# Pyrolysis – as an innovative Technology to increase Metal-Recycling from WEEE

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UMSICHT

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# Thermochemical Treatment – Feedstocks

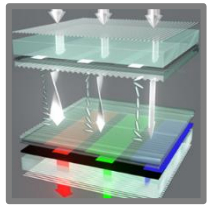
## Critical Metals and Residual Fractions in the Focus

### Selected Components with Critical Metals

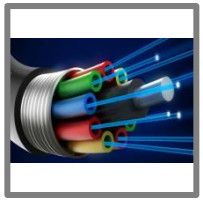
- Printed Wiring Boards
  - Ta, Nd, Ag

- LED
  - Ga

- LC-Displays
  - In, Sn



- Glass Fiber Cables
  - Ge





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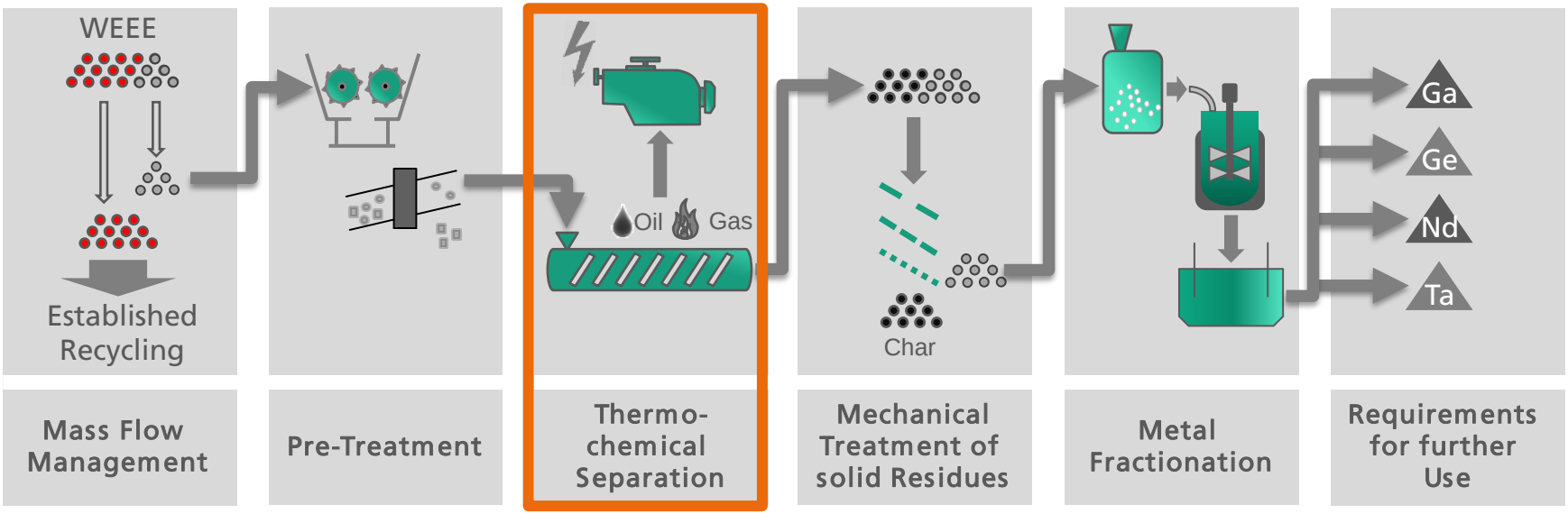
# Recovery of Critical Metals from WEEE

## gagendta+

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ALBA Wir nennen es Rohstoff.
INNOVA RECYCLING
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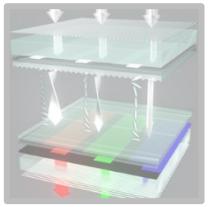

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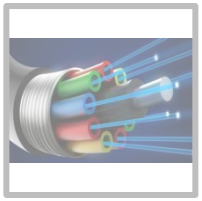

### Residual Fractions from WEEE Treatment

- Shredder-Residues

- Plastics with Flame Retardants

- Dust



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# Treatment of WEEE

## Manual & Mechanical Treatment

**Manual Disassembly**

- Pollution Elimination
- „Cherry Picking“

**Coarse Sorting**

- Magnetic Separation
- Eddy Current Separation

**Fine Sorting**

- Sensor Sorting
- Separation by Density

**20-25 % Shredder Residues**

References: VDI 2343; Kramer 2013



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# Shredder Residues from WEEE

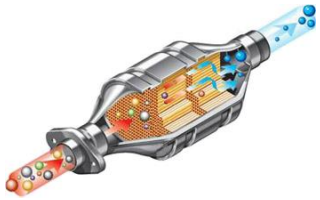
## Potential in Germany

359.000 km
Cable (3x1.5mm²)


7.929.000 €[1]

World Demand for LED
of 6.8 Years[2]

2.5 Mio.
TV[2]



1.5 Mio.
Car-Catalysts[3,4]

**17,000 Mg**

**Copper**

**220 kg**


**Gold**

**16.7 Mg**

**Gallium**

**4.9 Mg**


**Indium**

**1.1 Mg**


**Palladium**

References: [1]scheideanstalt.de; [2]Buchert et al. 2012; [3]Hagelüken et al. 2005; [4]Monolithos 2015



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# Shredder Residues from WEEE
## Status Quo of Treatment

Target

**Integrated Copper Smelters**

- ✓ Recycling of up to 17 Metals
- ✓ Recycling Rates >95 %
- ✗ No Recycling of Al and many critical Metals (Ge, Ta, REE, …)
- ✗ Limited Input Amounts[1] (<10 % of EU Amounts)[2,3,4,5]

Status Quo

**Thermal Treatment (MWI)**

- ✓ "Production" of Power & Heat
- ✓ Recovery of Fe, Al, Cu (>2 mm)
- ✗ No Recovery of Metals <2 mm (87 %)
- ✗ Oxidation of Metals
- ✗ High Costs (>100 €/t)

References: [1]Brusselaers et al. 2006; [2]Eurostat 2016; [3]Kawohl 2011; [4]Boliden 2016; [5]Katz 2013



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# Shredder Residues from WEEE
## Enabling Metal Recycling – Challenges

Shredder Residues from WEEE

Challenges

- Accumulation of Metals
- Reduction of Heating Value
- Transportable Products

- Added Value

Integrated Copper Smelters



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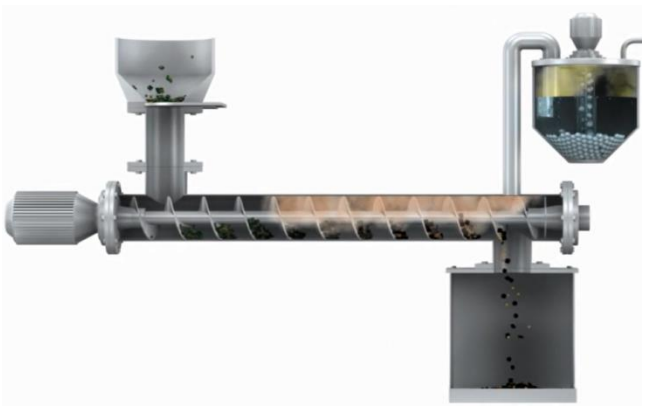
# Shredder Residues from WEEE

## Enabling Metal Recycling by Pyrolysis Treatment

Shredder Residues from WEEE



Thermo-chemical Process

Integrated Copper Smelters

- Accumulation of Metals in a solid Product
- Decomposition of Plastics
- Formation of high-heating by-products
- Flexible Scalability
- Profitable and innovative Solution



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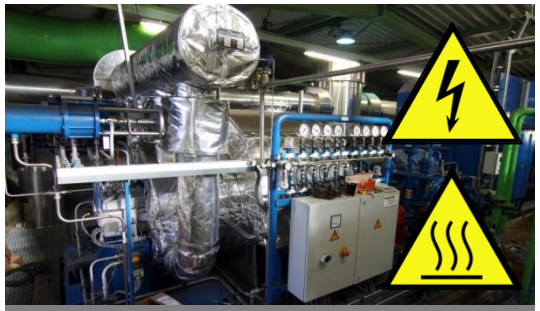
# Shredder Residues from WEEE

## Recycling @ Fraunhofer UMSICHT

Thermo-chemical Process


Pyrolysis Oil & Gas

Pyrometallurgical Recycling



Energetical Utilization



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# Shredder Residues from WEEE

## Application Scenario I: Recovery of Metals

Feedstock
1,000 kg

Combustion
& Heat Recovery*
2,381 kWh

*Pyrolysis*

Solid Product
553 kg

**Required Heat*
*➔ 26.5 % of Feedstock*



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# Shredder Residues from WEEE

## Application Scenario II: Recovery of Metals & Energy

Feedstock
1,000 kg

Syngas
269 kg

*Pyrolysis*

Oil
132 kg

CHP
1,687 kWh
2,576 kWh

Solid Product
553 kg

*including PP and Auxiliary Energy (1,001 kWh Natural Gas + 5.6 kg Heating Oil)



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# Shredder Residues from WEEE

## Application Scenario: Product Quality


| Solid Product | | | Oil | | | Gas | | |
|---|---|---|---|---|---|---|---|---|
| Cl: | 0.81 | wt.-% | $H_o$: | 37.7 | MJ/kg | $H_o$: | 28.5 | MJ/kg |
| Br: | 0.46 | wt.-% | $H_2O$: | 1.2 | wt.-% | $H_o$: | 35.7 | $MJ/m^3$ |
| ∑ PCDD/Fs < GGVSEB* | | | ρ: | 0.948 | $g/cm^3$ | ρ: | 1.27 | $kg/m^3$ |
| ∑ PBDD/Fs < GGVSEB* | | | v: | 1.159 | $mm^2/s$ | | | |

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

Picture Source Gas: PSC Wisconsin



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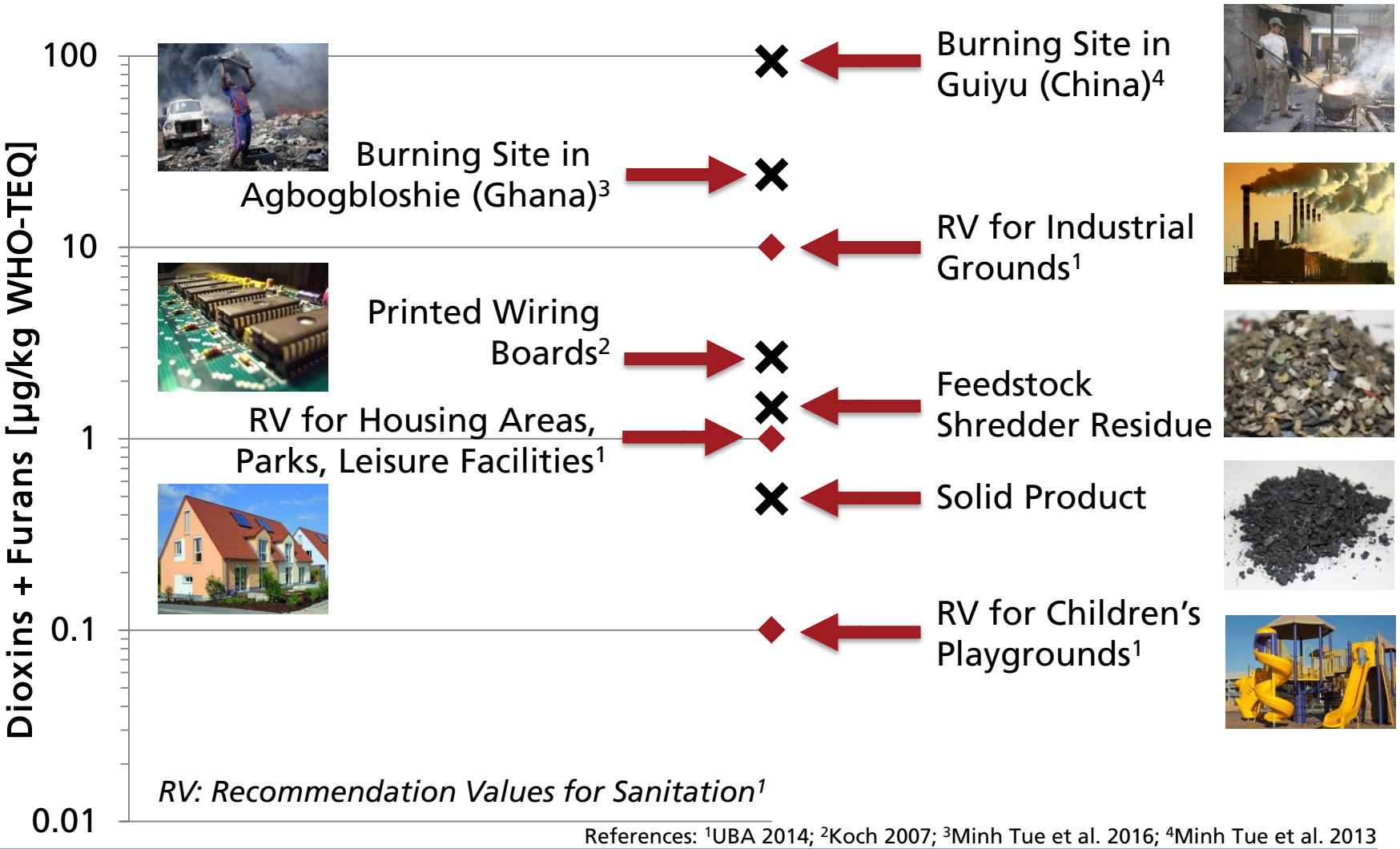
# Shredder Residues from WEEE

## Application Scenario: Product Quality




References: [1]UBA 2014; [2]Koch 2007; [3]Minh Tue et al. 2016; [4]Minh Tue et al. 2013



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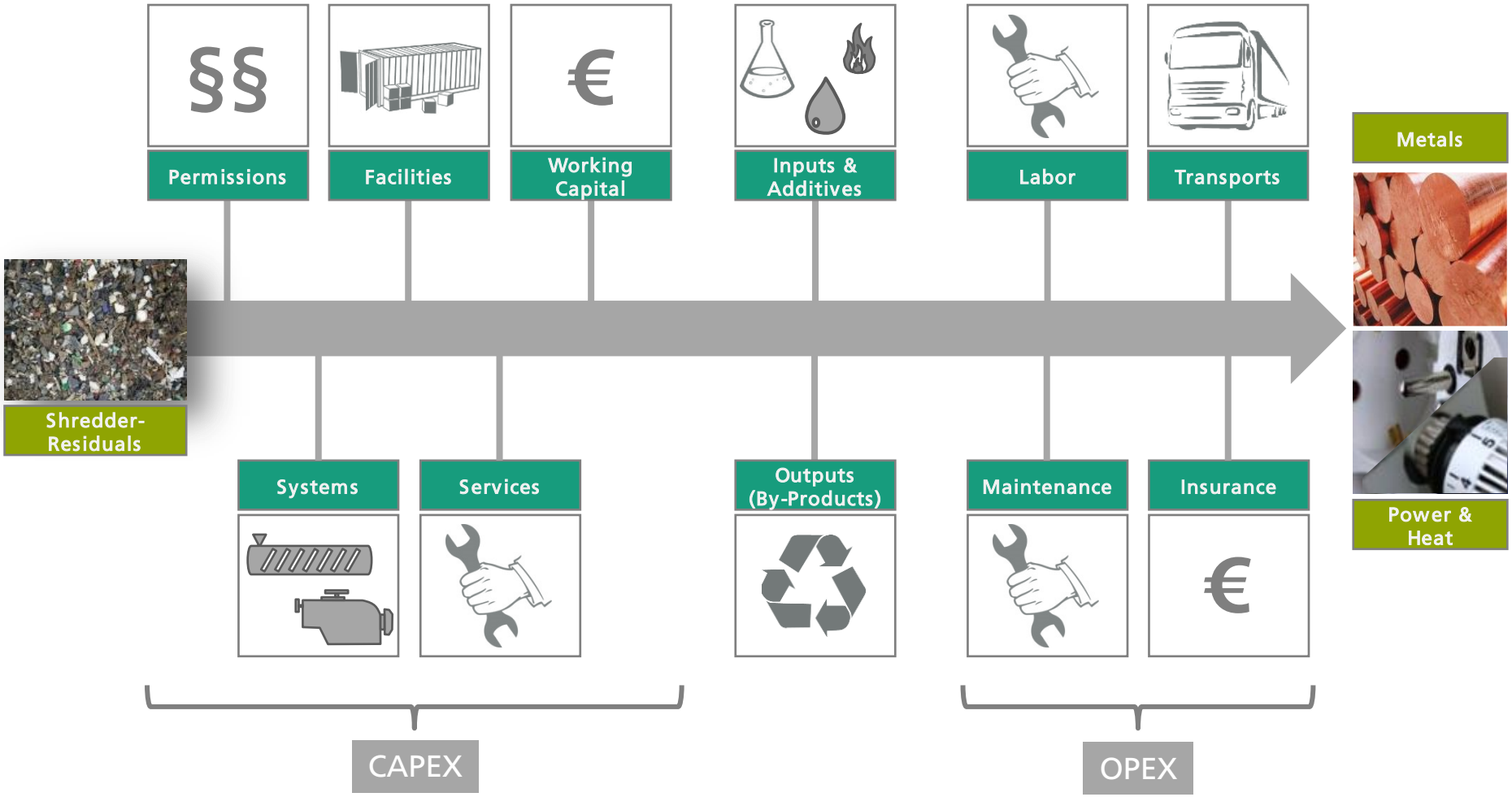
# Shredder Residues from WEEE

## Application Scenario: Economical Evaluation



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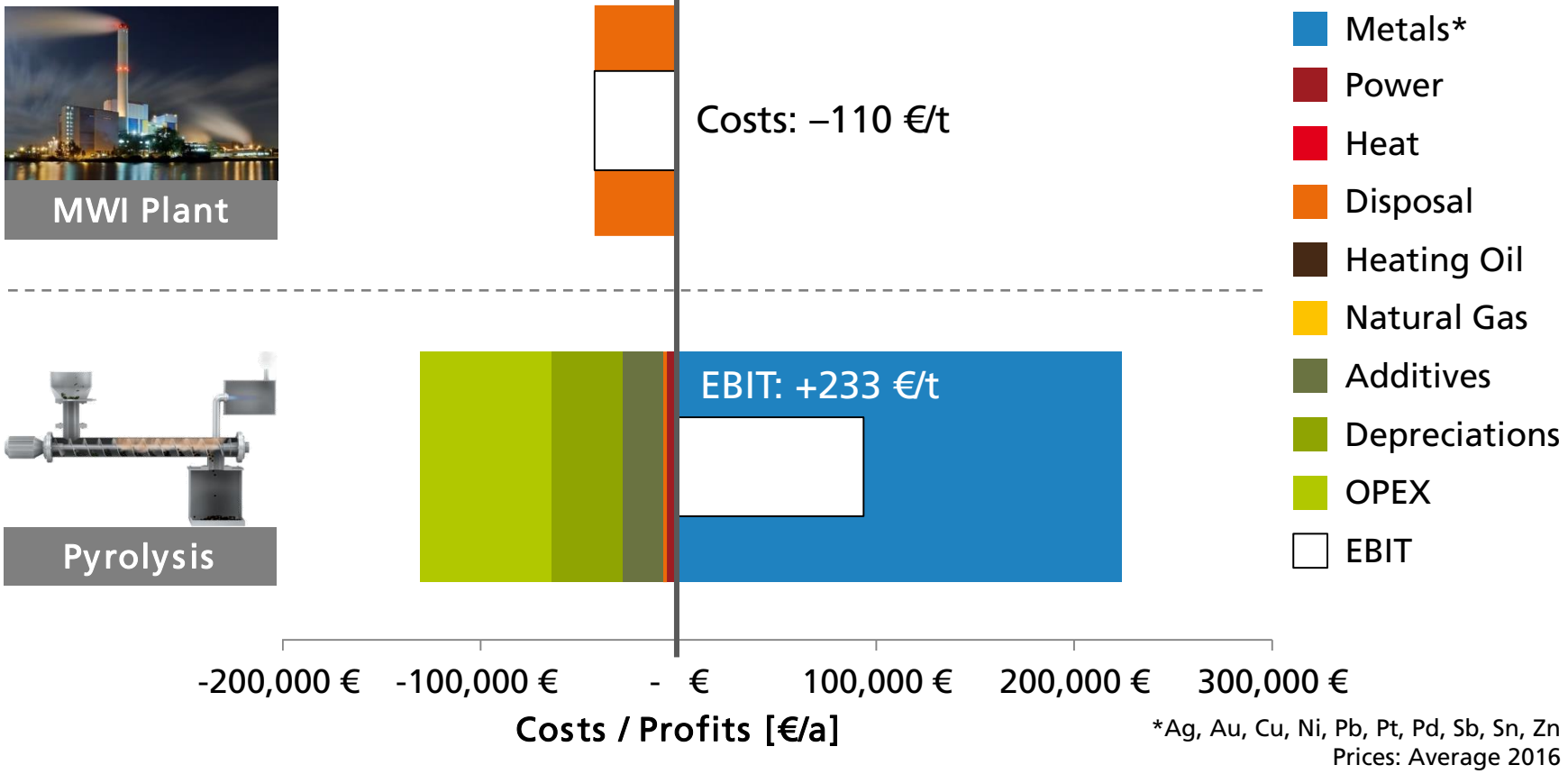
# Shredder Residues from WEEE

## Application Scenario I: Economical Evaluation

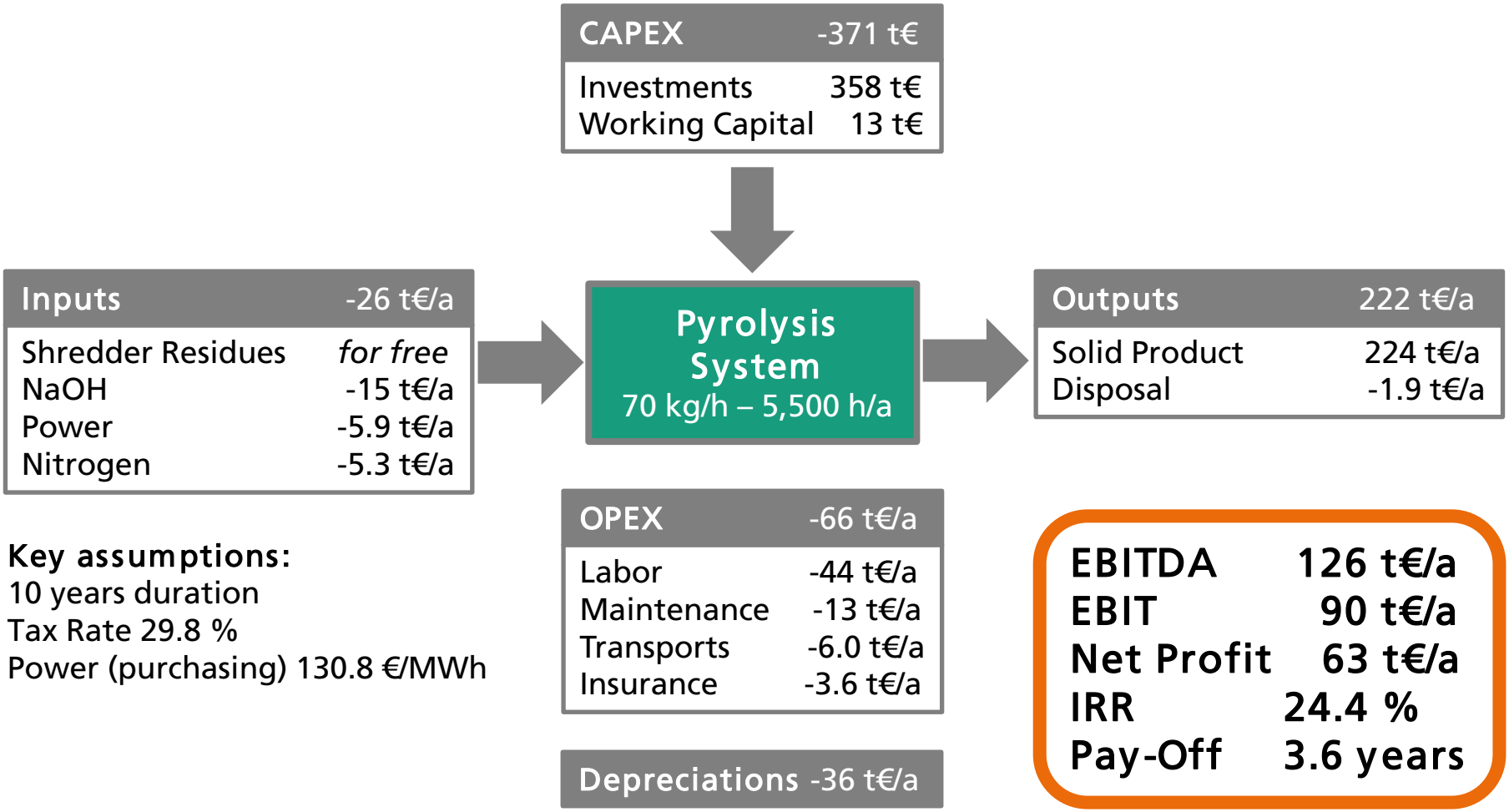
### Business Case: Scenario I with 70 kg/h – 385 t/a




*Ag, Au, Cu, Ni, Pb, Pt, Pd, Sb, Sn, Zn
Prices: Average 2016

# Shredder Residues from WEEE

## Application Scenario I: Economical Evaluation

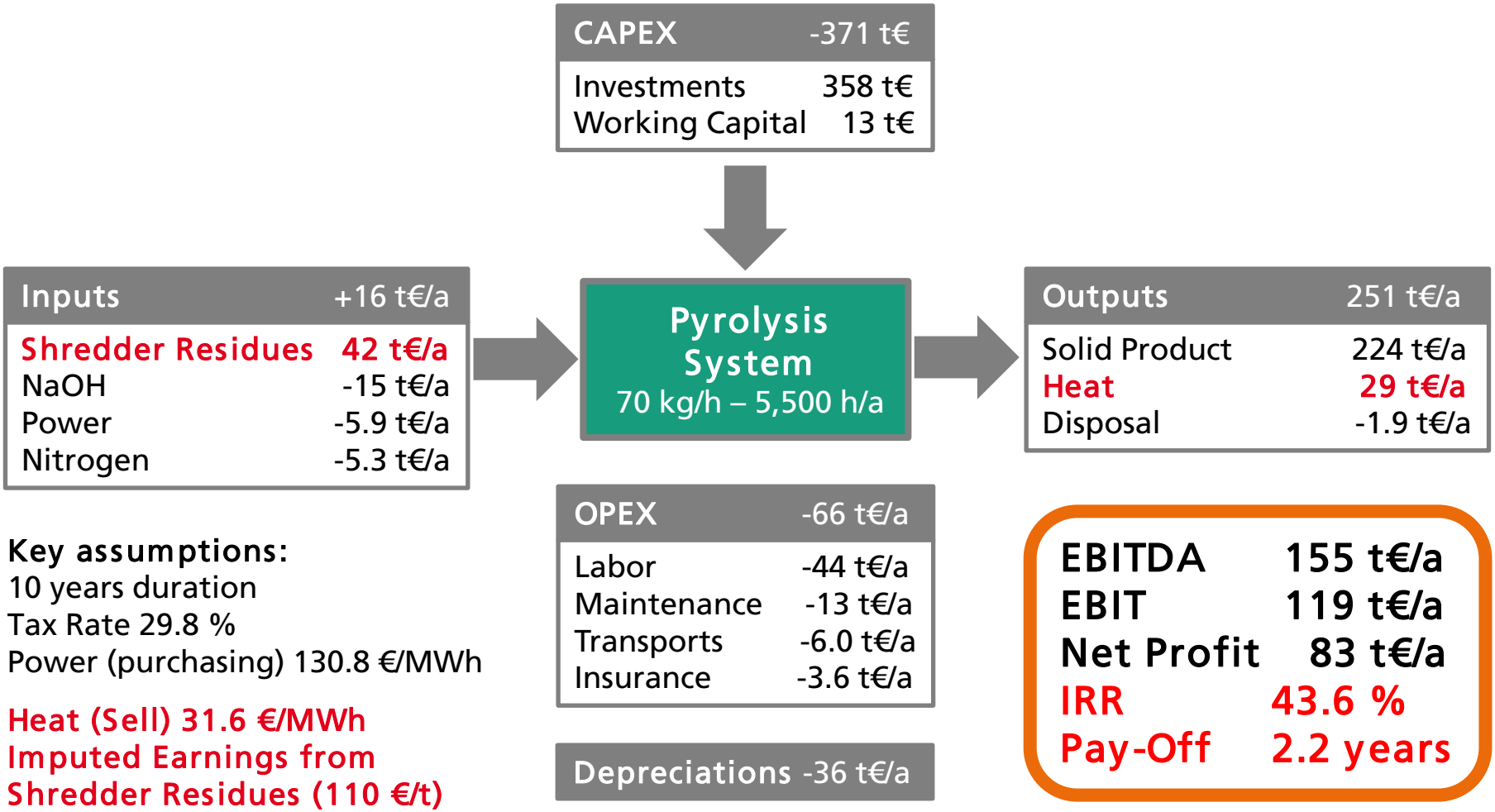



**Key assumptions:**
10 years duration
Tax Rate 29.8 %
Power (purchasing) 130.8 €/MWh

| | |
|---|---|
| EBITDA | 126 t€/a |
| EBIT | 90 t€/a |
| Net Profit | 63 t€/a |
| IRR | 24.4 % |
| Pay-Off | 3.6 years |

# Shredder Residues from WEEE

## Application Scenario I.I: Economical Evaluation



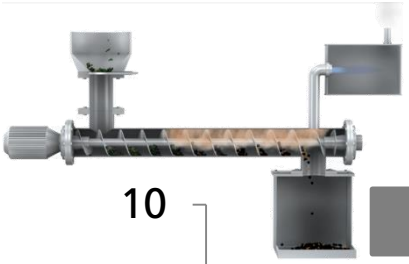

**Key assumptions:**
10 years duration
Tax Rate 29.8 %
Power (purchasing) 130.8 €/MWh

**Heat (Sell) 31.6 €/MWh**
**Imputed Earnings from Shredder Residues (110 €/t)**

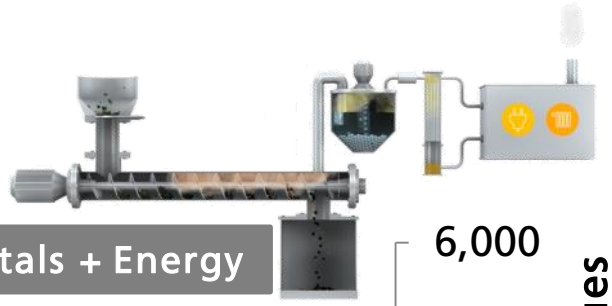
| | |
|---|---|
| EBITDA | 155 t€/a |
| EBIT | 119 t€/a |
| Net Profit | 83 t€/a |
| IRR | 43.6 % |
| Pay-Off | 2.2 years |

# Shredder Residues from WEEE

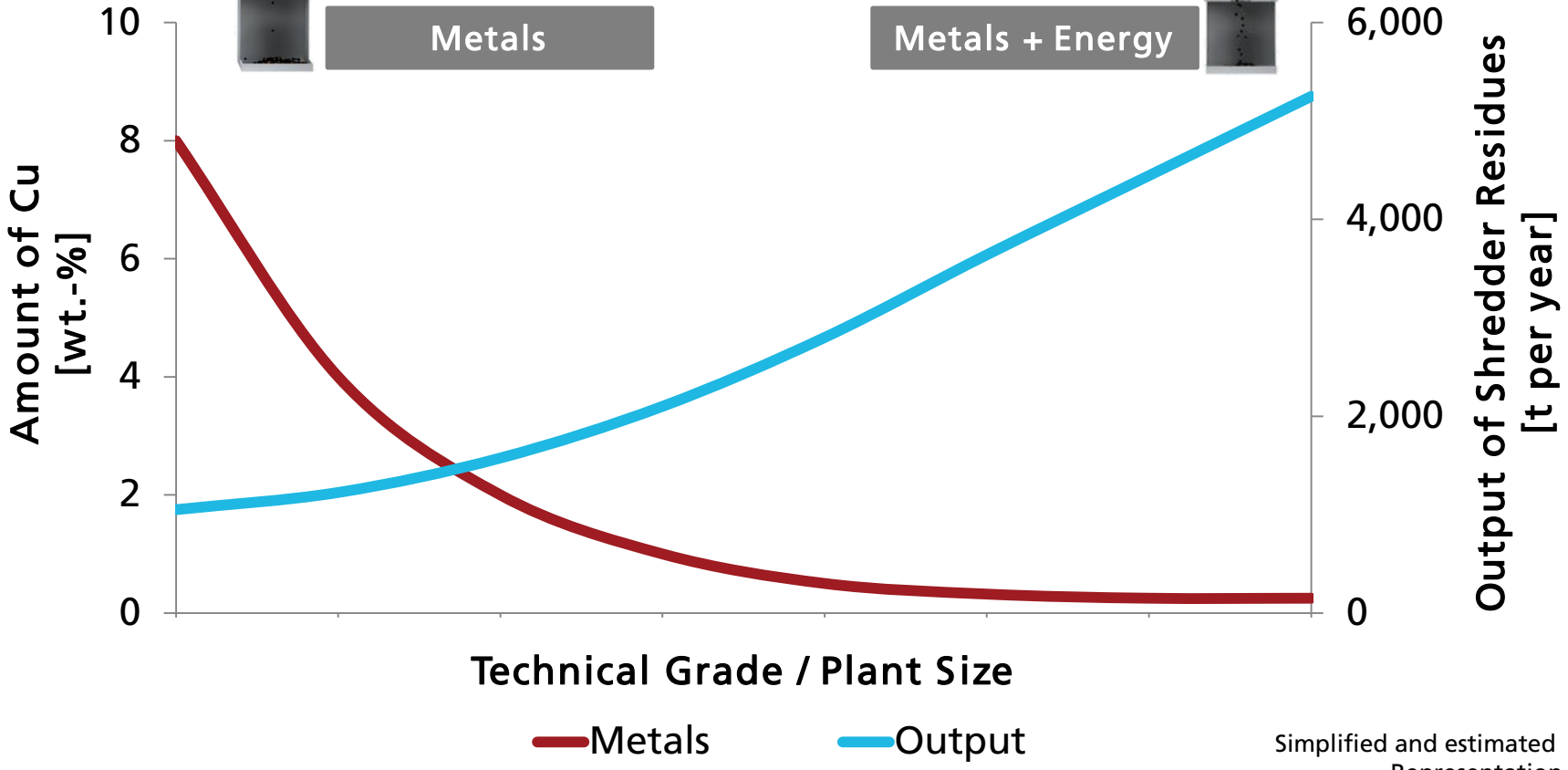
## Economies of Scale



Metals



Metals + Energy




Simplified and estimated Representation



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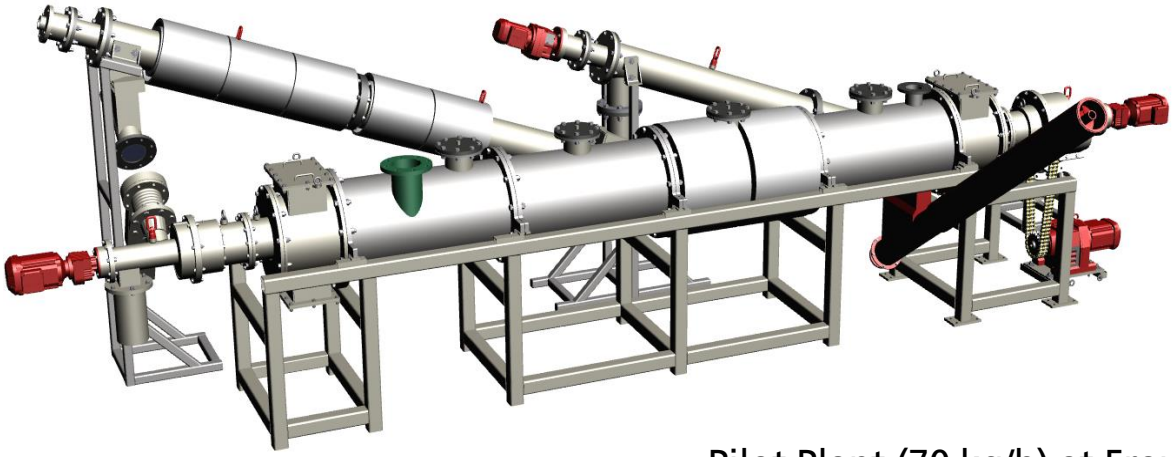
# Conclusions
## Thermo-chemical Treatment of Shredder Residues

- Profitable, innovative and patented Process
- Added Value due to Metal Recycling from Shredder Residues
- Recovery of Energy – Production of Power & Heat
- Individual Integration in existing Processes
- Flexible Scalability for a decentralized treatment
- Available on the Market from May 2017



Pilot Plant (70 kg/h) at Fraunhofer UMSICHT

iCycle®
intelligent composite recycling



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iCycle®
intelligent composite recycling

# Thank you very much for your kind attention!

***You are welcome to visit us at our exhibition booth!***

**Contact:**

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