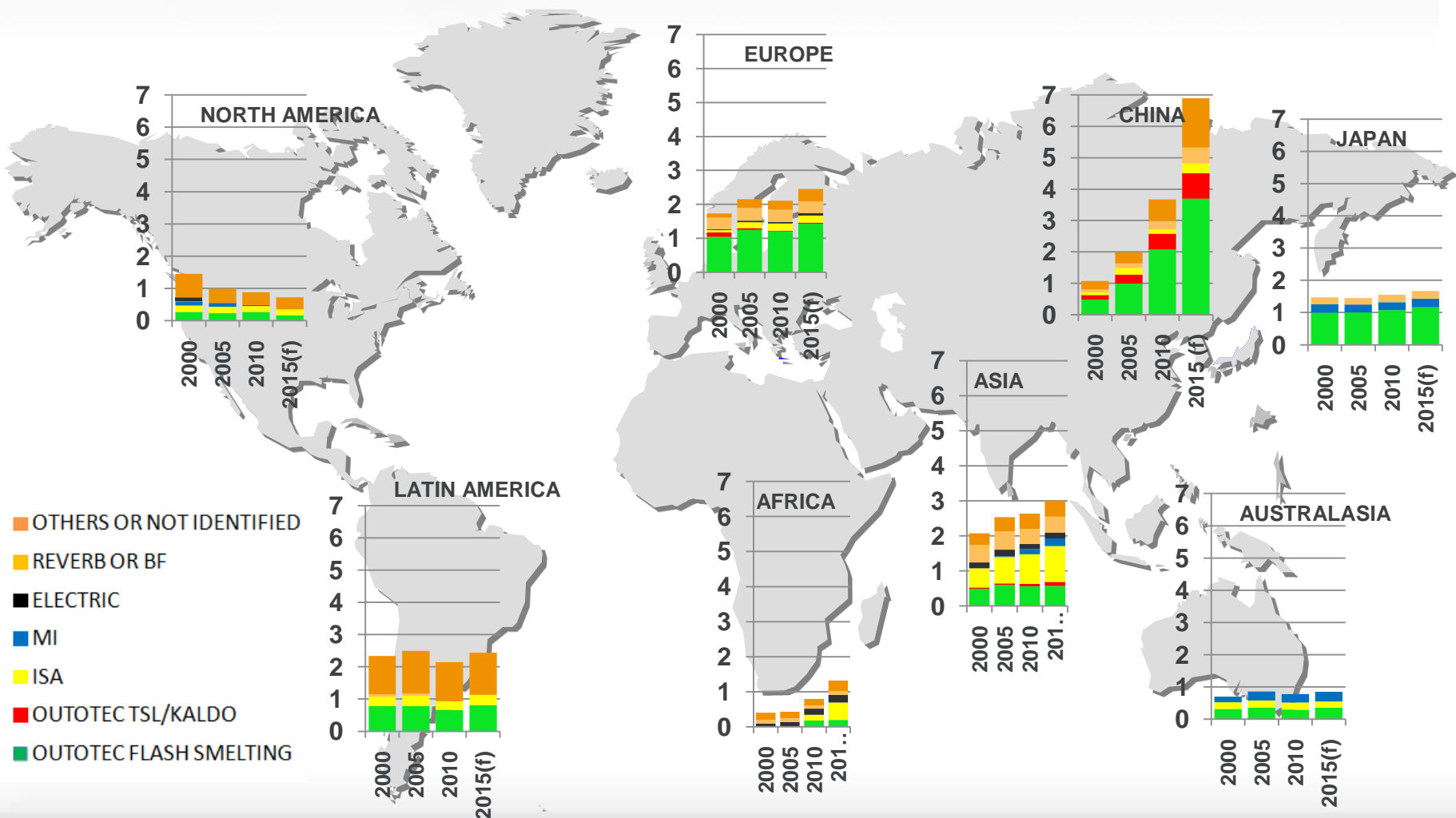
World's largest
pellet plant
(7.5 million tpy)
Samarco; Brazil



Xiangguang Copper highest
environmental award
Chinese Government.

Copper production (million tonnes/a)

Outotec world leading technology provider for copper production



Sources: ICSG Directory Excel tables - February 2013., Brook Hunt Global Copper production Dec. 2012

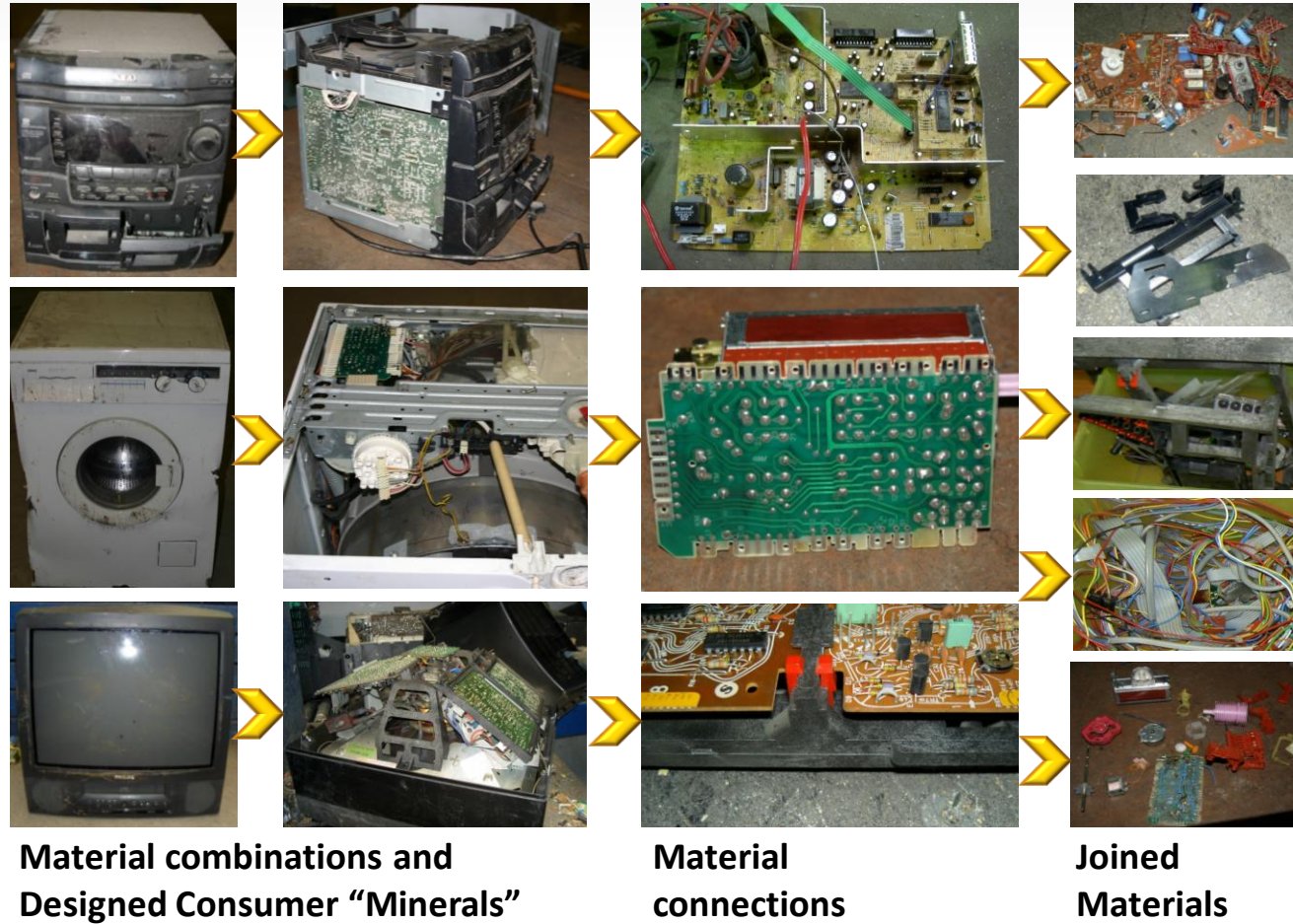
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Geological *vis-à-vis* Urban Mine “Minerals”

“Mineral Centric” from classical mining equivalent to “Product Centric” in Urban Mining



Geological Minerals
Chalcopyrite $CuFeS_2$
and
>15 minors
e.g. Au, Ag, PGMs, Se etc.



Designer “Minerals”

>40 elements complexly linked

Outotec Secondary Smelting Processes

Company	Location	Technology	Feed Capacity
Dowa Mining	Kosaka, Japan	Ausmelt TSL	150,000
Korea Zinc	Onsan, ROK	Ausmelt TSL	70,000
Global Resources & Materials	Danyang, ROK	Ausmelt TSL	120,000



E-Waste and Copper Recycling Dowa TSL (Japan)



Boliden – Rönnskår Smelter Kaldo (Sweden)



Copper Recycling GRM Danyang Smelter TSL (S. Korea)

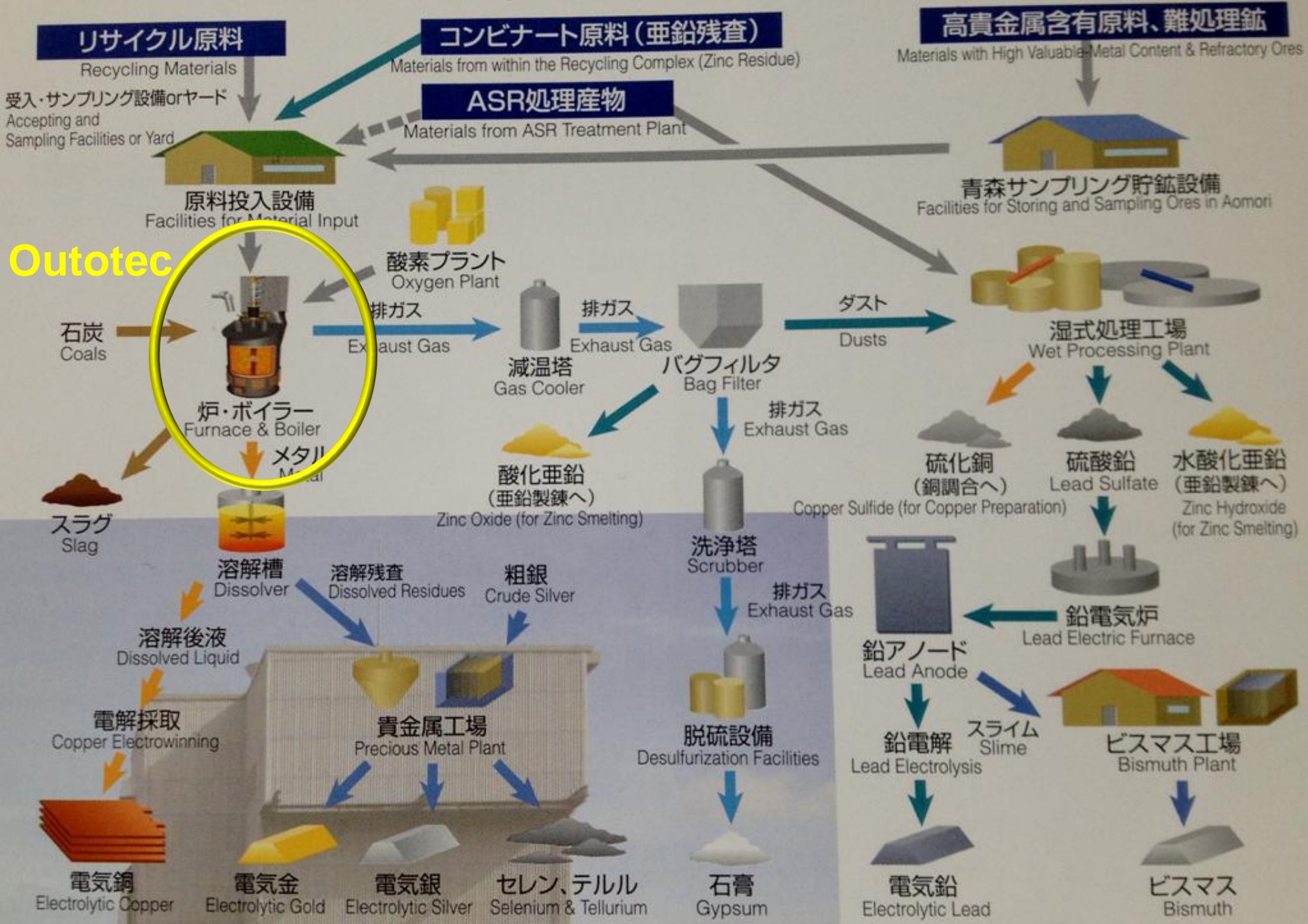


Xiangguang Yanggu Smelter Kaldo (China)



Lead Battery Recycling Recylex TSL (Germany)

複合リサイクル製錬プロセス Smelting Processes for Combined Recycling

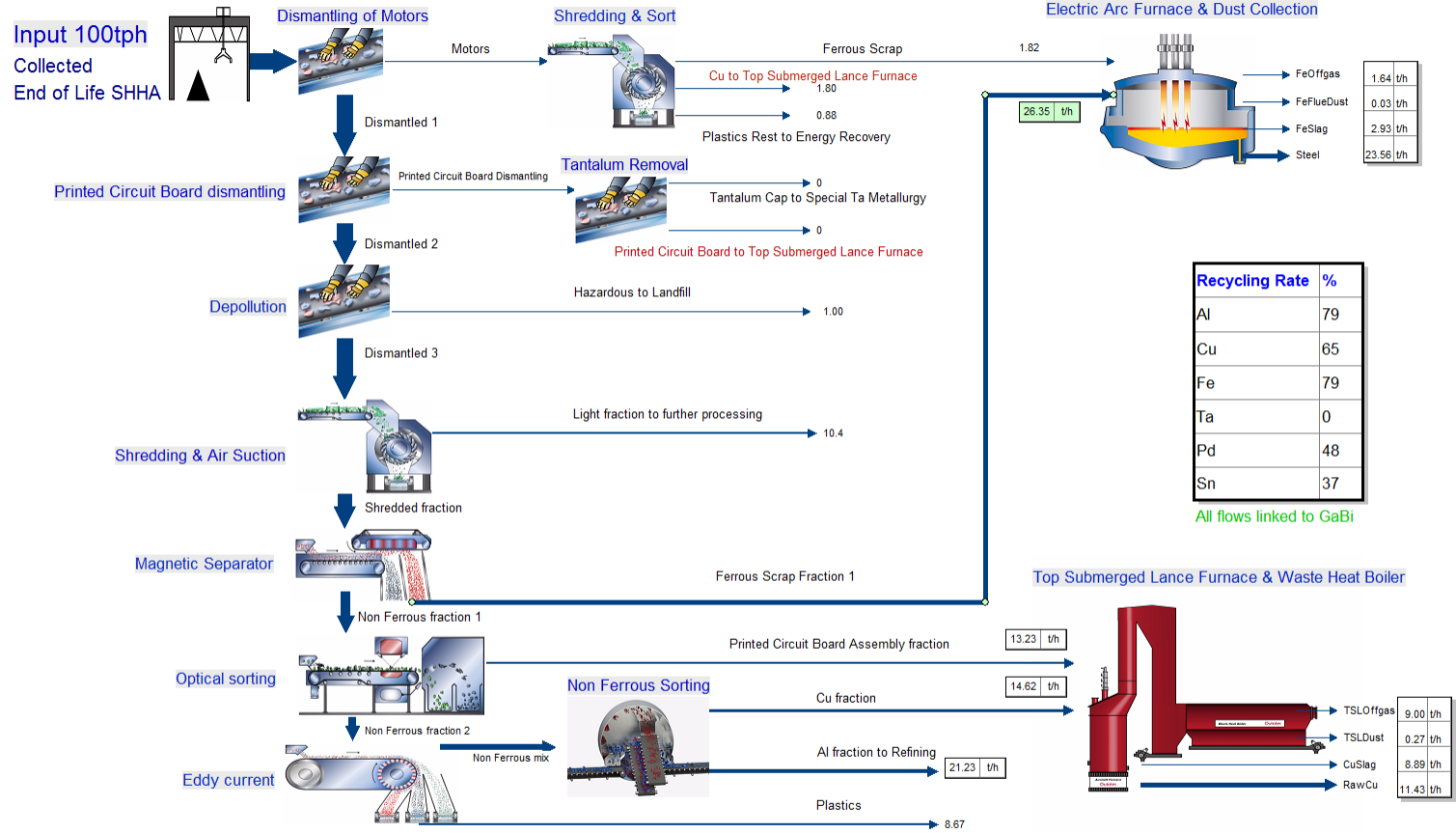


Product Centric - Processing Infrastructure

Sim FlowSheet - C:\HSC7\AAOwn\Recycling\AVS_DFRSeminar_DFRSeminarAugust\Case2b_v2\SHHA_20_8_13 UNEP.fs

Close Tools Copy Rounds: 5 Calculate Select: Variable Element Visualize Help

Recycling of Small Household Appliances (SHHA)



Recycling Rate	%
Al	79
Cu	65
Fe	79
Ta	0
Pd	48
Sn	37

All flows linked to GaBi

To right detailed composition of highlighted stream

STREAM DATA		
Amount	Distribution	Partides
Stream Name: Ferrous Scrap Fraction		
Source	Magnetic Separator	
Destination	Electric Arc Furnace &	
Total solids	26.35	t/h
Water		t/h
Pulp flowrate	26.35	m ³ /h
Pulp volumetr	3.76	m ³ /h
Solids SG	7.00	g/cm ³
Pulp SG	7.00	g/cm ³
%Solids	100.0	(w/w)
Solids Recove	26.35	Rec%
Ag	0.00883	wt%
Al	5.19	wt%
Al2O3	0.191	wt%
As	6.80E-5	wt%
Au	0.00123	wt%
BaO	0	wt%
Be	0.000222	wt%
Bi	0.00101	wt%
Br	0.00126	wt%
C	0.878	wt%
C11H22N2O4	0	wt%
C12H10xCix	0.0628	wt%
C2H3Cl	0	wt%
C3H6	3.85	wt%
C6H10O5	0.0449	wt%
CaO	0.135	wt%
Cd	3.52E-6	wt%
Cl	0.00126	wt%
Co	0.00150	wt%
Cr	0.0629	wt%
Cr2O3	0	wt%
Cu	1.95	wt%
Fe	66.97	wt%
Fe3O4	0	wt%
H	0.00301	wt%
Hg	0	wt%
Mg	0	wt%
MgO	0	wt%
Mn	0.0309	wt%
Mo	0	wt%
Na	0.00150	wt%
Ni	0.125	wt%
O	0.00301	wt%
P	0	wt%
Pb	0.0352	wt%
Pd	0.00118	wt%
Pt	0	wt%
RE	0.00601	wt%
S	0	wt%
Sb	0.00755	wt%
Si	0.138	wt%
SiO2	0.0759	wt%
Sn	0.0643	wt%
StrO	0	wt%
Ta	0.166	wt%
Te	0	wt%
Ti	0	wt%
V	0	wt%
Zn	0.0352	wt%
P80	32.92	mm
P50		mm
LC41	55.86	wt%
LC21	0.591	wt%
LC31	0	wt%
LC41	0.298	wt%
LC51	0	wt%
LC61	0	wt%
LC71	0	wt%

Product Composition + Dismantling & Physical Separation + Metallurgical Recovery = Recyclability Index & Rate

Designer & Functionality Physics, economics & flow sheet controls losses Thermodynamics, technology & Economics Sum of recovery of all elements & materials

Detailed composition all materials Connection and material liberation affect scrap quality Non-linear interactions determine recovery Link to GaBi determines true environmental impact

(c) Reuter & Van Schaik

Outotec understands the metals business

Examples for carrier metal routes

Carrier Metal Steel (Fe)

Steel recycling route

Au
Ag
Pt
Pd
Rh
Cu

Mg
Nb
Mo
Si

Steel, which predominantly consists of iron along with some other alloying elements, is the metal with the largest global volumes and its recycling infrastructure has been established for centuries. Today up to 90% of the steel reaching its end-of-life is recycled. However, other metals which enter the steel recycling route are not recoverable. While in some cases they still contribute to the functionality of the recycled steel as alloying elements (e.g. silicon, molybdenum, niobium, manganese) other elements (e.g. copper or platinum-group metals) are lost and even detrimental to the quality of the recycled product.

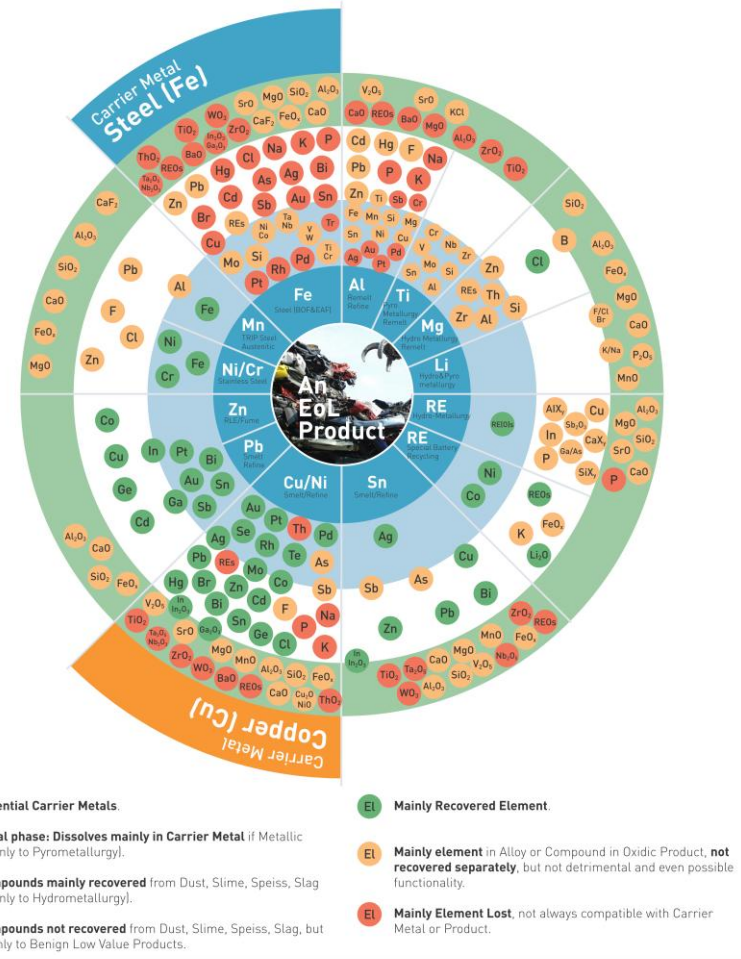
In very specific PM recycling processes iron can serve as a solvent and then be sent to the copper route in which the precious metals are recovered and the small quantity of iron used is lost to slag.

Carrier Metal Copper (Cu)

Copper recycling route

Au
Ag
Pt
Pd
Rh
FeO

The physico-chemical properties of copper make it act as a collector for many precious metals (e.g. gold, silver, platinum, palladium, rhodium) during pyro-metallurgical processing (metallurgical smelting). These metals, e.g. present in printed wiring boards and electronic components, which have high value but in commercial products generally occur in trace quantities only, are concentrated in the copper phase and can subsequently be recovered. Also nickel can be won back this way. Aluminium, rare earths or lithium accumulate as oxides in the slag and are generally not recovered due to the high related effort. Slags are generated in pyro-metallurgical processes in large volumes and today are mainly used as low-grade products e.g. in road construction.



M.A. Reuter et al., "UNEP Metal Recycling: Opportunities, Limits, Infrastructure", United Nations Environmental Programme 2013
<http://www.unep.org/resourcepanel/Publications/MetalRecycling/tabid/106143/Default.aspx>.



Top Submerged Lance (TSL)

TSL Furnace



Furnace

Intense Agitation

The intense mixing promotes rapid reaction kinetics and high specific smelting rates

Chemical and combustion reactions take place in slag layer

Feed System

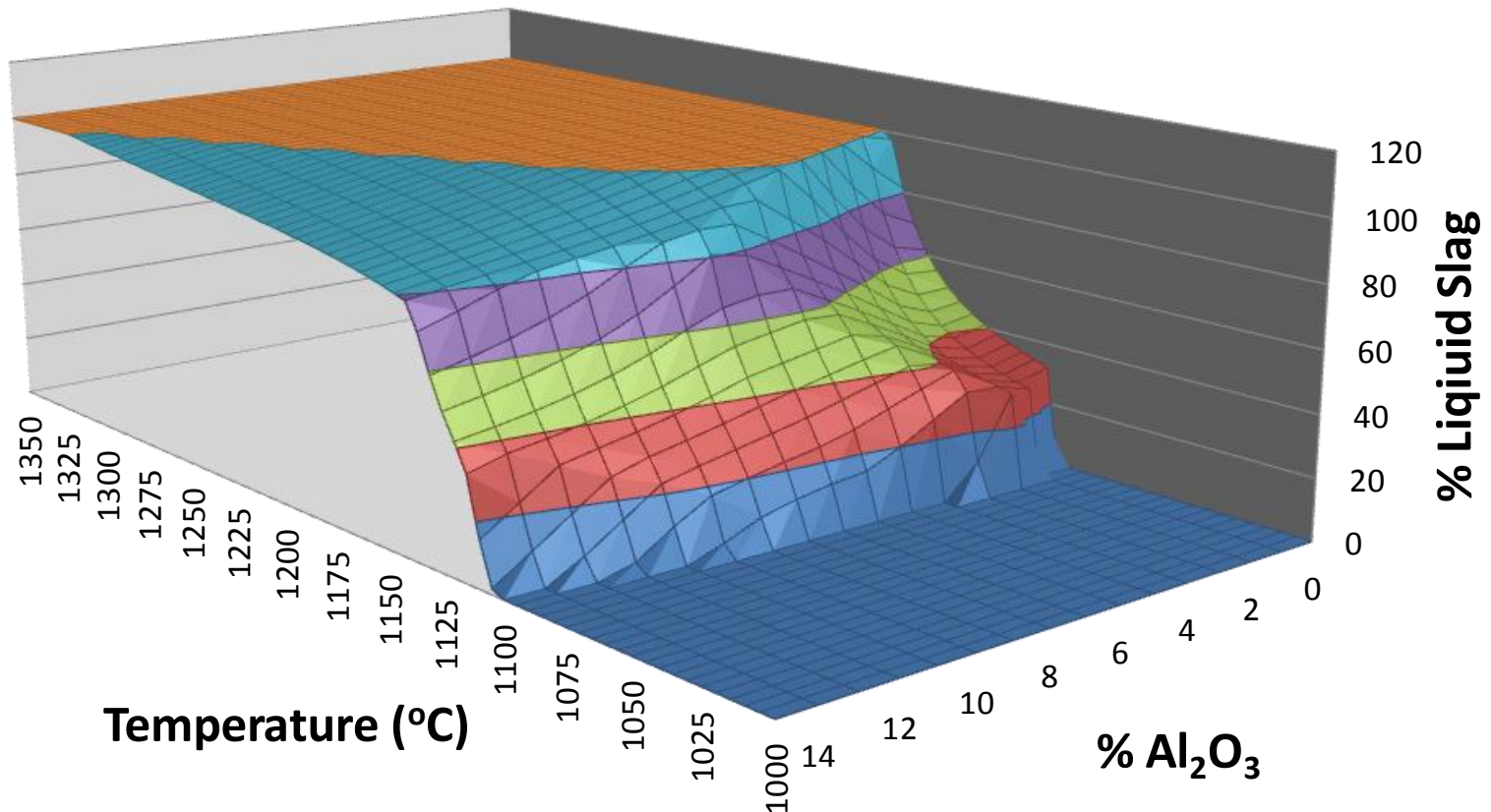
Wet, agglomerated or shredded feed materials can be added directly

Simple feed delivery system

Controlling the Furnace

Controlling the slag...

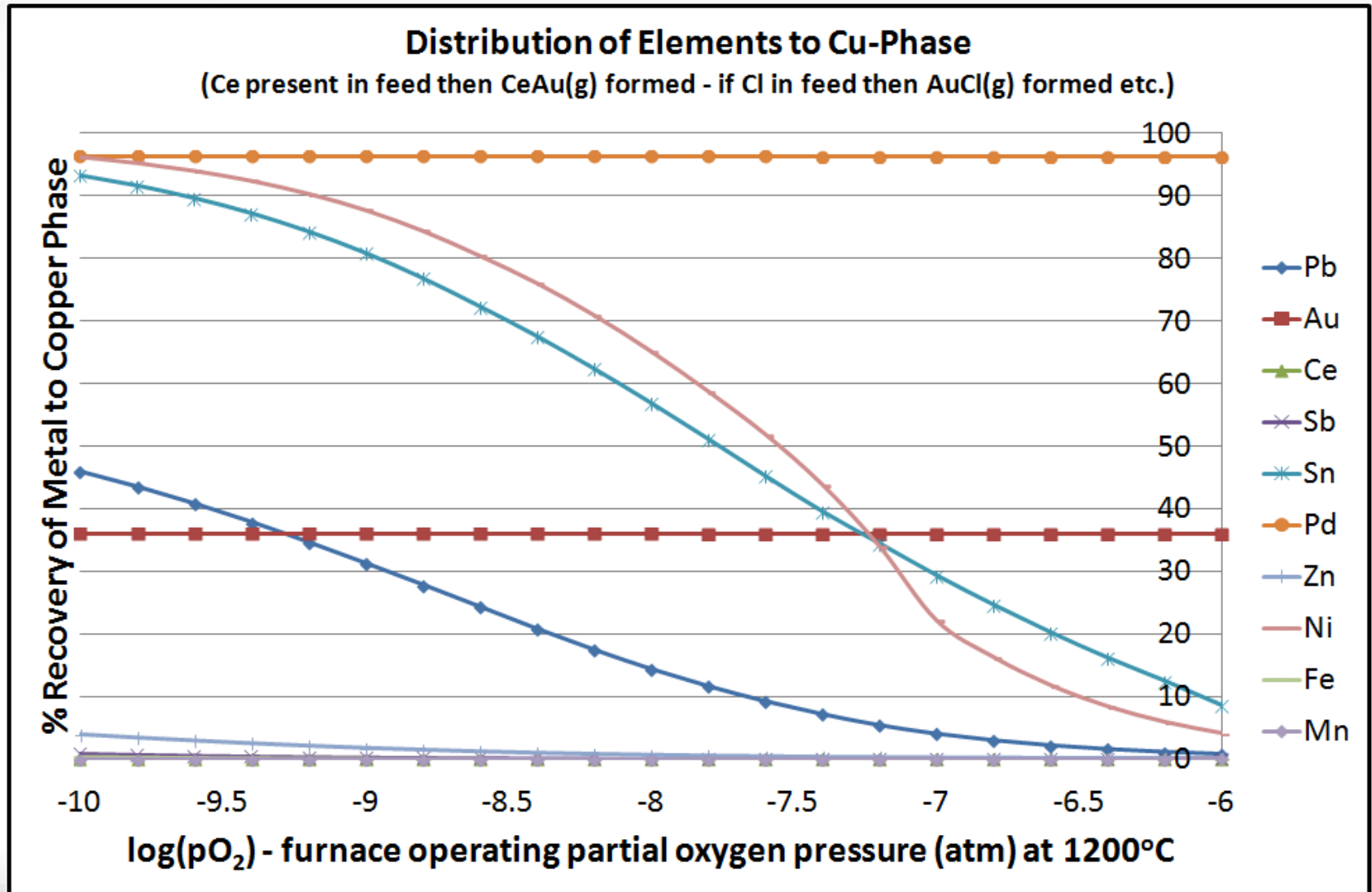
% Slag Liquid: Fe/SiO₂=1.4: %CaO=5: log(pO₂)=-10



FACTSage 6.2/Reuter

Simulation results for 1% & 8% Al on PCB

At 1150, 1200 and 1250°C



Metal Recycling UNEP



Launched April 24th 2013 by UNEP via Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (BMU) in Berlin in the presence of the German Federal Minister of Environment.

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Sustainable use of Earth's natural resources

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