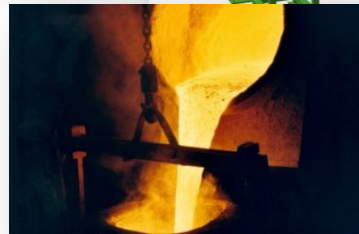


Pyrolysis – Key Technology to recover Metals from Shredder Residues

Electronics & Cars Recycling Congress – WRF 2017
November 16th 2017, Macau

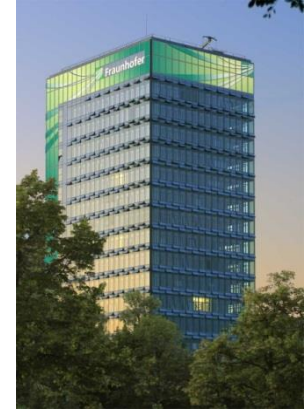


Dr. Peter Hense (Ph.D.)
M. Eng. Jonathan Aigner
Hon. Prof. Dr.-Ing. Matthias Franke
Prof. Dr. Andreas Hornung



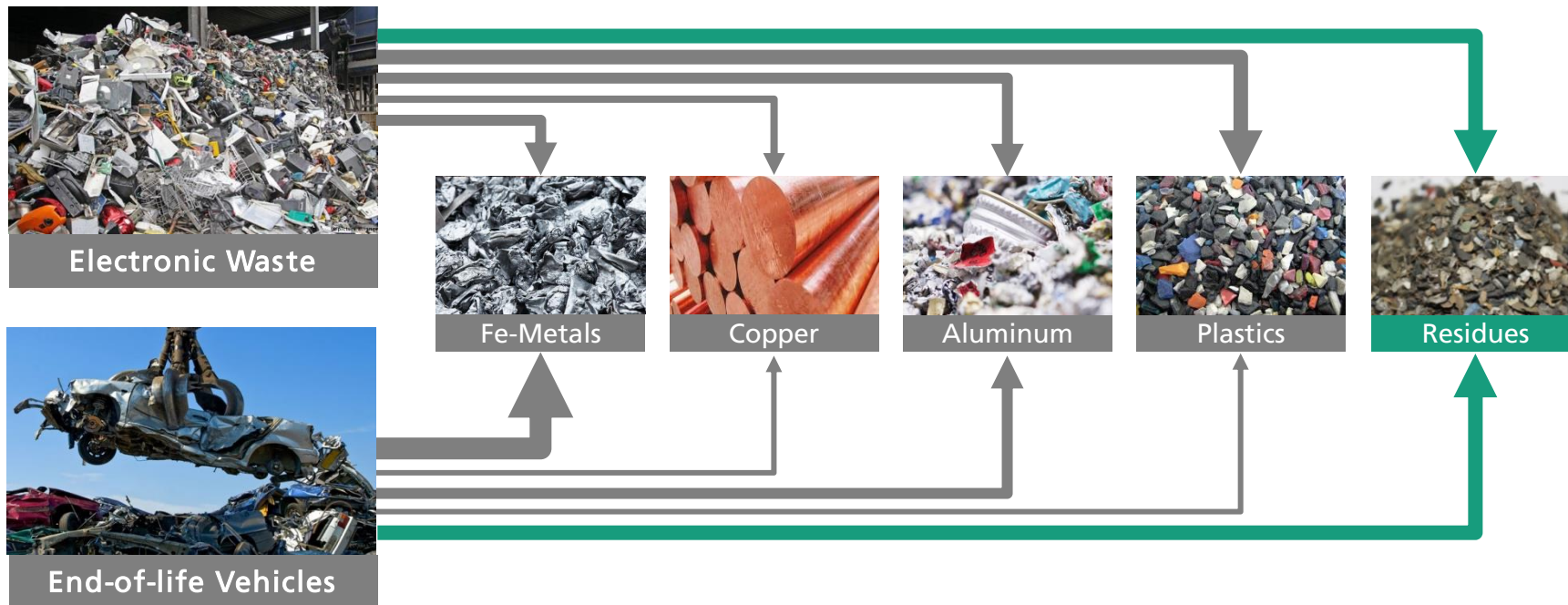
Fraunhofer-Gesellschaft

- Europe's largest R&D organization
 - 69 research institutes
 - >24 000 staff members
 - >2,1 Bn. € annual research budget
- Applied research in an international context, of direct utility to private and public sectors
- Entrepreneurship
 - Institutes organized as profit-centers
 - A third of the budget are revenues of industrial projects
 - Spin-offs are promoted



Metals from Shredder Residues

Motivation



Metals from Shredder Residues

Key Technology: iCycle[®] process



Waste Plastics



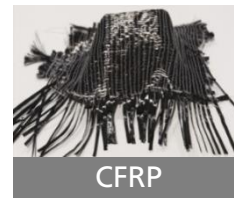
E-Waste



Dust



ASR



CFRP



GFRP



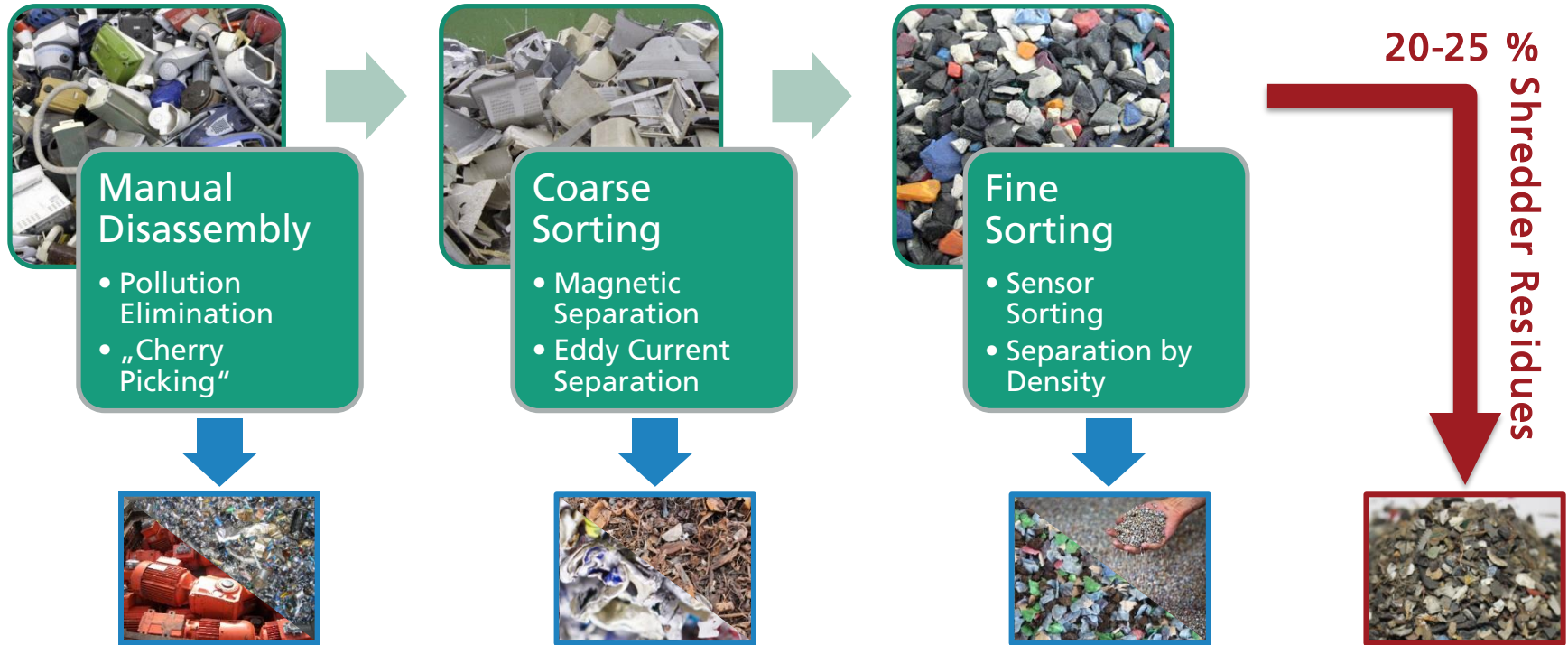
Metal-Recycling



Energetical Utilization

Metals from Shredder Residues

Example: Manual & Mechanical Treatment of WEEE



References: VDI 2343; Kramer 2013

Shredder Residues from WEEE

Potential in Europe

43x



1,712,900 km
Cable (3x1.5mm²)



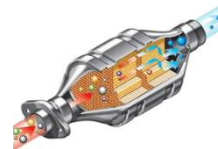
94.900.000 €¹



World demand for LED
of 33 years²



11.6 Mio.
TV²



7 Mio.
Car-Catalysts^{3,4}

81,000 t



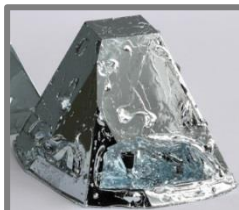
Copper

2,751 kg



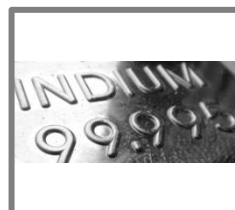
Gold

79 t



Gallium

23 t



Indium

5.4 t



Palladium

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

Shredder Residues from WEEE

Status Quo of Treatment



Integrated
Copper Smelters

Target

- ✓ Recycling of up to 17 Metals (Ag, Au, Cu, Pd, Pt, ...)
- ✓ Recycling Rates >95 %
- ✗ Limited Input Amounts due to high energy contents¹ (<10 % of EU Amounts)^{2,3,4,5}



Thermal
Treatment (MWI)

Status Quo

- ✓ "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: ¹Brusselaers et al. 2006; ²Eurostat 2016; ³Kawohl 2011; ⁴Boliden 2016; ⁵Katz 2013

Shredder Residues from WEEE

Enabling Metal Recycling – Challenges



Shredder Residues
from WEEE

Challenges



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

- Added Value



Integrated Copper
Smelters

Shredder Residues from WEEE

Enabling Metal Recycling by Pyrolysis Treatment



Shredder Residues
from WEEE



iCycle® Process

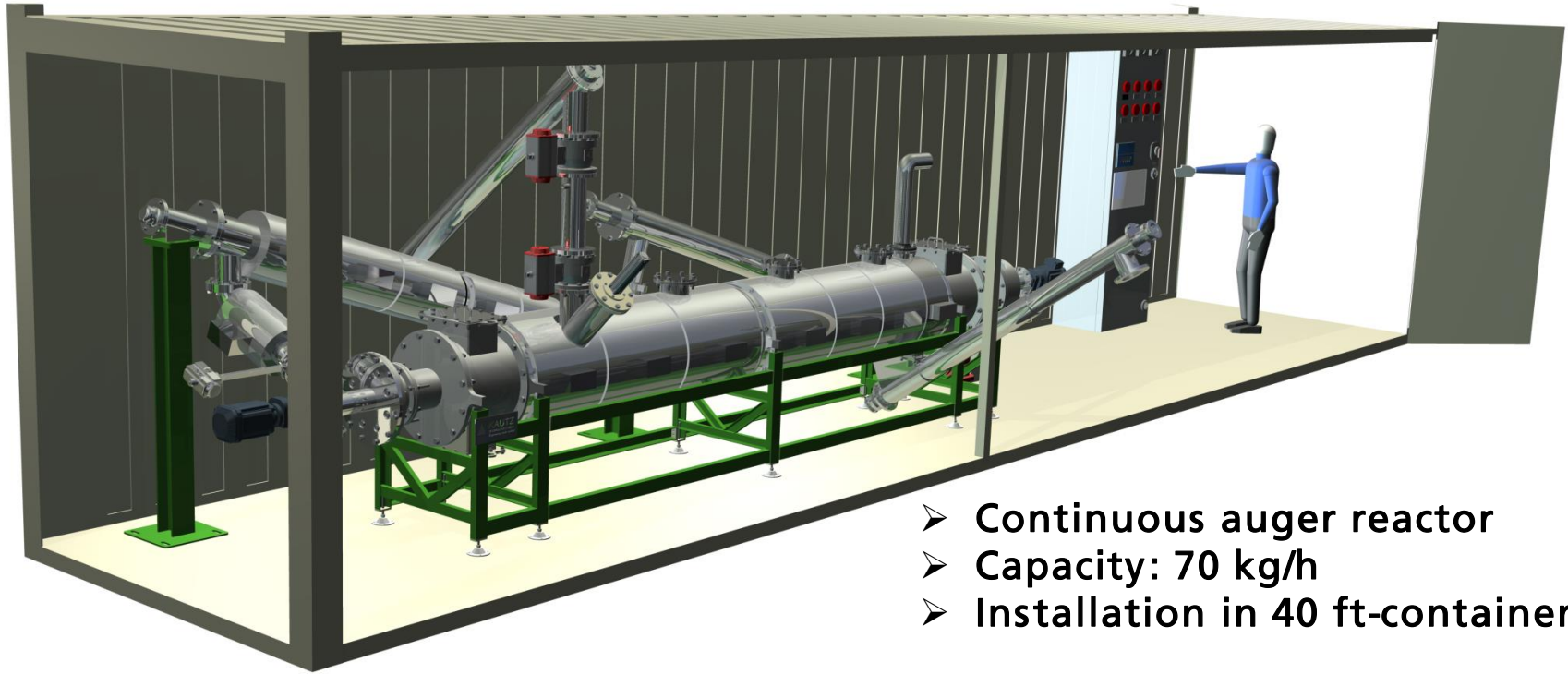


Integrated Copper
Smelters

- Accumulation of metals in a solid product
- Decomposition of plastics
- Formation of high-heating by-products
- Flexible scalability
- Profitable and innovative solution

Shredder Residues from WEEE

The iCycle[®] process – Pilot plant



- Continuous auger reactor
- Capacity: 70 kg/h
- Installation in 40 ft-container

Shredder Residues from WEEE

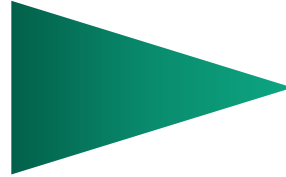
The iCycle[®] process



Solid metal concentrate



Pyrometallurgical Recycling



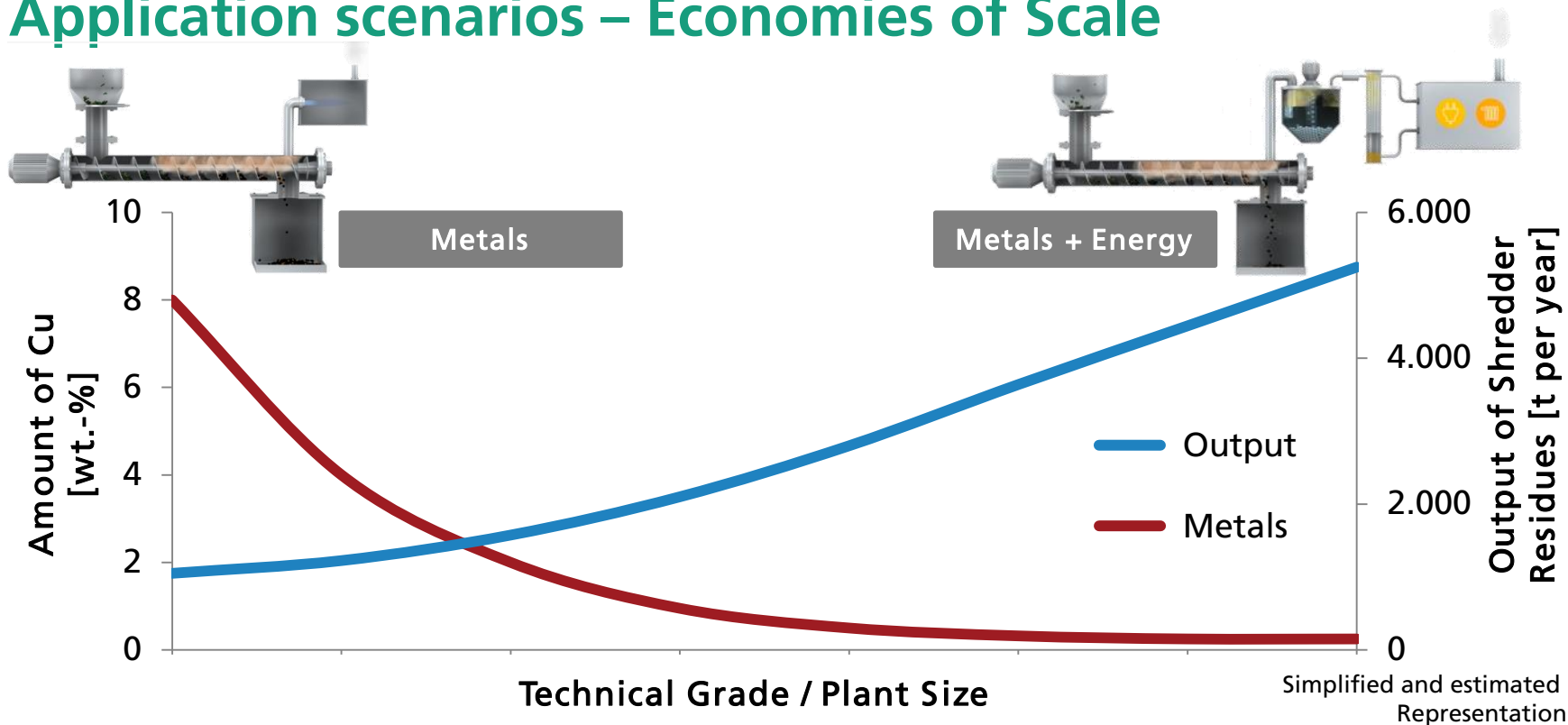
Pyrolysis Oil & Gas



Energetical Utilization

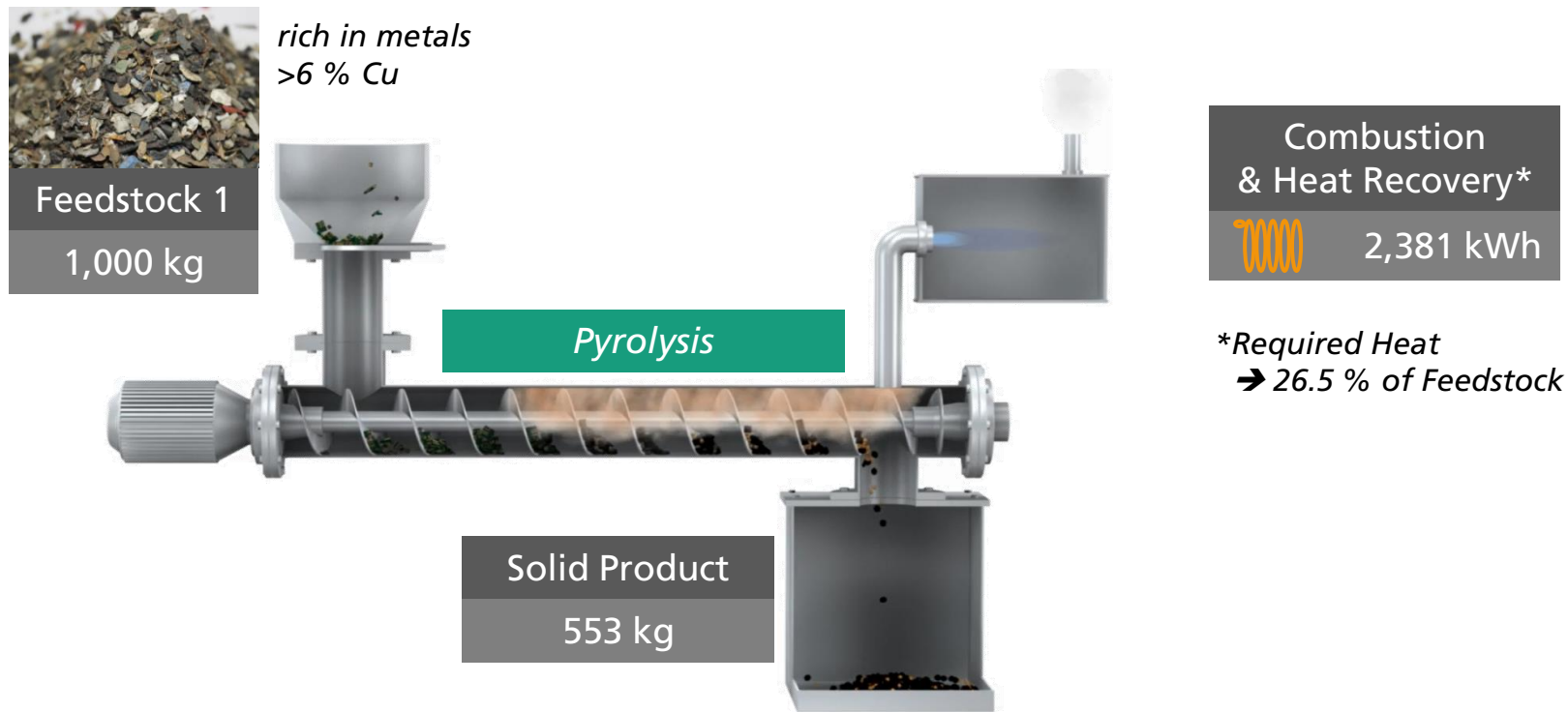
Shredder Residues from WEEE

Application scenarios – Economies of Scale



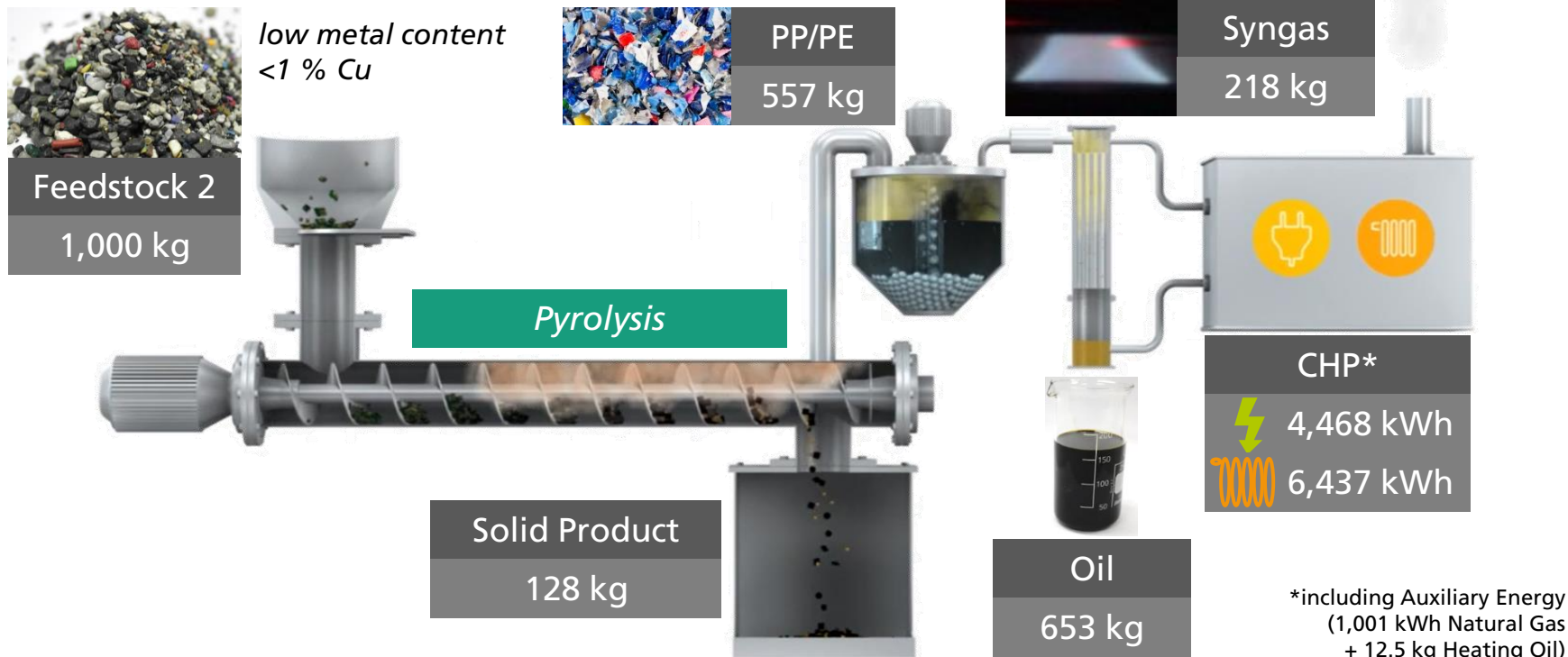
Shredder Residues from WEEE

Application Scenario I: Recovery of Metals



Shredder Residues from WEEE

Application Scenario II: Recovery of Metals & Energy



Shredder Residues from WEEE

Application Scenario: Product Quality



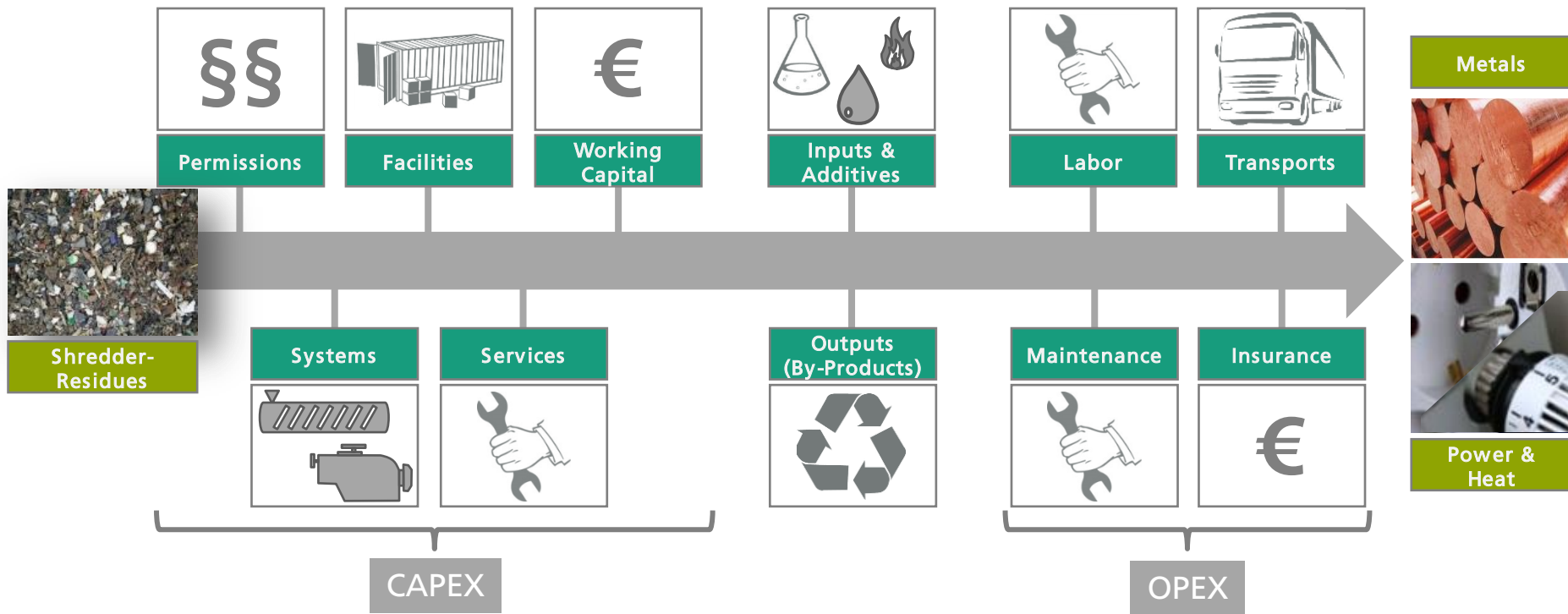
Metal Concentrate	Oil	Gas
Earnings: >1,000 €/t	H _o : 37.7 – 42.5 MJ/kg	H _o : 28.5 – 37.0 MJ/kg
Cl: <1 wt.-%	H ₂ O: <0.5 wt.-%	H _o : 35.7 – 47.9 MJ/m ³
Br: <0,5 wt.-%	ρ: 0.85 – 0.96 g/cm ³	ρ: 1.1 – 1.3 kg/m ³
Σ Dioxins < ChemVerbotsV*	v: 0.95 – 1,47 mm ² /s	

* ChemVerbotsV: German Chemicals Prohibition Ordinance

Picture Source Gas: PSC Wisconsin

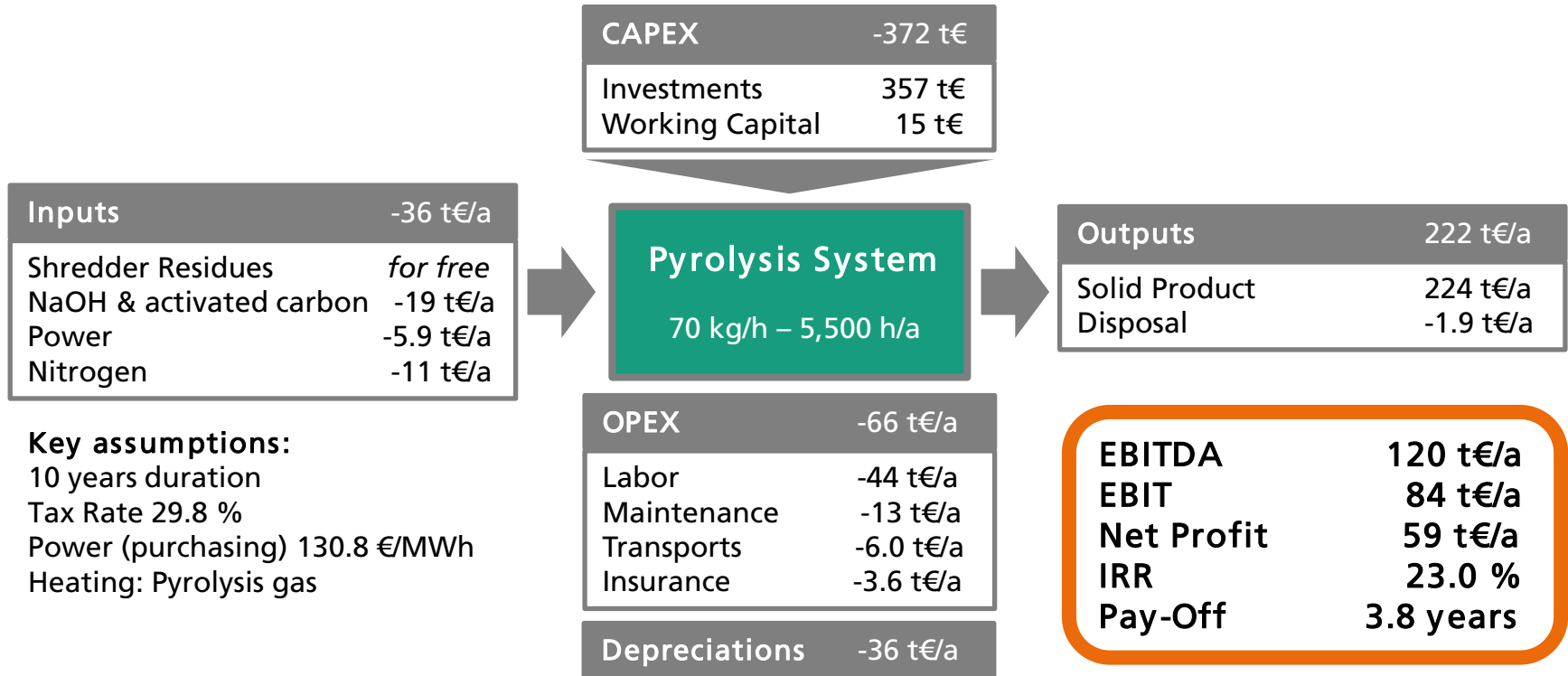
Shredder Residues from WEEE

Application Scenario: Economical Evaluation



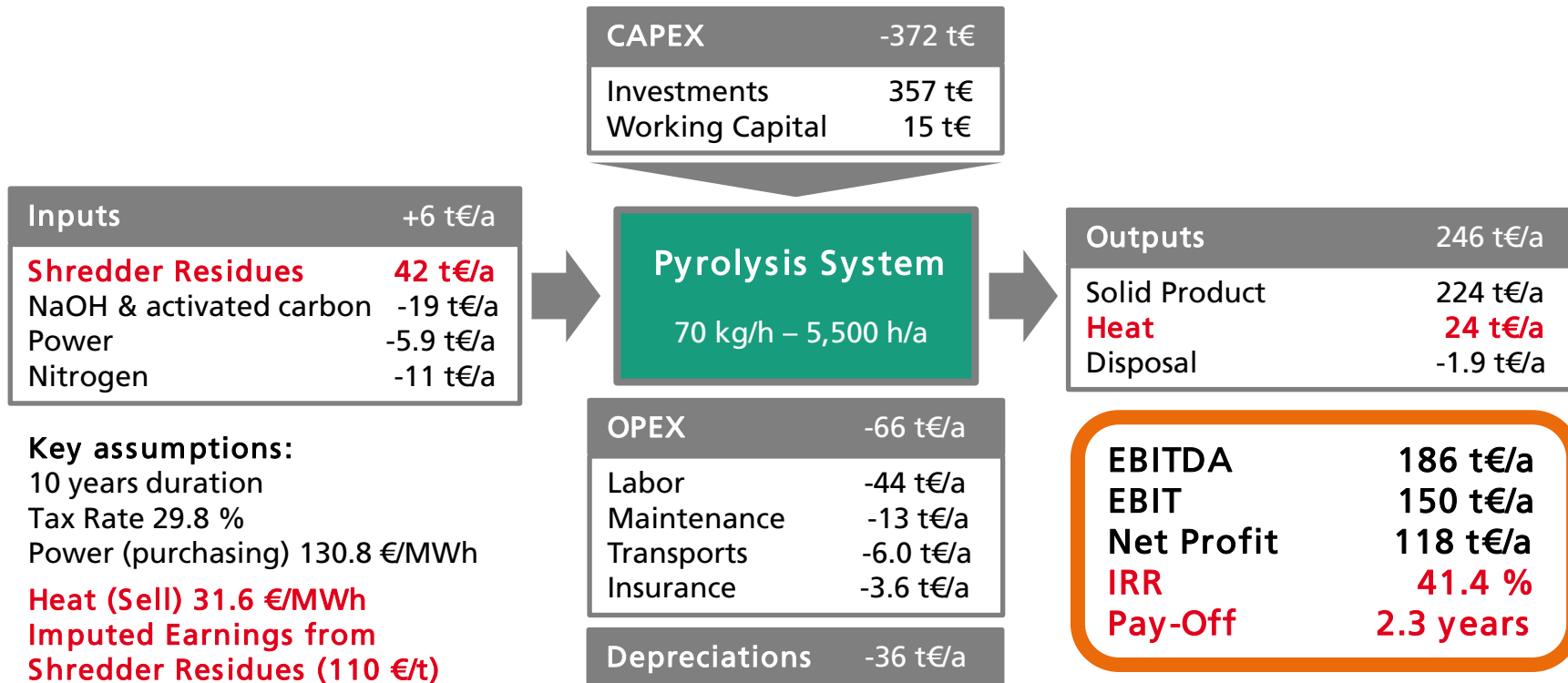
Shredder Residues from WEEE

Application Scenario I: Economical Evaluation



Shredder Residues from WEEE

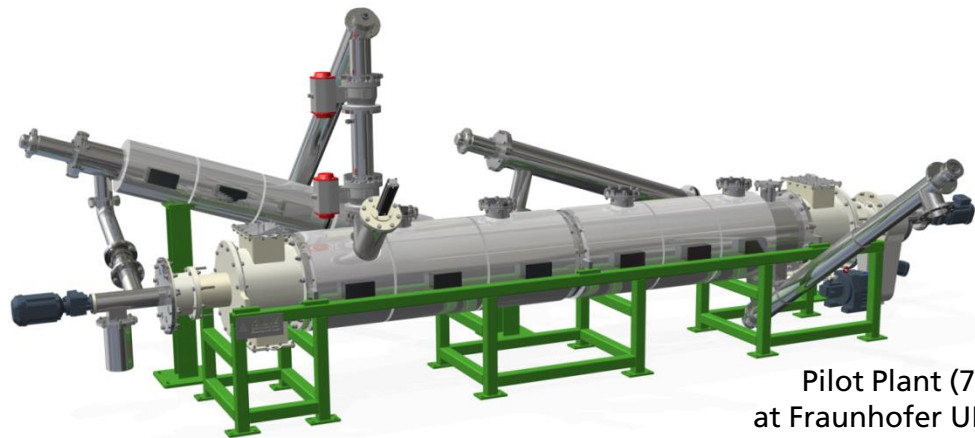
Application Scenario II: Economical Evaluation



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



Pilot Plant (70 kg/h)
at Fraunhofer UMSICHT



iCycle[®]
intelligent composite recycling



Fraunhofer

UMSICHT



iCycle[®]

intelligent composite recycling

**Thank you very much
for your kind attention!**

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