
Pyrolysis

Decentralized Recovery of High-Tech Metals

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May 11th 2016, Nancy

**Fraunhofer Institute
for Environmental, Safety
and Energy Technology
UMSICHT**

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AGENDA

1. **gagendta⁺**
Aim & Concept
First Results



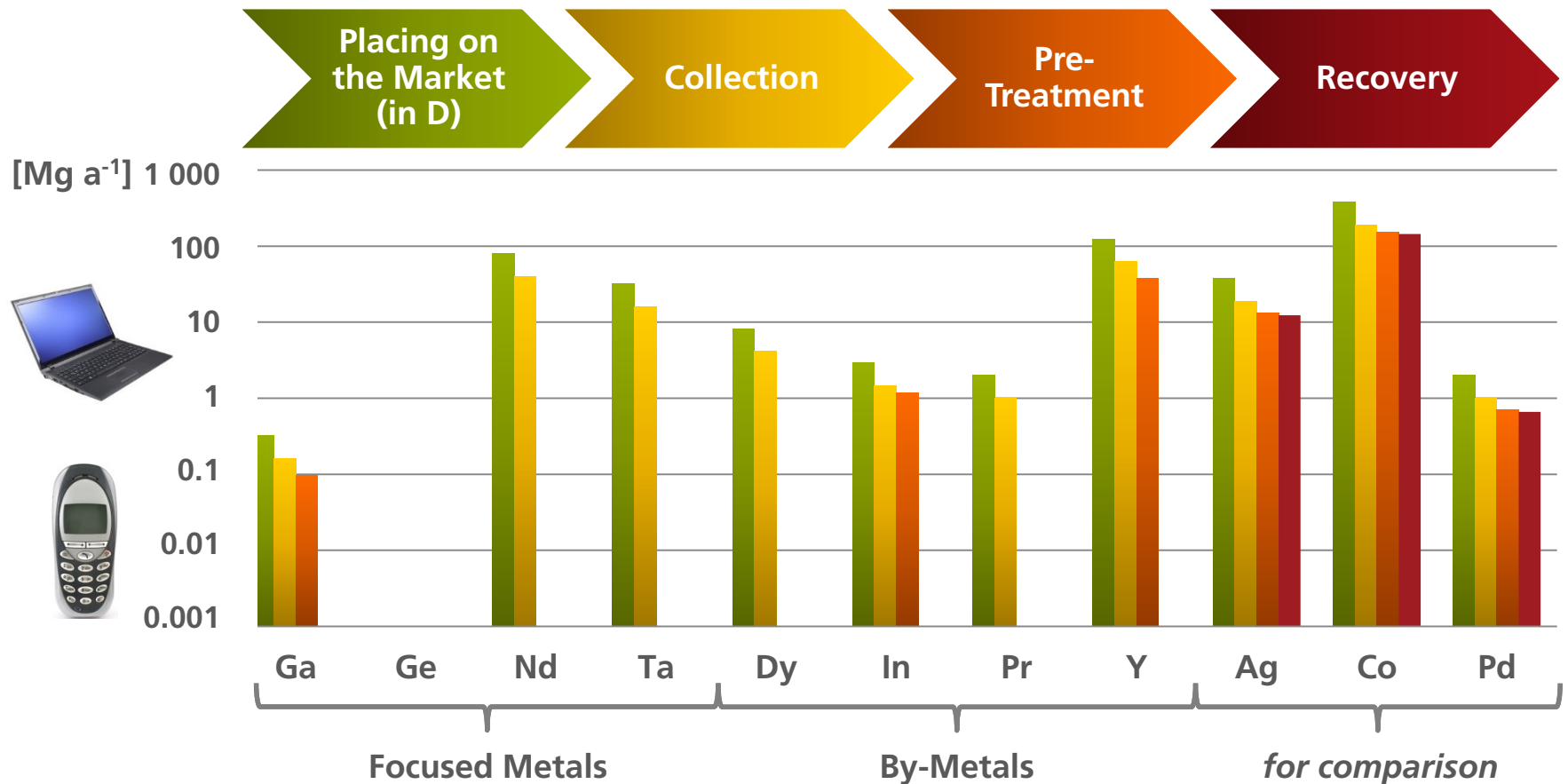
2. **Treatment of Shredder Residues from WEEE**
Technique
Ecological Assessment



3. **Conclusions & Outlook**

gagendta⁺ – Decentralized Treatment of WEEE

Focused Fractions & Status Quo

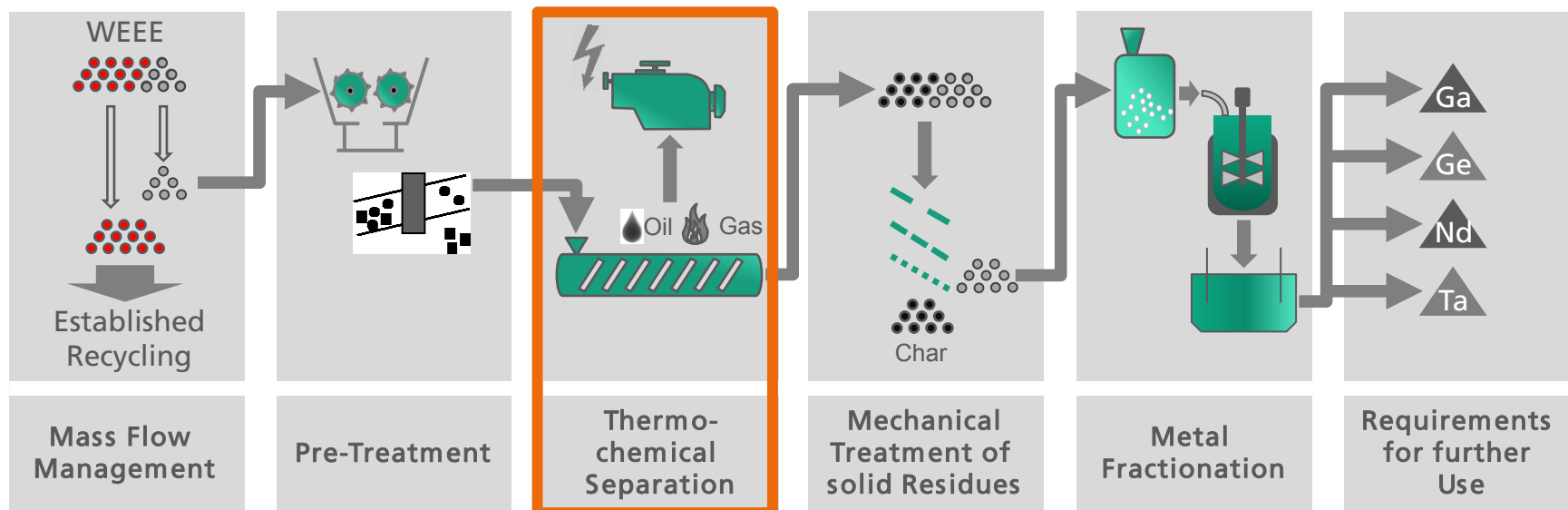


Basis: German Collection Group 3 (IT-Equipment)

References: Sander et al. 2012; Buchert et al. 2012

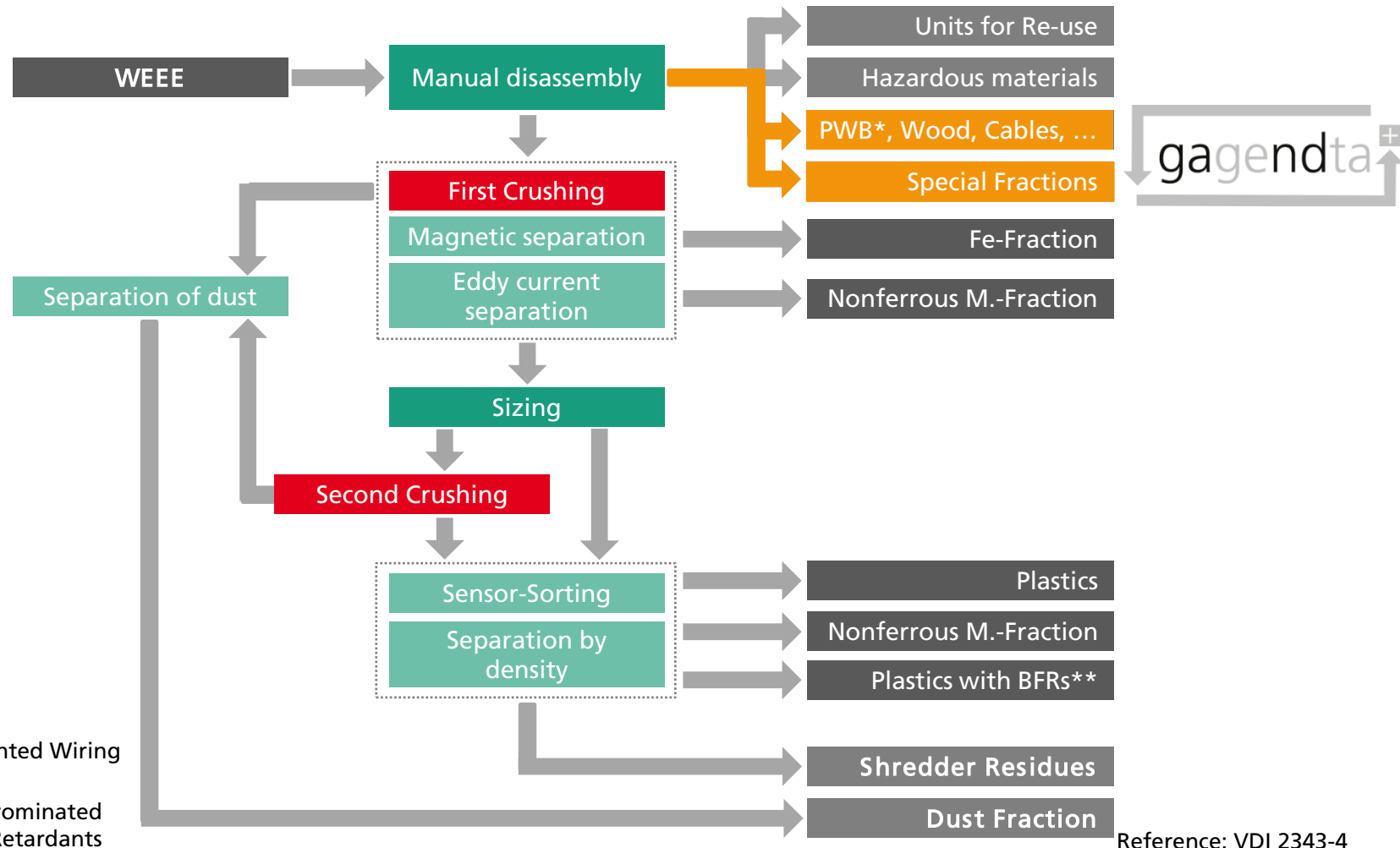
gagendta⁺ – Decentralized Treatment of WEEE

Process Chain – Recovery of Critical Metals



gagendta⁺ – Decentralized Treatment of WEEE

Mechan. Treatment – Example: IT-Equipment



* PWB: Printed Wiring Boards

** BFRs: Brominated Flame Retardants

Reference: VDI 2343-4

gagendta⁺ – Decentralized Treatment of WEEE Focused Fractions



Examples of „Special Fractions“ containing Critical Metals

■ Printed Wiring Boards

■ Capacitors

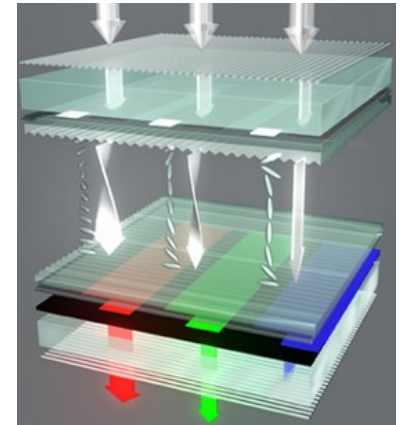
Ta



■ LC-Displays

■ ITO-Layer

In, (Ga)



■ LED

■ LED-Chip

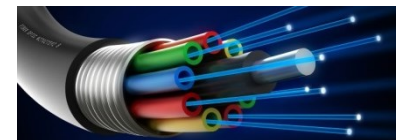
Ga, (In)



■ Glass Fiber Cables

■ Optical Waveguide

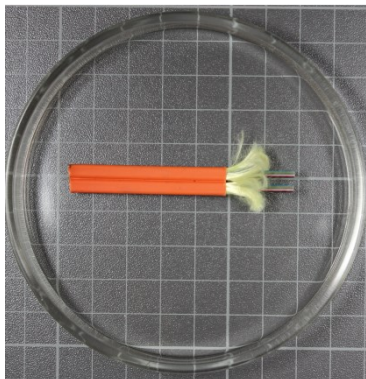
Ge



References: European Commission 2014; Merck 2004; Pixelio; Suehring 2016

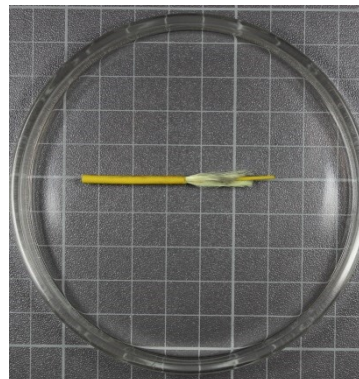
gagendta⁺ – Decentralized Treatment of WEEE

First results: Glass Fiber Cables



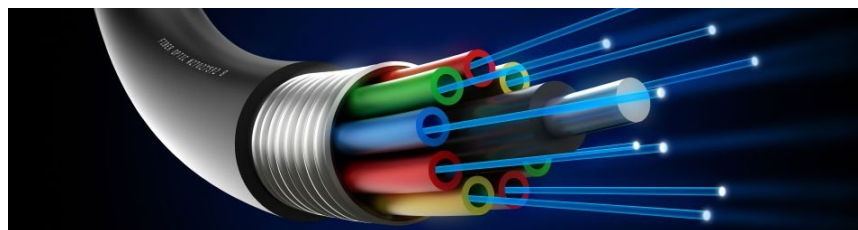
In-House Line
Orange

■ Ge:	0,41 %
■ Mg:	9,7 %
■ Br:	0,01 %
■ Cl:	0,13 %



Overhead Line
Yellow

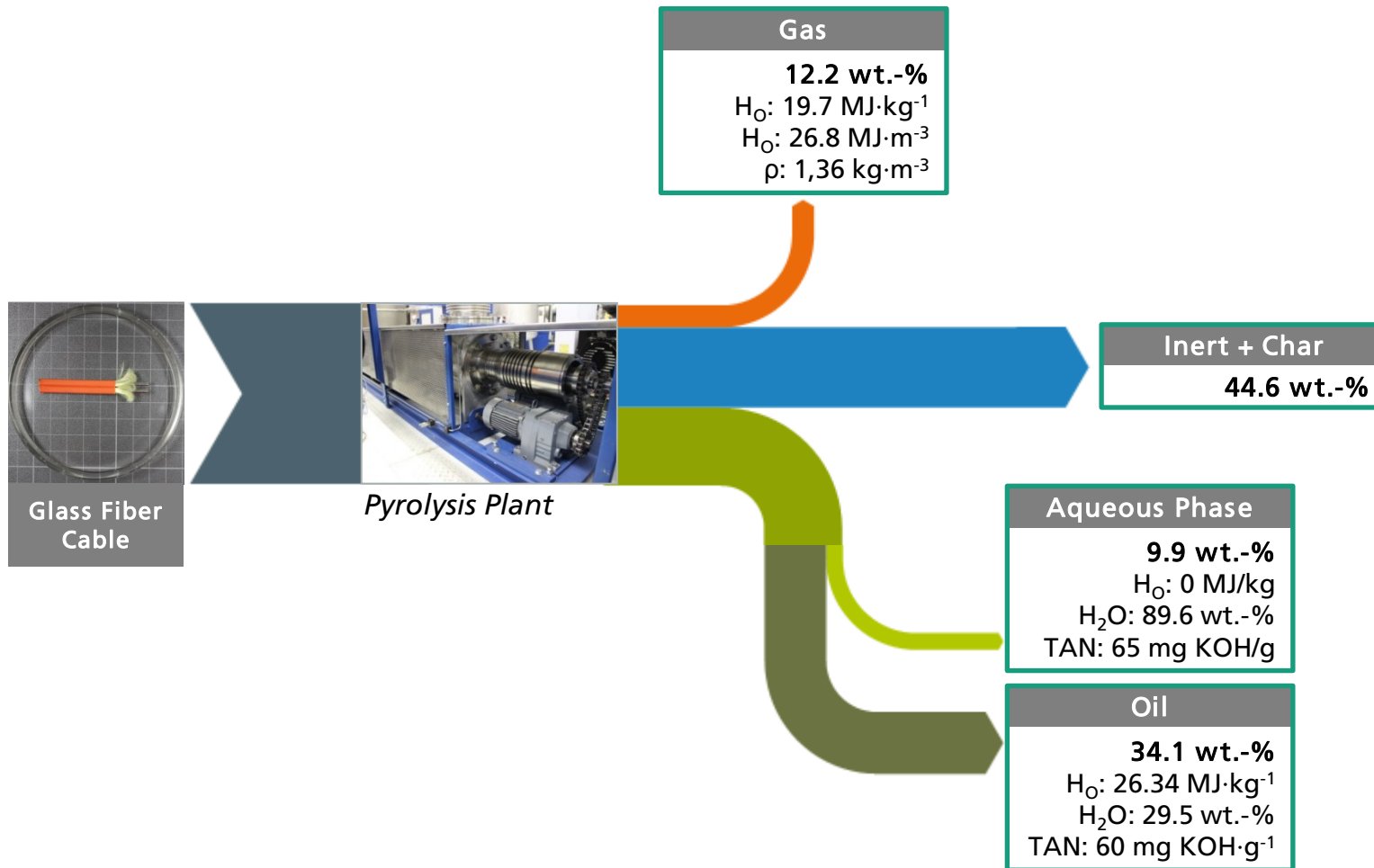
■ Ge:	0,0012 %
■ Mg:	9,4 %
■ Br:	0,001 %
■ Cl:	0,07 %



Picture Source: Suehring 2016

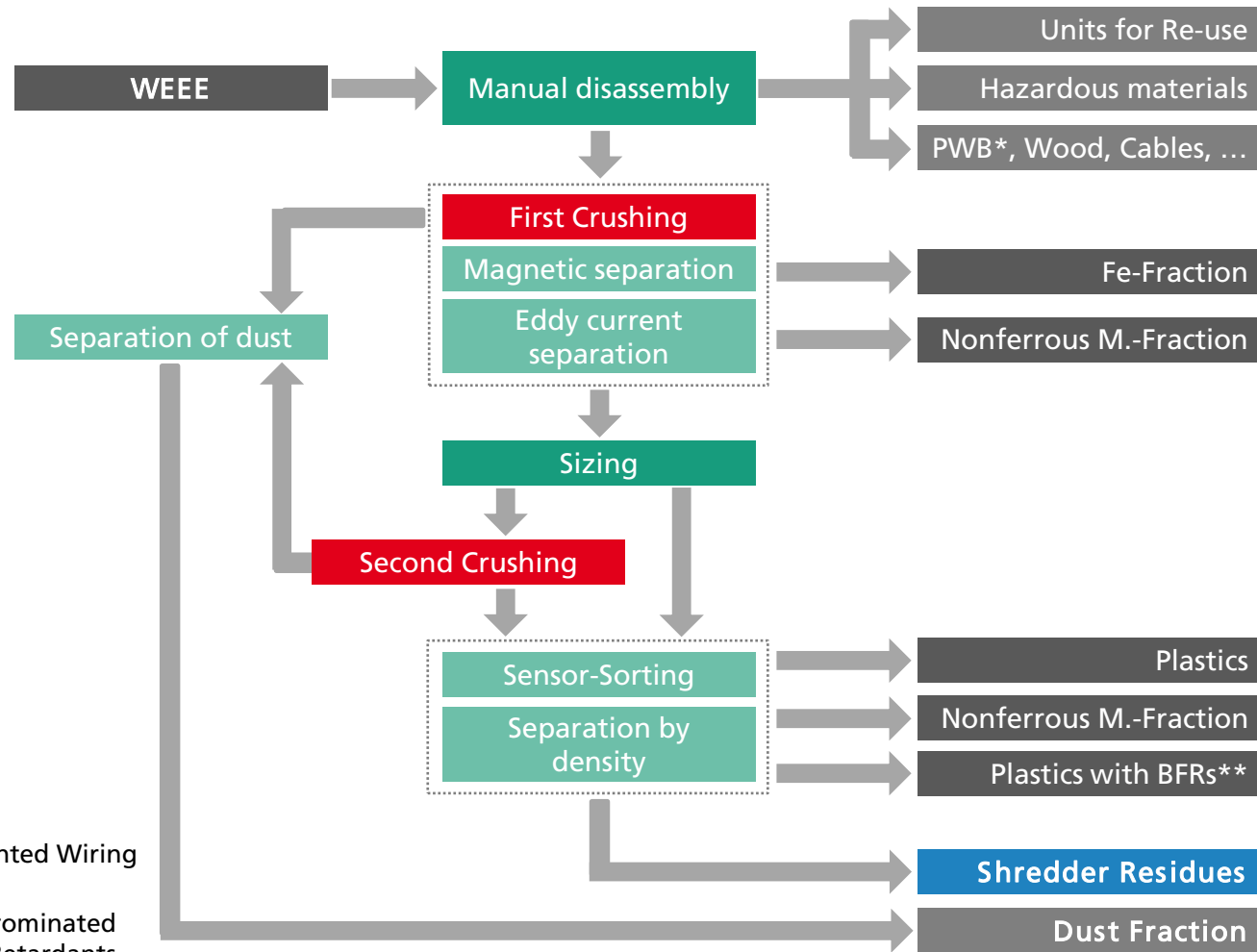
gagendta⁺ – Decentralized Treatment of WEEE

First results: Glass Fiber Cables



Treatment of WEEE

Mechanical Treatment – Example: IT-Equipment



* PWB: Printed Wiring Boards

** BFRs: Brominated Flame Retardants



Reference: VDI 2343-4

Treatment of WEEE

Shredder Residues: Status Quo of Treatment

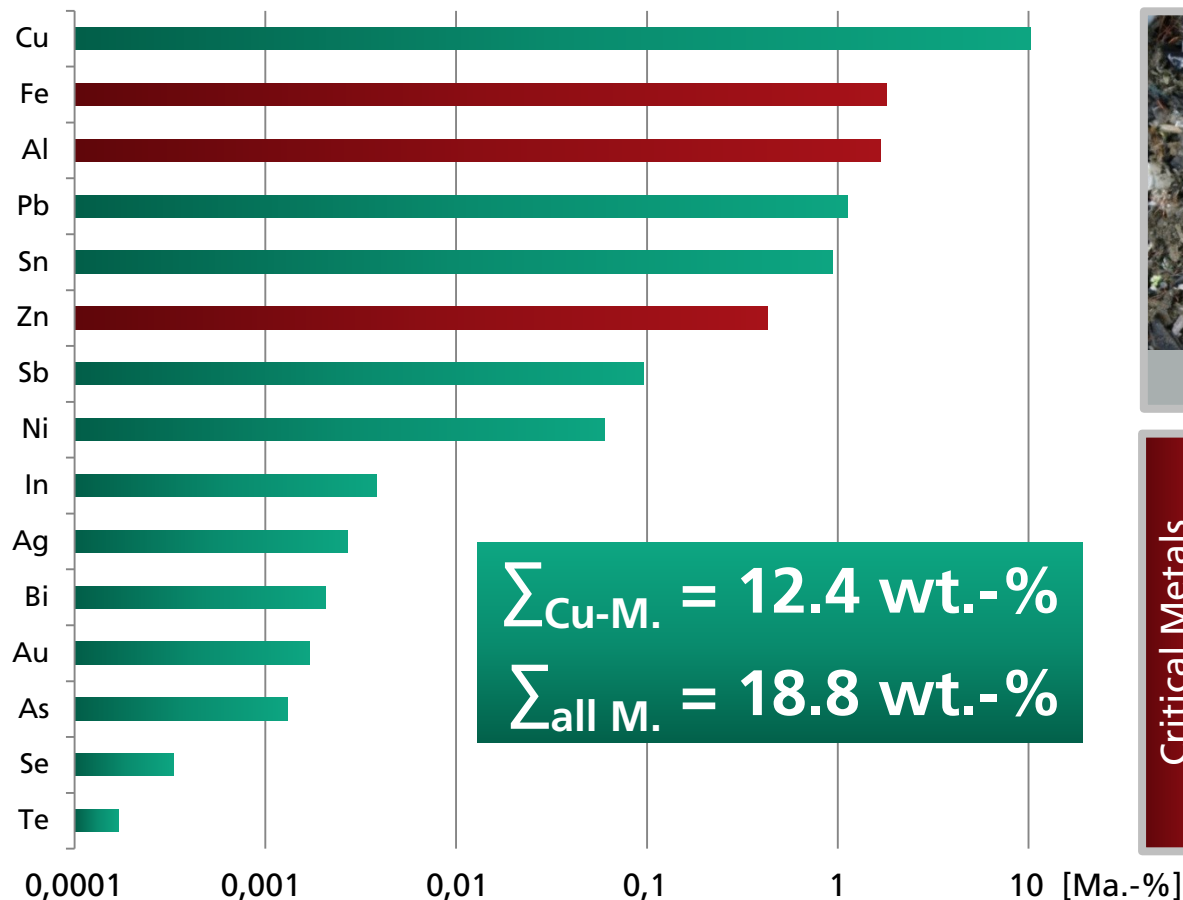
- Output from WEEE Treatment: Approx. 22 % ^[1]
 - D: 146 300 Mg·a⁻¹ EU: 701 700 Mg·a⁻¹ ^[2]
- Complex mechanical Treatment
 - <4 mm: 87 wt.-% <5 mm: 96 wt.-%
- Limited Input in Copper Smelters ^[3]
 - Max. about 76 800 Mg·a⁻¹ or 10.9 wt.-% (EU) ^[4,5,6]
- Status Quo: Thermal Utilization in MWI
 - Marginal Metal Recovery (87 wt.-% <2 mm), small Energy Efficiency
- Significant Amount of Critical Metals
- Partly high loads of Br and Cl



References: ¹Kramer 2013; ²Eurostat 2016; ³Brusselaers et al. 2006; ⁴Aurubis 2015; ⁵Boliden 2016; ⁶EUWID 2013

Treatment of WEEE

Shredder Residues: Content of Metals

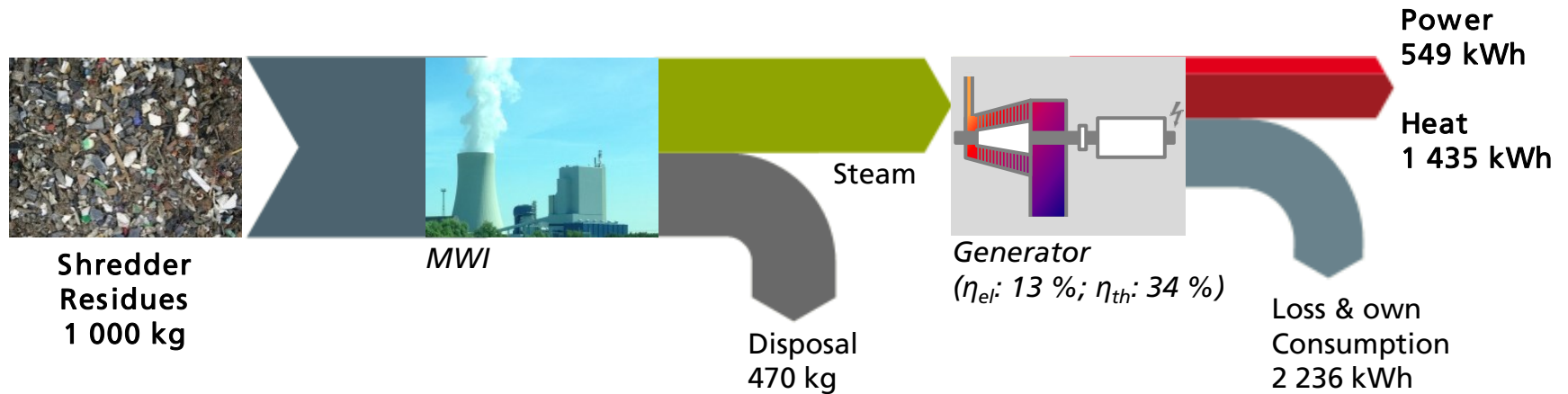


WEEE Shredder Residue

Critical Metals (per kg)	23 mg	Praseodymium
	98 mg	Neodymium
	102 mg	Lanthanum
	130 mg	Cobalt
	133 mg	Gallium
	954 mg	Antimony
	4 g	Magnesium

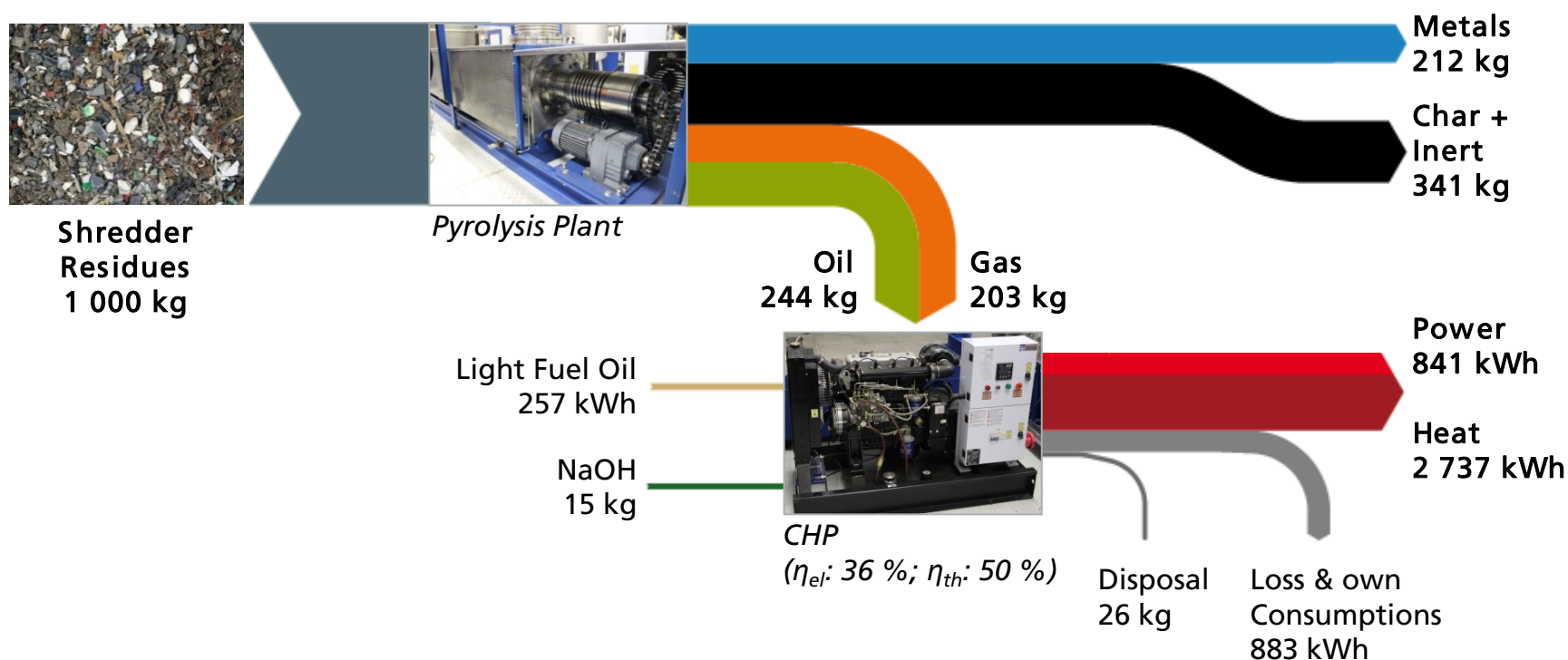
Treatment of WEEE

Shredder Residues: Combustion in MWI (Status Quo)



Application Scenario for Pyrolysis

Recycling via Pyrolysis Plant: Process Overview



Application Scenario for Pyrolysis

Recycling via Pyrolysis Plant: Product Quality



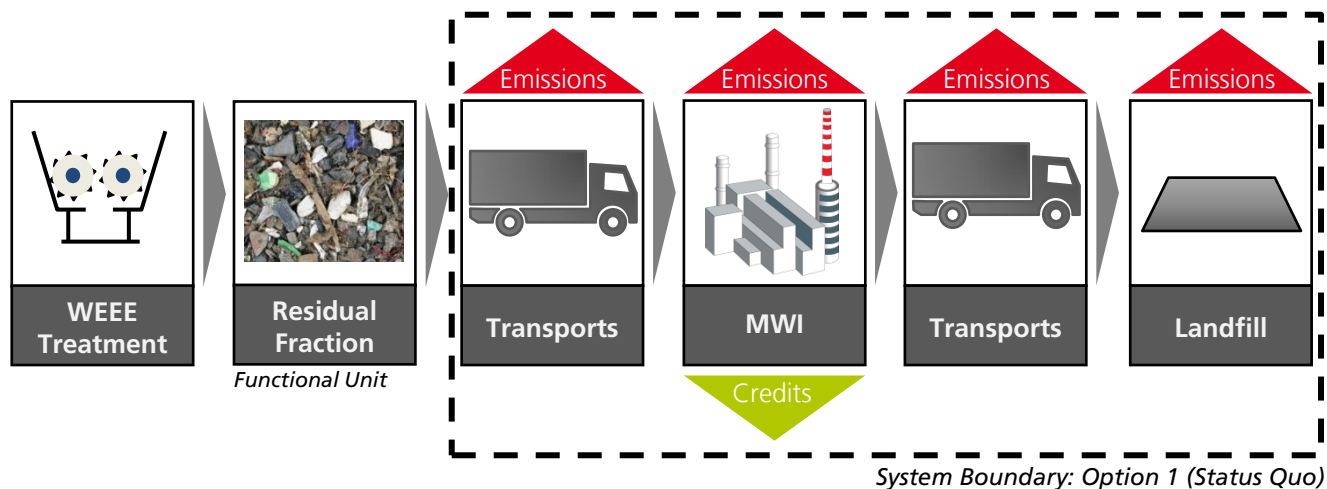
Char & Metals			Oil			Gas		
Cl:	0.81	wt.-%	H _o :	38.0	MJ·kg ⁻¹	H _o :	32.3	MJ·kg ⁻¹
Br:	0.46	wt.-%	H ₂ O:	1.9	wt.-%	H _o :	41.0	MJ·m ⁻³
Σ PCDD/Fs < GGVSEB*			ρ:	0.948	g·cm ⁻³	ρ:	1.27	kg·m ⁻³
Σ PBDD/Fs < GGVSEB*			v:	1.159	mm ² ·s ⁻¹			

* GGVSEB: German Dangerous Goods Regulation for domestic and transboundary Transports

Picture Source Gas: PSC Wisconsin

Application Scenario for Pyrolysis

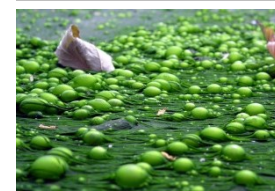
Ecological Evaluation / LCA



GHG-Emissions



Acidification



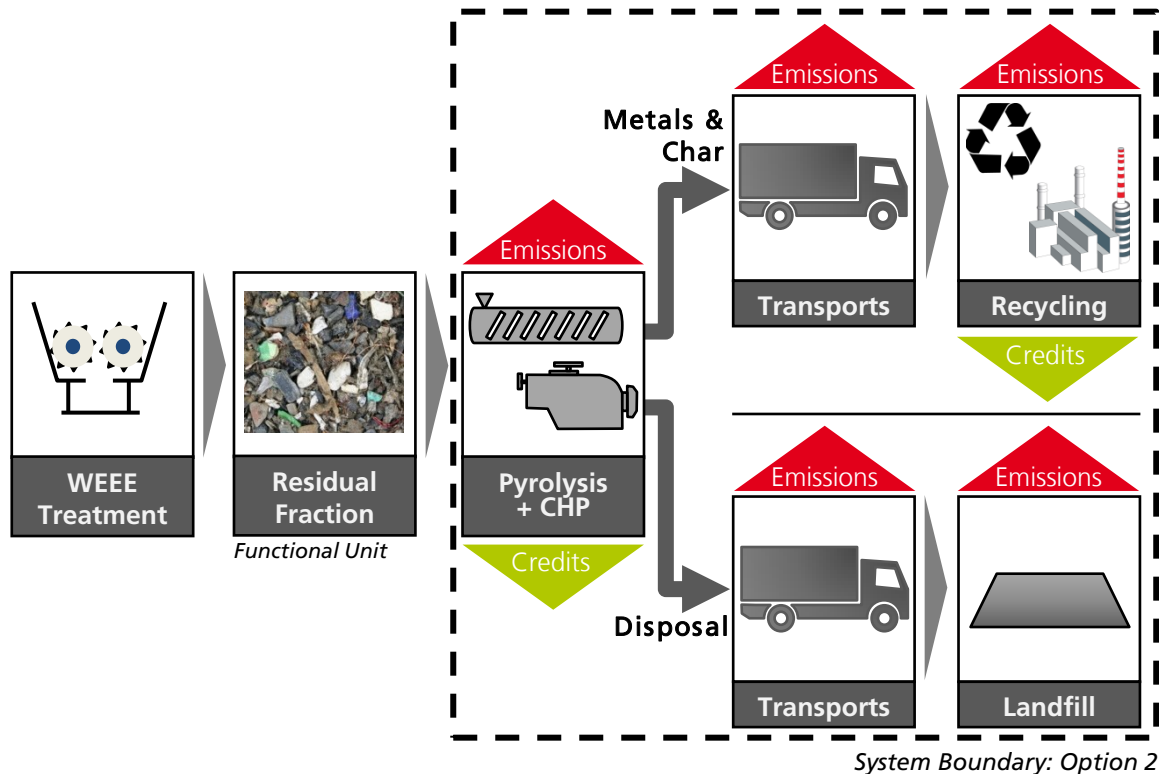
Eutrophication



Resource Depletion

Application Scenario for Pyrolysis

Ecological Evaluation / LCA



GHG-Emissions



Acidification



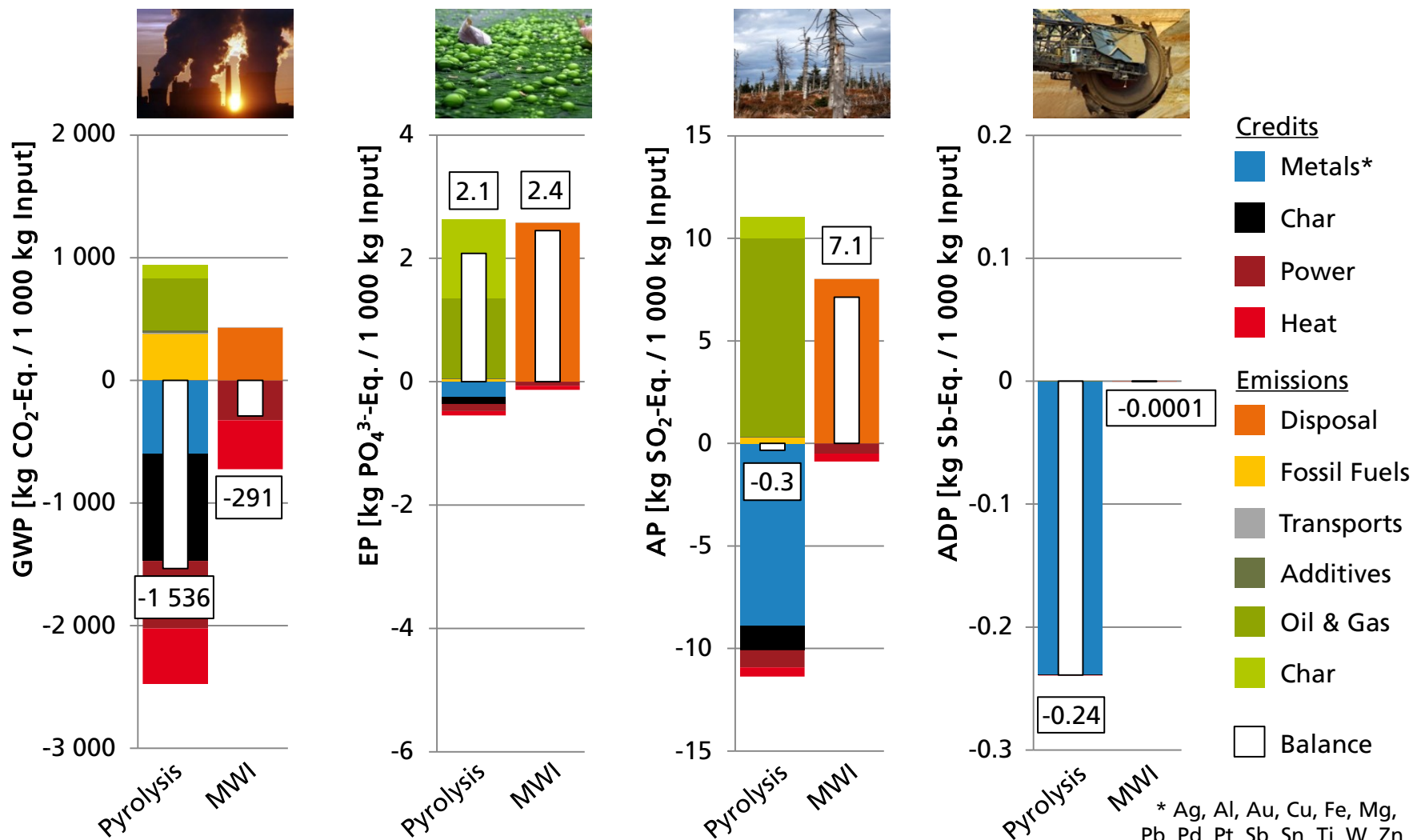
Eutrophication



Resource Depletion

Application Scenario for Pyrolysis

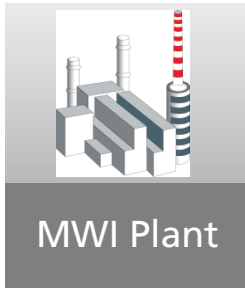
Life Cycle Impact Assessment



The Analysis are forward-looking and based upon the current expectations, estimates and projections; are not guarantees of future performance; and are subject to certain risk, uncertainties and other factors, many of which are beyond Fraunhofer UMSICHT control.

Conclusions

Comparison between Status Quo and Pyrolysis



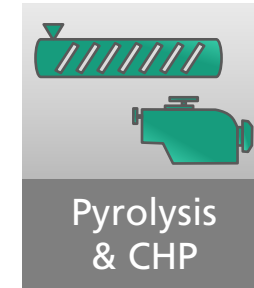
Centralized Process

Oxidation of Metals

Bottom Ash Vitrification

No Recovery of Metals <2 mm

Costs



Decentralized Process (on-site)

No Oxidation of Metals

Brittle Char

Pre-Treatment for Recycling

Ecological & Economical Benefits

FRAUNHOFER UMSICHT

Institute Branch Sulzbach-Rosenberg

Thank you very much
for your kind Attention!



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