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

Chris Bryan (Exeter Uni. / BRGM)
Anne Gwenaelle Guezennece (BRGM)
Patrick d’Hugues (BRGM)
3 years R&D project from June 2016; project budget ~3.2M€

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, including economic and environmental assessment

Industrial Ecology & Symbiosis

CEReS

Research Fund for Coal & Steel

GeMMe

Université de Liège

Geoscience for a sustainable Earth

brgm

GIG

EXETER

UNIVERSITY OF

TAURON

WYDOBYCIE

Caspeo

Sulfidic Waste

Disposal or Reuse

Energy

Coal

Tailings

Sulfidic Waste

Disposal or Reuse

Energy

Coal

High Grade

Low Grade

Value Recovery

Further Processing

PCB

Casing, Batteries, etc.

Disassembly

WEEE

ROM

Comminution & Beneficiation

Tailings

Disposal or Reuse

Energy

Coal
CEReS: Industrial Context

- Poland is Europe’s largest hard coal producer and produces ~25 Mt coal waste per annum; ~90% reused in civil/geotechnical engineering.
- Many coal production wastes contain sulfides (pyrite); Microbial decomposition causes acid mine drainage (AMD).
  - Capping and other methods prevent formation, but do not remove potential; Continuous monitoring, potentially limited lifespan.
  - Issues where sulfidic material has been used in construction.

- Tauron Wydobycie S.A. own Brzeszcze, Janina & Sobieski coal mines.
  - Largest coal reserves in Poland.
  - Mines produce sulfidic wastes.

- Investigating alternate routes for wastes to improve economic and environmental performance; Need for long-term solution to AMD-generating wastes.
CEReS: Industrial Context

- EU-reliance on importation of Raw Materials well-documented

- Improvement/new ideas in recycling of WEEE / EoL products still needed to close the loop (circular economy context)

- Comet Traitements, part of Groupe Comet
  - Cover entire recycling and valorisation chain
  - Currently recover 95 % of an ELV for reuse

- Developed pyrolytic process to process light shredder residues (LSR)
  - High organic content; Produces hydrocarbon fuel, carbon-rich concentrates and metal-bearing char

- Wish to broaden application to scrap PCB (Low Grade)
Integrated Process

Coal Mine site

AMD generating Coal Production Wastes

PCB

Existing E-waste handling programme

Non-AMD generating solids

Preprocessing & catalytic cracking

Liquid hydrocarbon fuels, halogen brine, C-rich concentrates

Lixiviant production ($H^+$, $Fe^{3+}$)

Char leaching

PLS for metal recovery

Solid residue processing

Raffinate

Metal (Cu) and separate concentrates (precious metals, Sn-Pb, REEs, Ga and Ta)

Benign residues, Fe-based products
CEReS: Progress

Raw Materials characterisation / preparation

- Four coal waste streams: Selection of Janina Spiral Tails (~12% Py)
- WEEE processing in Poland: 3 PCB categories - selected low-grade

Catalytic Cracking

- Adaption of Comet’s pyrolysis process to PCB
  - Initial bench-scale tests Pilot scale tests – Phoenix reactor
- Produced and characterised char and hydrocarbon outputs
CEReS: Progress

Coal Waste Leaching

• Selection of bioleaching consortia
  – Selection of the microbial consortium and the temperature
  – Optimisation of nutrients composition \(\rightarrow\) prevention of Fe precipitation

• Development and optimisation of coal waste bioleaching unit
  ➢ To produce a liquor with the highest FeIII concentration
    - maximising the solid load in the input of the bioreactor
    - maximising the sulfide leaching yield while preventing Fe precipitation
  ➢ To favor the presence of an active biomass which will be able to re-oxidise FeII during the char leaching step and to maintain an adequate FeIII concentration.
Coal Waste Leaching

- Huge problem with corrosion
  - caused by Cl content of waste…

CEReS: Progress

Non-AMD generating solids

Lixiviant production (H\(^+\), Fe\(^{3+}\))

Char leaching
CEReS: Progress

Coal Waste Leaching

Issues: Two leaching kinetics

- [Fe] vs. time
- Time (days)
- [Fe] mg/L

- CERES : Réacteur B2-1
- R2L-BC 2 15%
- R2L-12
- R2L-BC 4
- R2L-6 B (15%)
- R2L-13

Is all the pyrite fully liberate? => Grinding materials

Non-AMD generating solids

Lixiviant production (H+, Fe3+)
Char leaching
CEReS: Progress

Coal Waste Leaching

• **Issues encountered**
  - Slow leaching kinetics
  - Low final $[\text{Fe}^{3+}]$ and uncomplete sulphide leaching
  - Corrosion

• **Tests**
  - Coal waste re-grinding
    - To enhance pyrite liberation
    - To increase leaching kinetics
  - Coal waste washing to remove chloride
CEReS: Progress

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 by microorganisms possible and beneficial

- Currently testing reuse of fine-grained waste in production of ceramic products
- Consulting with potential manufacturer of concrete polymer products
Process Integration on going

- Cracking flow-sheet elaborated and basic simulation done
- Initial data from coal waste bioleaching available and being used to improve existing bioleaching unit models
- Elaboration of char leaching and metal refining circuit underway
- Final process simulator to be compiled
Summary

- Concept of integrated process using wastes from opposite ends of value chain proven as possible: mixing waste streams as an option to improve “competitiveness” of waste treatment? (Regulation aspects).

- Alternate reprocessing route for sulfidic mine wastes
  - Permanently removes acid-generating potential

- Economically/environmentally viable option for valorisation of low grade PCB? (decrease of AMD potential & char metal content)

- Aim to scale up to fully integrated pilot plant (in another project!)

- Explore application to other regions (RSA) and wastes
  - Metal mine wastes, e.g. tailings
  - Upgrade metal content
Thank you