

### CEReS -Co-processing of Coal Mine & Electronic Wastes: Novel Resources for a Sustainable Future

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#### International Biohydrometallurgy Symposium

23<sup>rd</sup> October, 2019 Fukuoka, Japan

# CEReS: Co-processing of Coal Mine and Electronic Wastes

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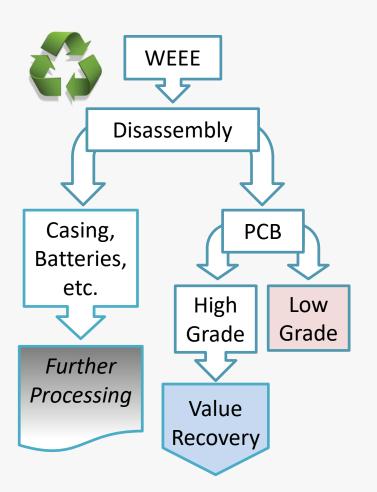


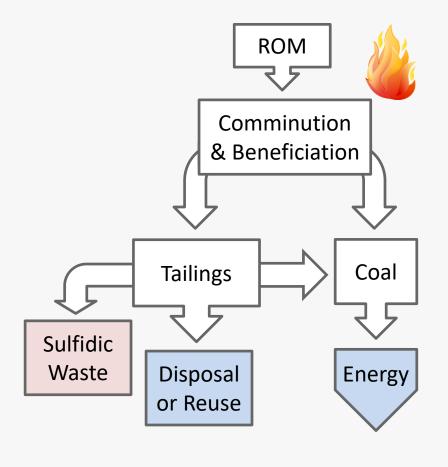






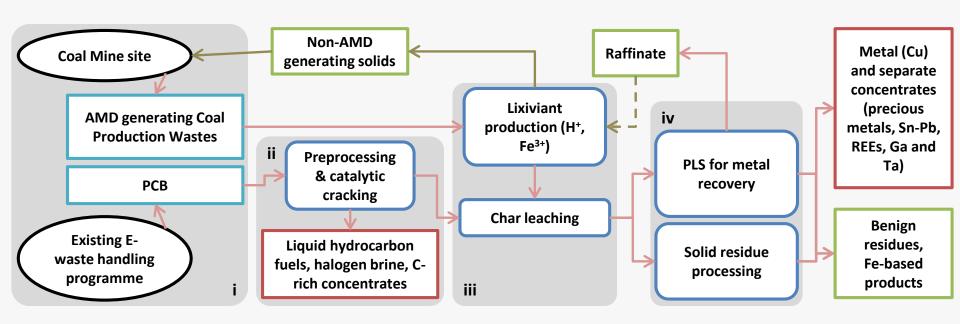
#### **Industrial Ecology & Symbiosis**







#### **Integrated Process**





#### **Key Details**

- Received funding from the Research Fund for Coal and Steel (RFCS)
- Three-year R&D project from June 2016; project budget ~3.2M€
- Eight partners from five countries

_	University	of Exeter (	(Coordinator)	) UK
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- BRGM; <u>Caspeo</u>FR
- Université de Liège; <u>Comet Traitements</u>
   BE
- GIG; TAURON Wydobycie
   PL
- University of Cape TownRSA



#### **Key Details**

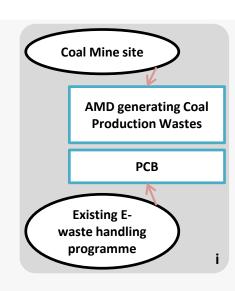
- Use Poland as case study region
- Prove technical feasibility of individual unit processes
  - At (mini) pilot-scale
- Integrate through modelling and simulation
  - Demonstrate viability of concept
  - Include economic assessment
- Evaluate environmental benefit vs "do nothing" scenario
  - LCA





#### **Raw Materials**

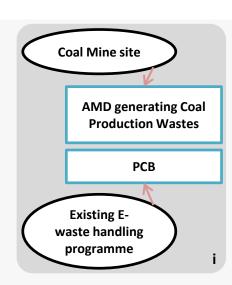
- Analysed four coal waste streams
  - Selected Janina Spiral Tails (~12% Py)
  - Detailed mineralogical characterisation
- Bioprospecting
  - Two bioleaching consortia (30°C & 48°C)
  - Microbial ecology of Janina waste dump (NGS)
- Characterised AMD-generating potential
  - "Missing Acid" question...





#### **Raw Materials**

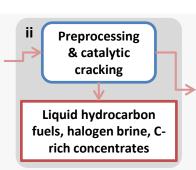
- Analysed WEEE processing in Poland
  - Three PCB categories; selected low-grade
- Not as required; ~35% PCB
  - use Comet own stock
- Detailed characterisation & analysis
  - Metal/value breakdown
  - Au and PM highest values; Cu significant.
- Produced database and cross-map.





#### **Catalytic Cracking**

- Adaption of Comet's pyrolysis process to PCB
  - Initial orientative bench-scale tests
  - Pilot scale tests Phoenix reactor



- Produced and characterised char and hydrocarbon outputs
  - Hydrocarbon 18% original mass; requires removal of Si prior to use in co-generation engine
  - Char four size categories: +8 mm; 2-8 mm; 75 μm-2 mm;
     -75 μm
  - Bromine 74% recovered in quench water
- >90% Ag, Au and Cu concentrated in two fractions
  - ~47% input; concentration factor ~2





#### Cataly

₩FEI » 5.6% 16% Char attrited -8000 +2000 $\mu m$ Char attrited +8000 $\mu m$ Cu 56% Cu 6.2% \*FEI 29% 31% Cu 35% Cu 4.2% Char attrited  $-2000 + 75 \mu m$ Char attrited -75µm

#### CEReS :: Progress

Non-AMD generating solids

#### **Coal Waste & Char Leaching**

- Selection of bioleaching consortia
  - Two enriched from Janina waste, two existing bioleaching consortia
  - Selected 48°C "TW48" consortium from Janina waste
- production (H+, Fe³+)

  Char leaching

Lixiviant

- Biolixiviant capable of leaching char
- Huge problem with corrosion
  - caused by CI content of waste...
- Decide on appropriate strategy
  - washing or using different waste?



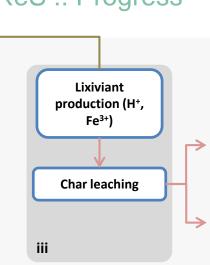
#### CEReS :: Progress

Non-AMD generating solids

#### **Coal Waste & Char Leaching**

 Improved environmental stability of bioleached coal waste

- Geochemical modelling + Quantitative
   mineralogy to investigate "missing acid" phenomenon
  - Biokinetic AMD test provides useful additional information
- Potential issue of latent acidity...

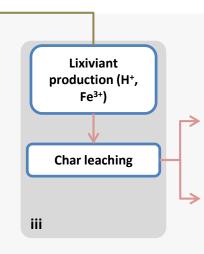


#### **CEReS**:: Progress

Non-AMD generating solids

#### **Coal Waste & Char Leaching**

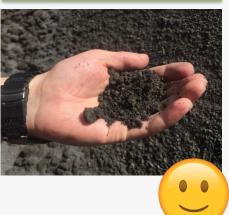
 Possible reuse of fine-grained waste in production of ceramic products, granulates, concrete products



#### ceramic products



# production of granulates



#### concrete products



#### polymerconcrete



#### **CEReS**:: Progress

Lixiviant production (H+,

Fe<sup>3+</sup>)

**Char leaching** 

iii

Non-AMD generating solids

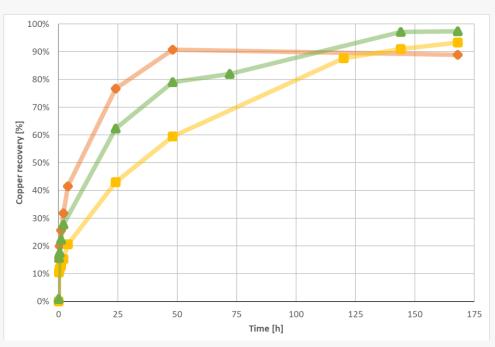
#### **Coal Waste & Char Leaching**

- Char leaching options tested
  - Reactor type, design, operating conditions
  - Char pre-processing

Char leaching can result in 100% Cu

dissolution

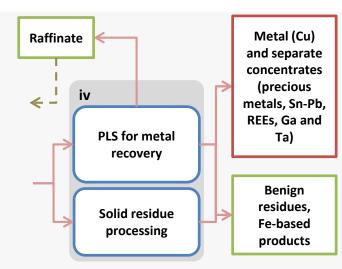
- Colonisation of char leaching reactor possibly beneficial
- Bi-phasic...





#### **Refining of Products**

- Selected Acorga for SX due to high selectivity
- Iron management possible via precipitation of jarosite and conversion to hematite



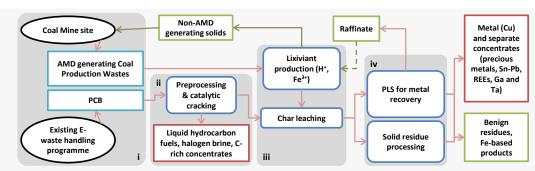
- Only able to valorise Cu within the scope of the project
  - Work required to recover PM

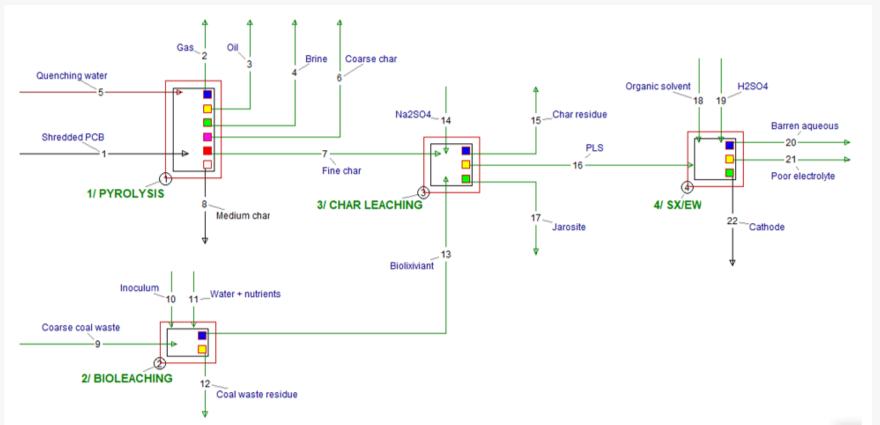


#### **CEReS**:: Progress

#### **Process Integration**

 Process simulator compiled in USIM PAC





#### CEReS :: Progress

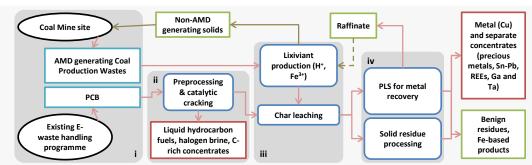
#### Non-AMD Raffinate Metal (Cu) **Coal Mine site Process Integration** generating solids and separate concentrates Lixiviant (precious iv AMD generating Coal production (H+, metals, Sn-Pb, **Production Wastes** Fe<sup>3+</sup>) REEs. Ga and Evaluate & compare Preprocessing PLS for metal Ta) & catalytic PCB recovery cracking **Char leaching** different scenarios Benign Existing E-Liquid hydrocarbon residues, Solid residue waste handling fuels, halogen brine, C-Fe-based processing programme products rich concentrates Oil + gas Brine \* Coarse char (763 t/y) (2 576 t/y) (269 t/y) Medium char (2 152 t/y) Na<sub>2</sub>SO<sub>4</sub> (638 t/y) PCB (14 000 t/y) **PYROLYSIS** Fine char (8 240 t/y) Char residue (6 658 t/y) **CHAR** Jarosite (4 011 t/y) **LEACHING** Coal waste (79 000 t/y) Fe 3+, H2SO4 (7 266 t/y) **BIOLEACHING** SX feed (6 349 t/y) O2 (4 730 t/y) Barren aqueous (5 758 t/y) H<sub>2</sub>SO<sub>4</sub> (5 535 t/y) Nutrients (79 t/y) SX/EW Organic solvent (312 t/y) Poor electrolyte (5 514 t/y) Coal waste residue (76 252 t/y) Raw materials Cathode (923 t/y) Products or waste

Intermediate flows



#### **Process Integration**

 CEReS does not make money if...



- Cost of PCBs based on market value (Umicore)
- Coal waste cost-neutral
- Stabilised (bioleached) coal waste has no value

#### BUT...

 LCA analysis shows significant benefit of CEReS process over the do nothing (business as usual) scenario (for majority of impact categories)



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## ありがとう Thank You, Merci, Dziękuję, Dankie

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