Solution Architect for Global
Bioeconomy & Cleantech Opportunities

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Material Value Chains

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Thermal separation of valuable elements at power plant furnace conditions

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Valmet

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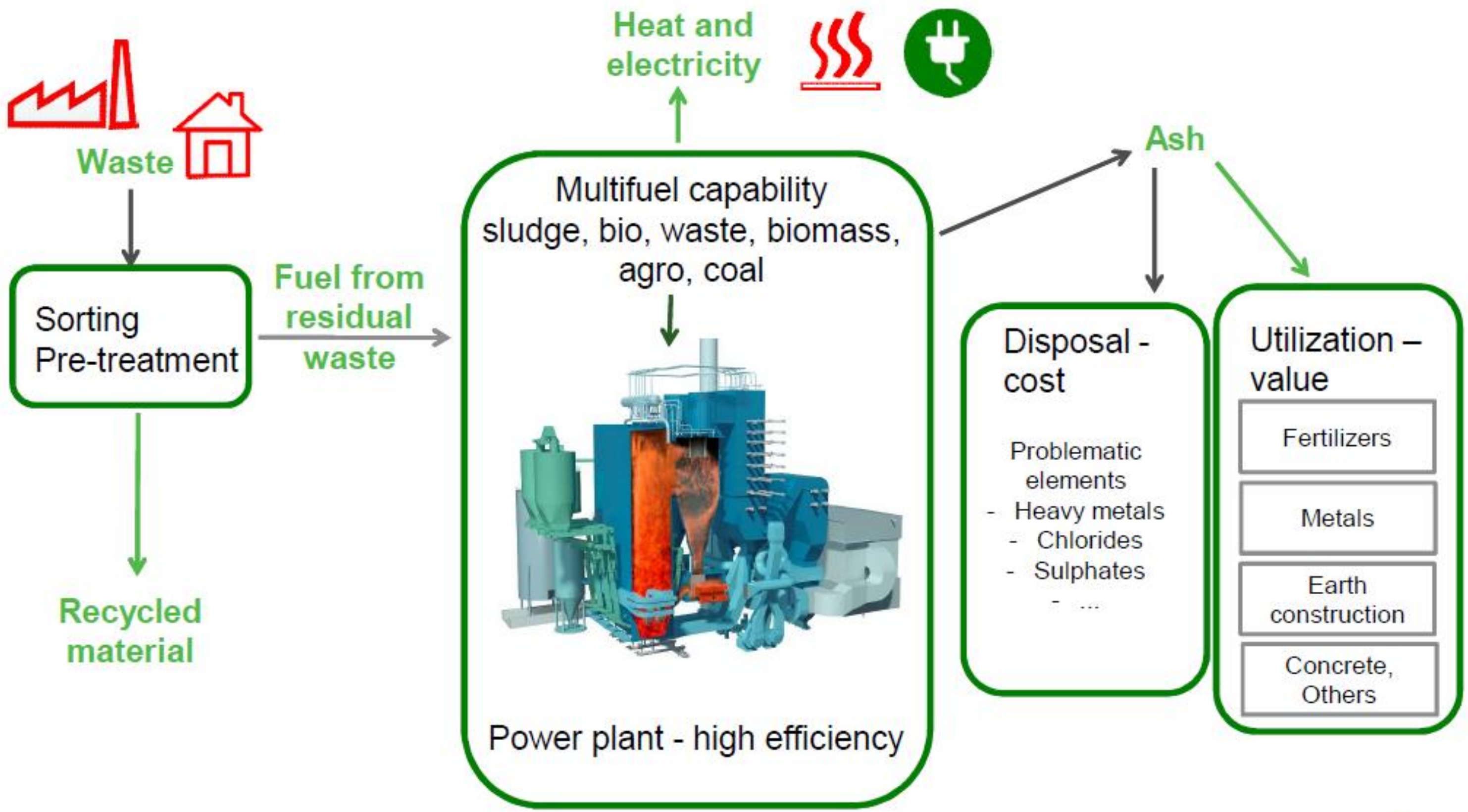
Recovery of valuable elements from WtE ashes



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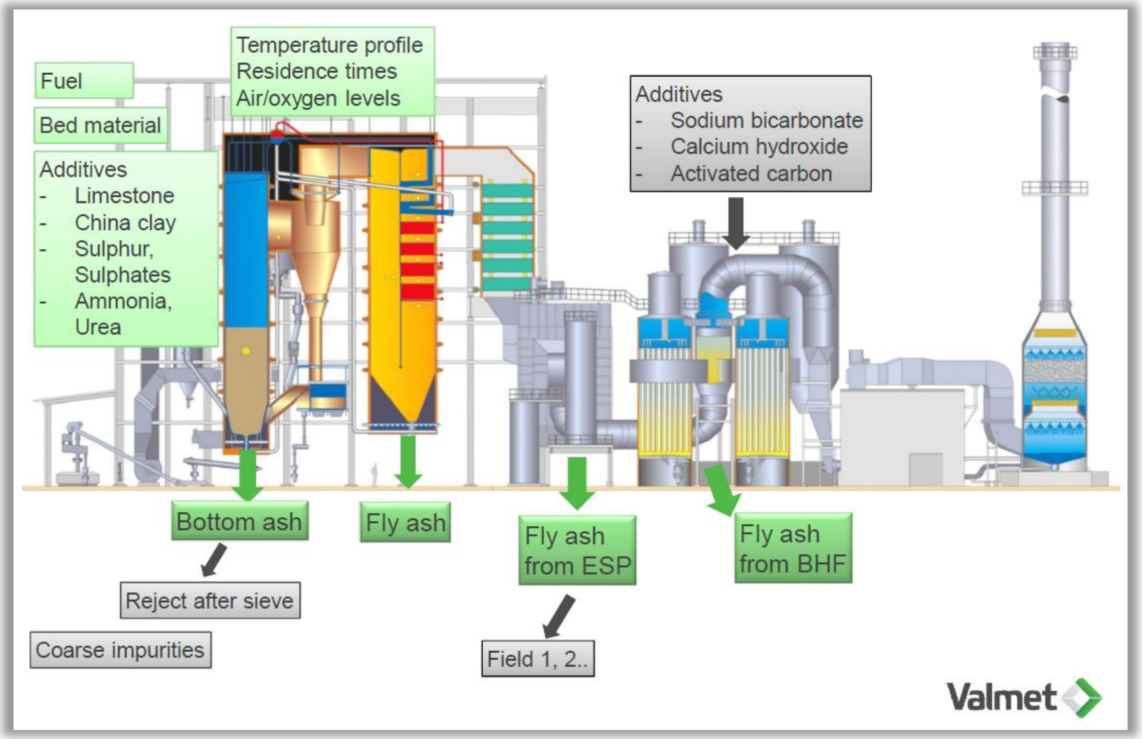
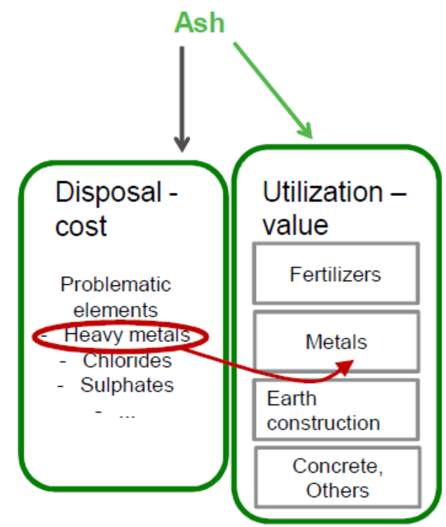
Prediction of ash quality and influencing on ash quality during combustion





Knowledge on WtE ashes quality and potential

Jutta Laine-Ylijoki, John Bacher, Tommi Kaartinen,
Kirsi Korpijärvi, Margareta Wahlström
& Malin zu Castell-Rüdenhausen,
VTT Technical Research Centre of Finland Ltd.

Review on Elemental Recovery Potential of Ashes

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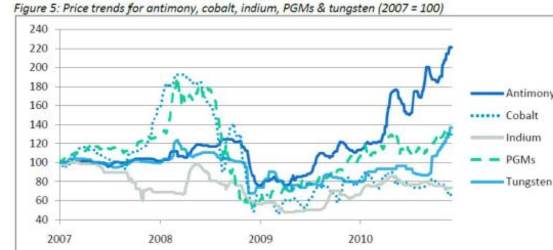
Why? Case: Antimony, Sb

- Annual growth in demand: 4-5%
- Global supply: 84% from China (Xikuangshan Mine)
- Price: +175% from 2009
- Occurrence:
  - < 0.5 ppm in earth crust
  - 500-2000 ppm in FB WtE fly ash

Figure 5: Price trends for antimony, cobalt, indium, PGMs & tungsten (2007 = 100)



Source: Metal Pages; see Annex A for details

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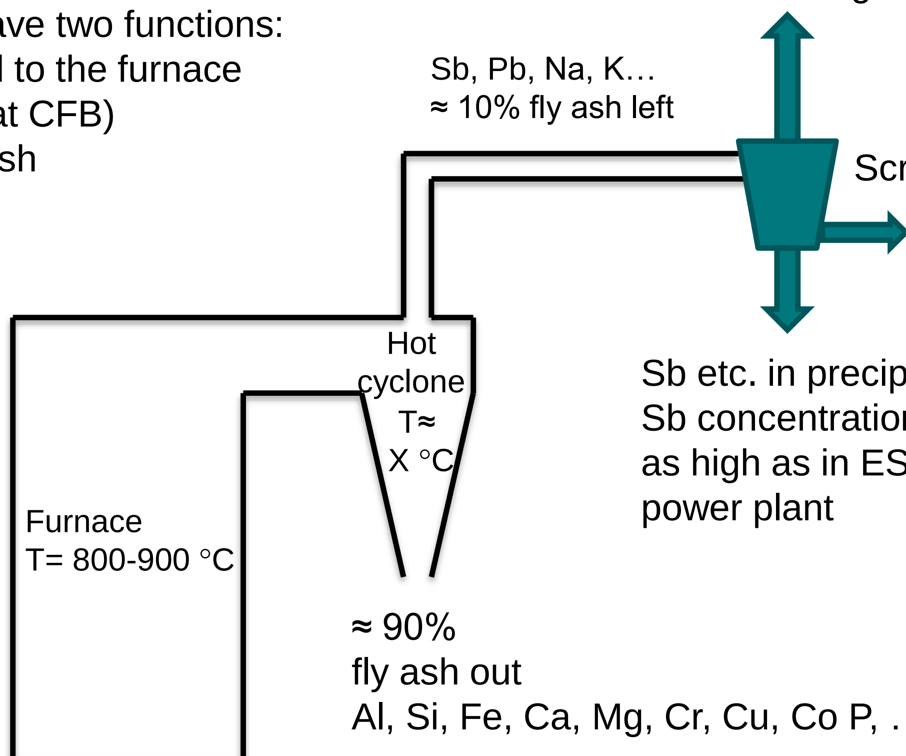
Presentation of idea to be tested to complete VTT's preliminary results and ideas of Valmet/ VTT

Hot cyclone can have two functions:
a) to circulate sand to the furnace
(return cyclone at CFB)
b) to separate fly ash



Sb etc. in precipitate where for example Sb concentration can be tens of times as high as in ESP ashes at traditional power plant

Conducted set of experiments

Test no.	Fuel	T cyclone [°C]
1	Wood waste + cable cord	650
2	Wood waste	650
3	Wood waste	600
4	Wood waste	550
5	Wood waste	470

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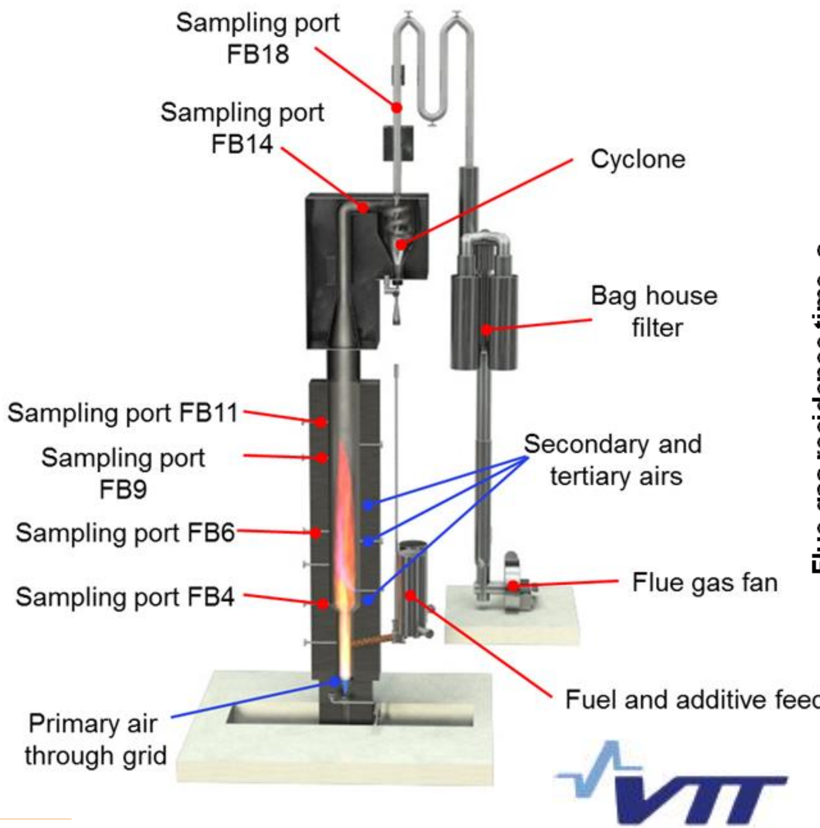
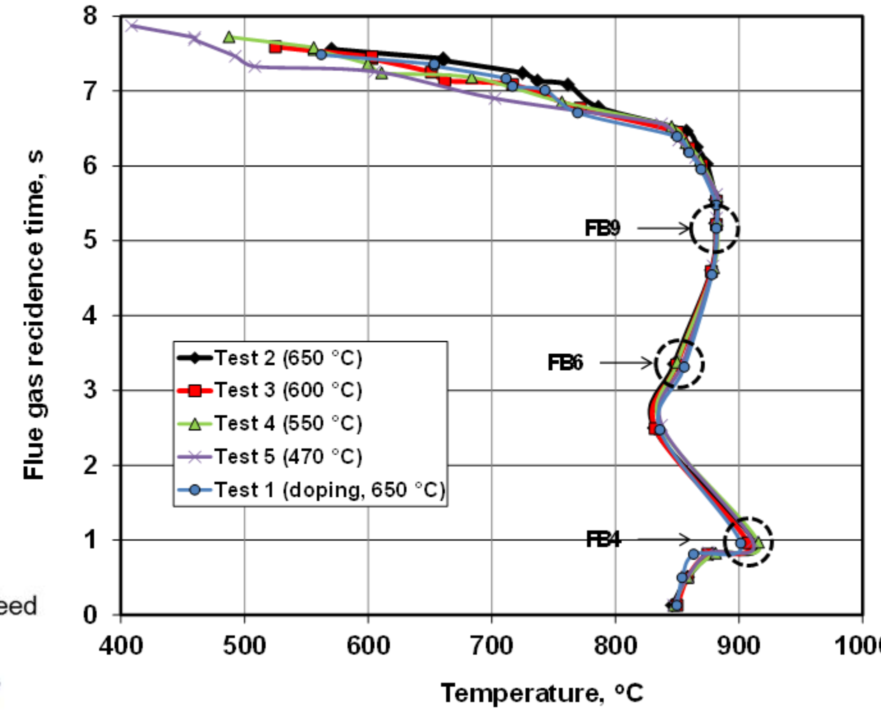
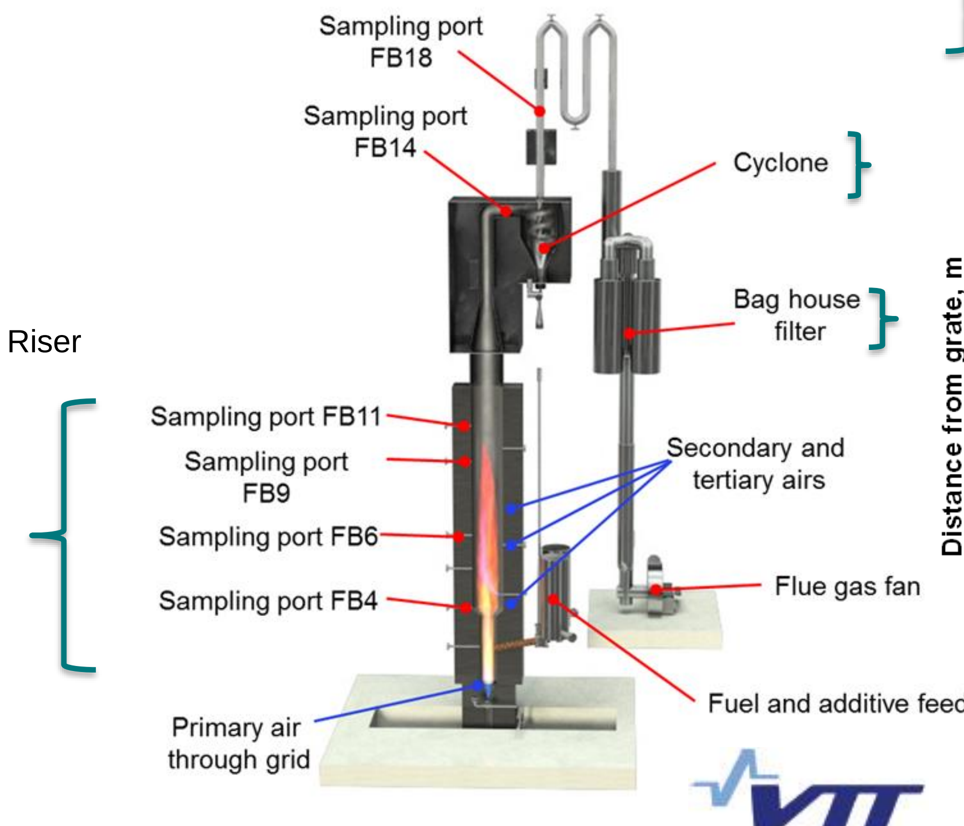
VTT's 20 kW BFB reactor with T vs. t data

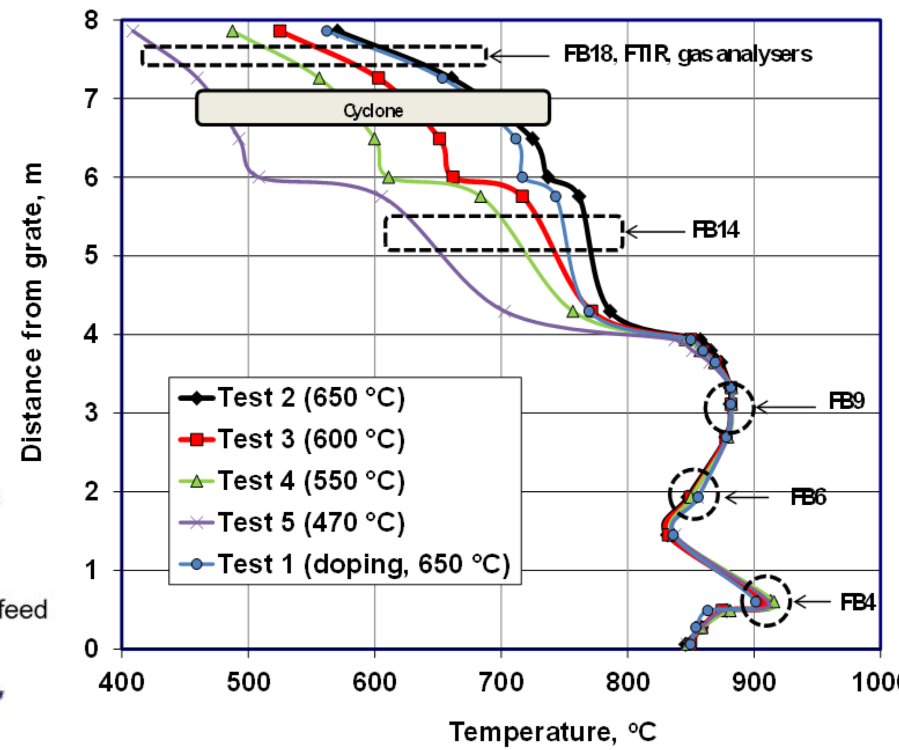




VTT's 20 kW BFB reactor with T vs. distance data

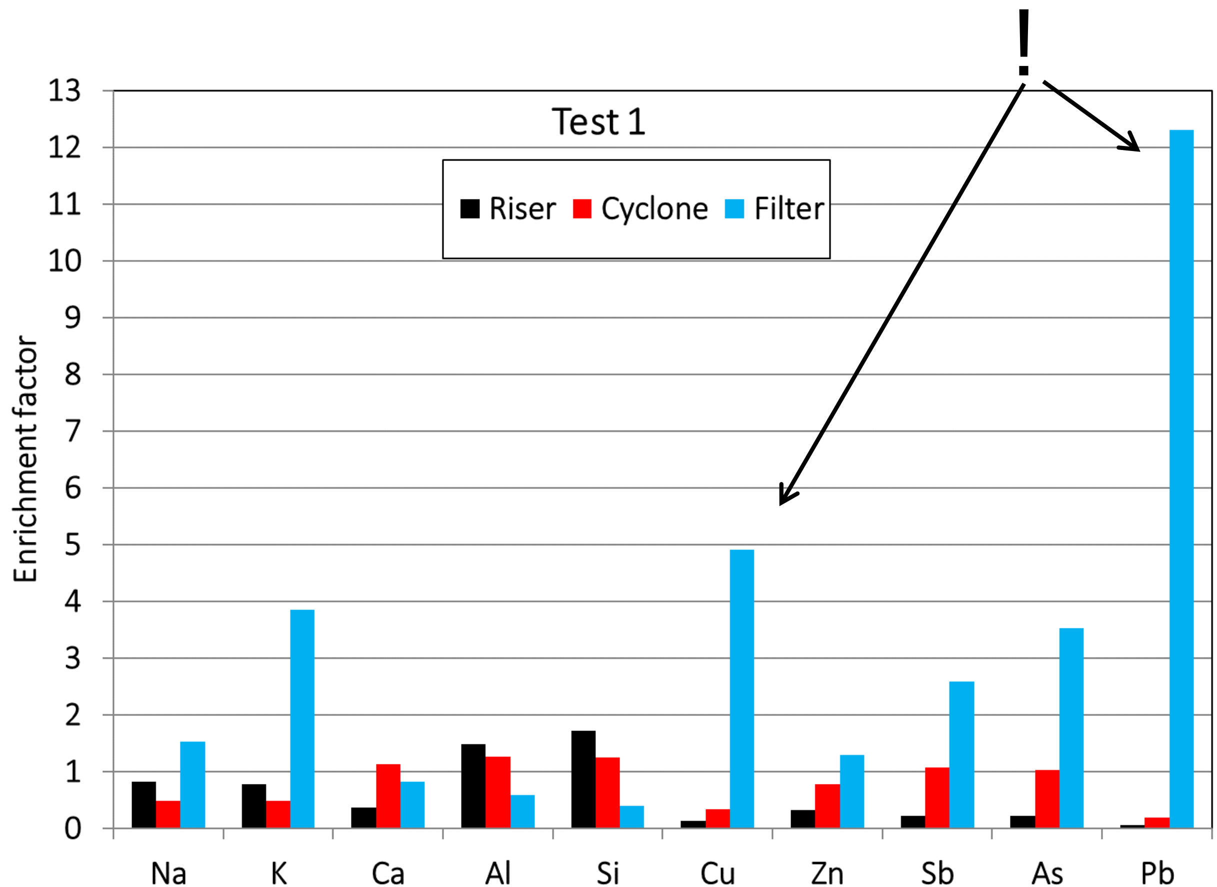
} = ash collection zones





Enrichment of elements

Enrichment factors (related to bulk ash composition)



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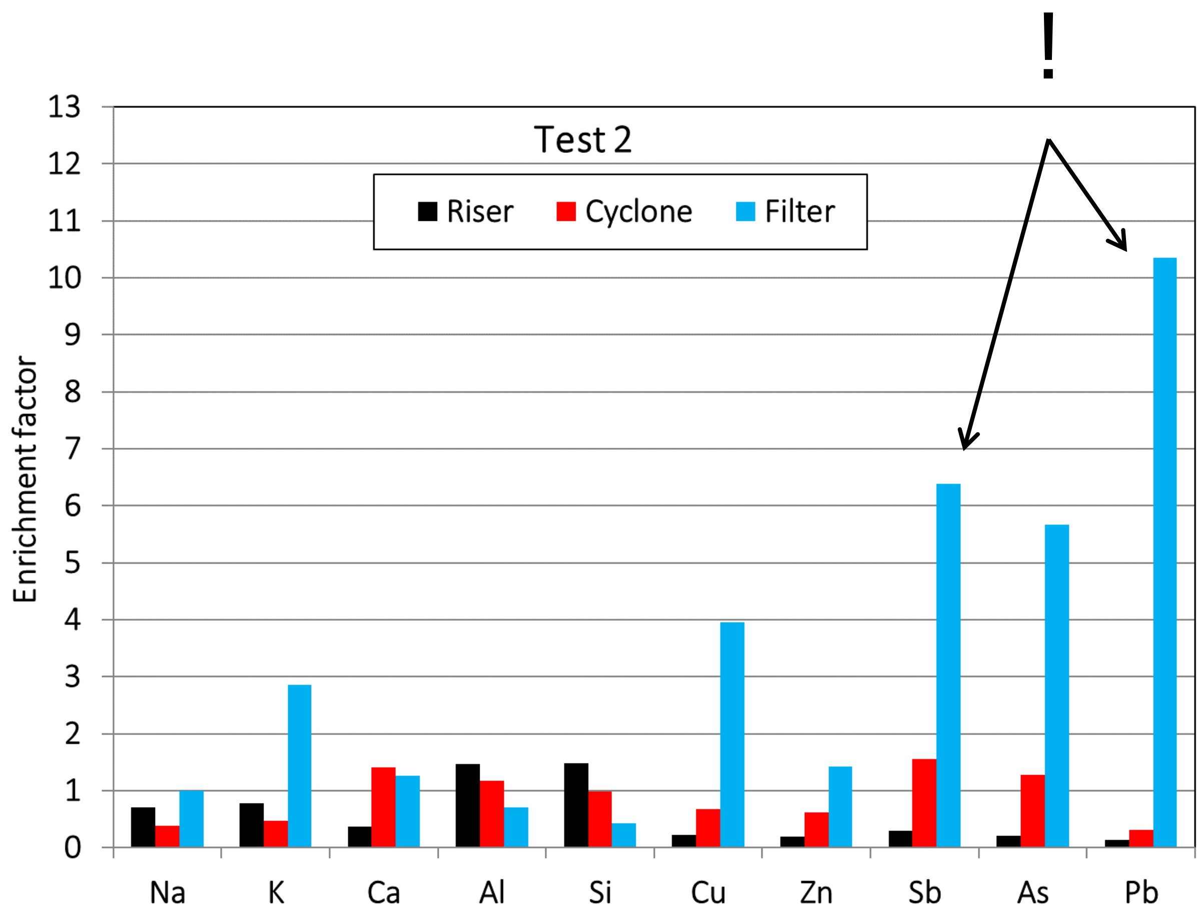
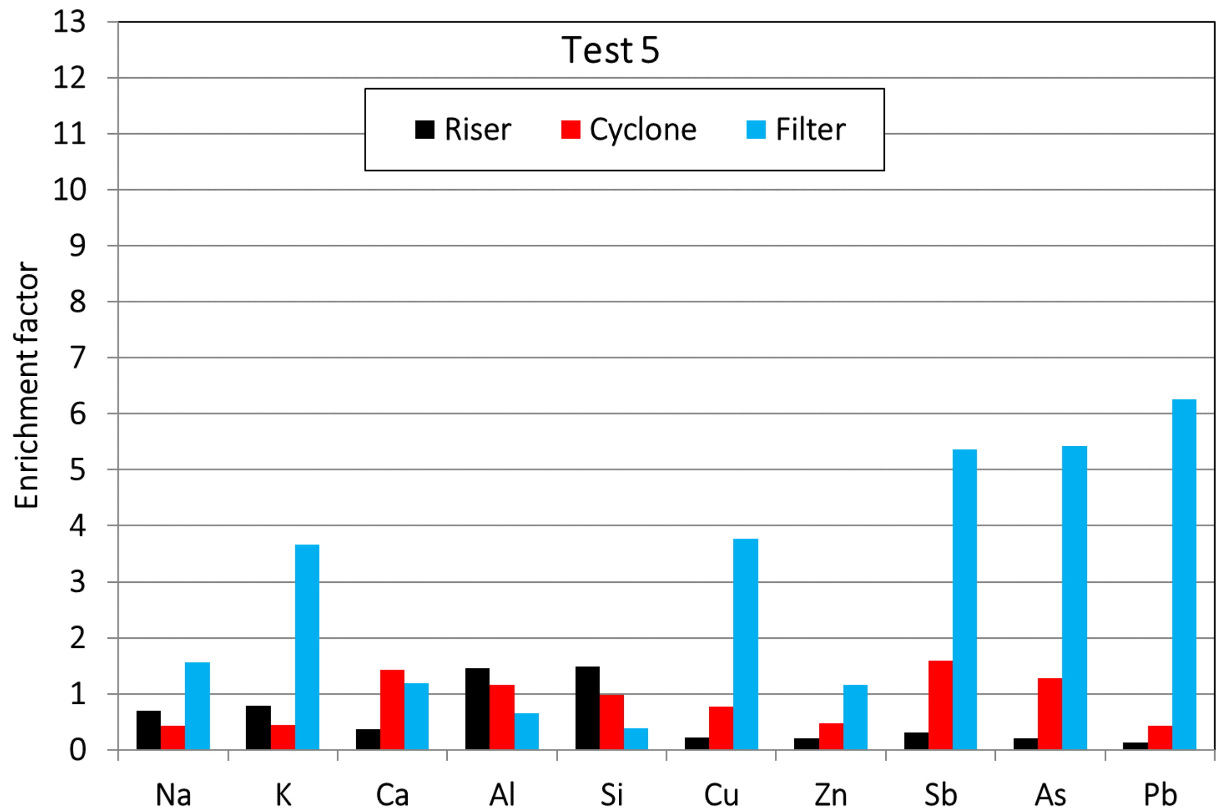


Enrichment factors (related to bulk ash composition)



Fly ash cleaning in cyclone

Modelling -> Experimental results

Modeling Gas Phase Partitioning of Sb, Cu, Pb (Basis)

- Fuel used: Model Waste wood composition

- Thermodynamic calculations were performed using global approach at 1 atm and air-to-fuel ratio range of 0.4 – 1.6 corresponding to the reducing and oxidizing conditions in the combustion system. The temperature range simulated is 500°C to 1200°C.

- FactSage 6.4: Database used are from FactPS, FTOxid and FTSalt, these are thermodynamic databases that come part of FactSage 6.4. FTOxid and FTSalt represent the molten or liquid phases.

- Gas phase partitioning:

$$\phi_{i,gas} = \frac{\text{mole of element } i \text{ in } \textit{gas phase}}{\text{mole of element } i \text{ in fuel}}$$

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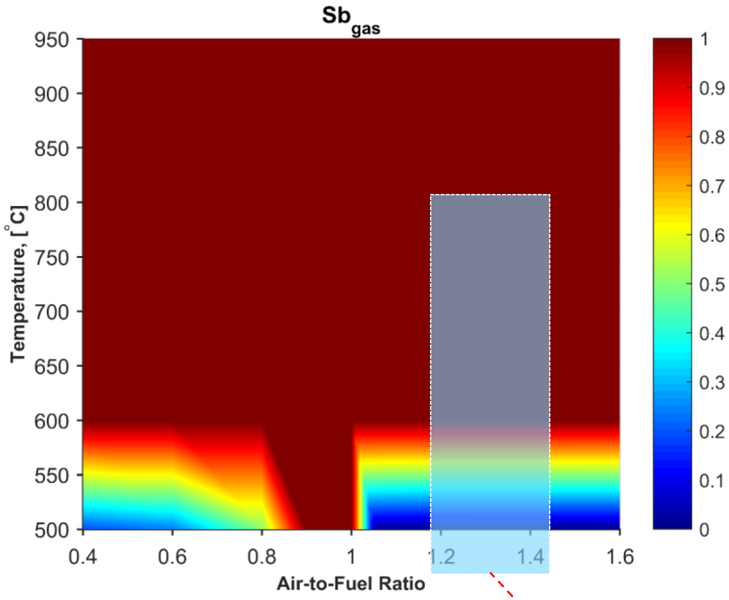
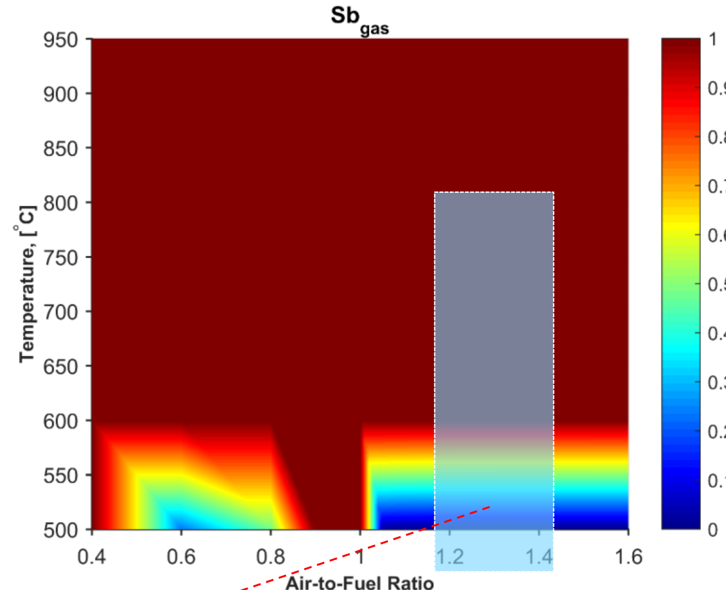
Modeling Gas Phase Partitioning of Sb, Cu, Pb (Antimony)

Base Case: Cl = 0.17 wt% db



High Cl Case: Cl = 0.36 wt% db



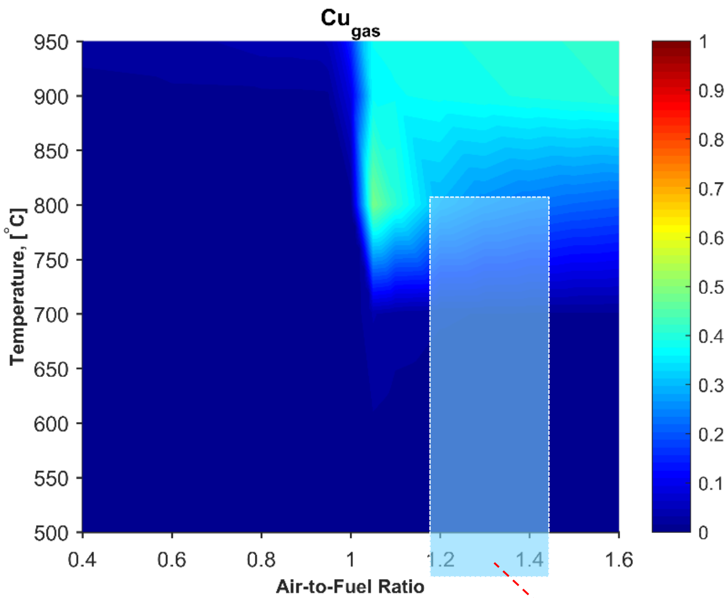
- Sb starts to condense at 600°C.
- At 500°C most of the Sb feed should have condensed.

- In the oxidizing zone, Sb's gas phase partitioning is not affected by Cl
- In the reducing zone (λ<0.5) gas phase partitioning is enhanced.

Region of interest: air/fuel ratio at cyclone, possible temperature range of operation

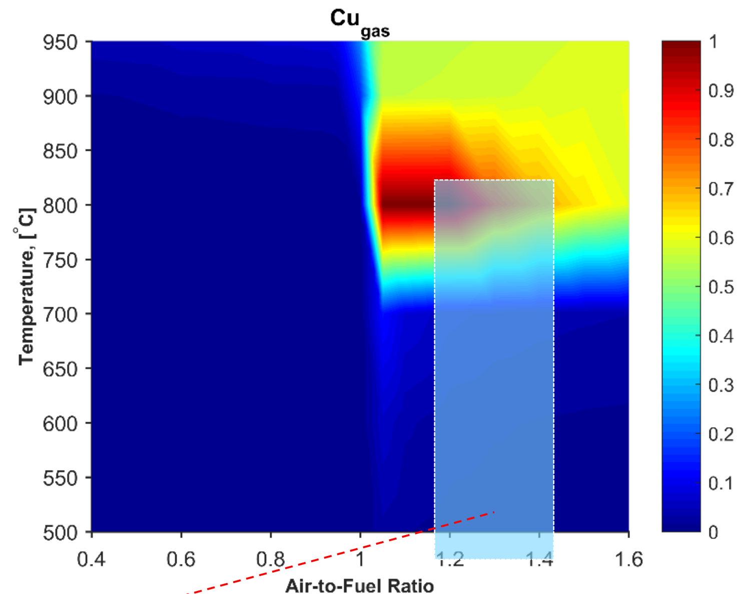
Modeling Gas Phase Partitioning of Sb, Cu, Pb (Copper)

Base Case: Cl = 0.17 wt% db



- Majority of Cu (>70%) has condensed at 800°C and below

High Cl Case: Cl = 0.36 wt% db



- Enhanced volatility of Cu at around 700 - 800°C
- Cu - Cl species formation is enhanced.

Region of interest: air/fuel ratio at cyclone, possible temperature range of operation

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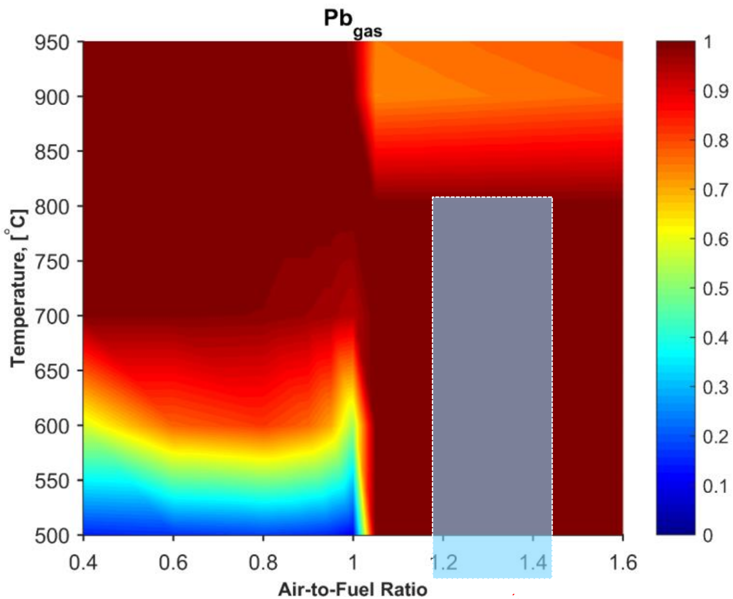
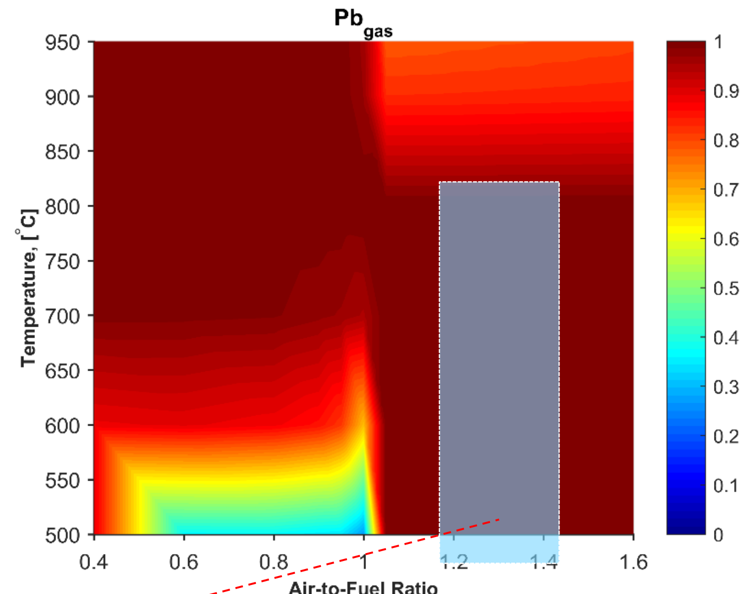
Modeling Gas Phase Partitioning of Sb, Cu, Pb (Lead)

Base Case: Cl = 0.17 wt% db



- Pb remains in the gas phase from 800 down to 500°C.

High Cl Case: Cl = 0.36 wt% db



- Pb remains in the gas phase from 800 down to 500°C.
- Pb is relatively more volatile at T > 800°C (around 10% more)
- In the reducing atmosphere, Pb is also more volatile.

Region of interest: air/fuel ratio at cyclone, possible temperature range of operation

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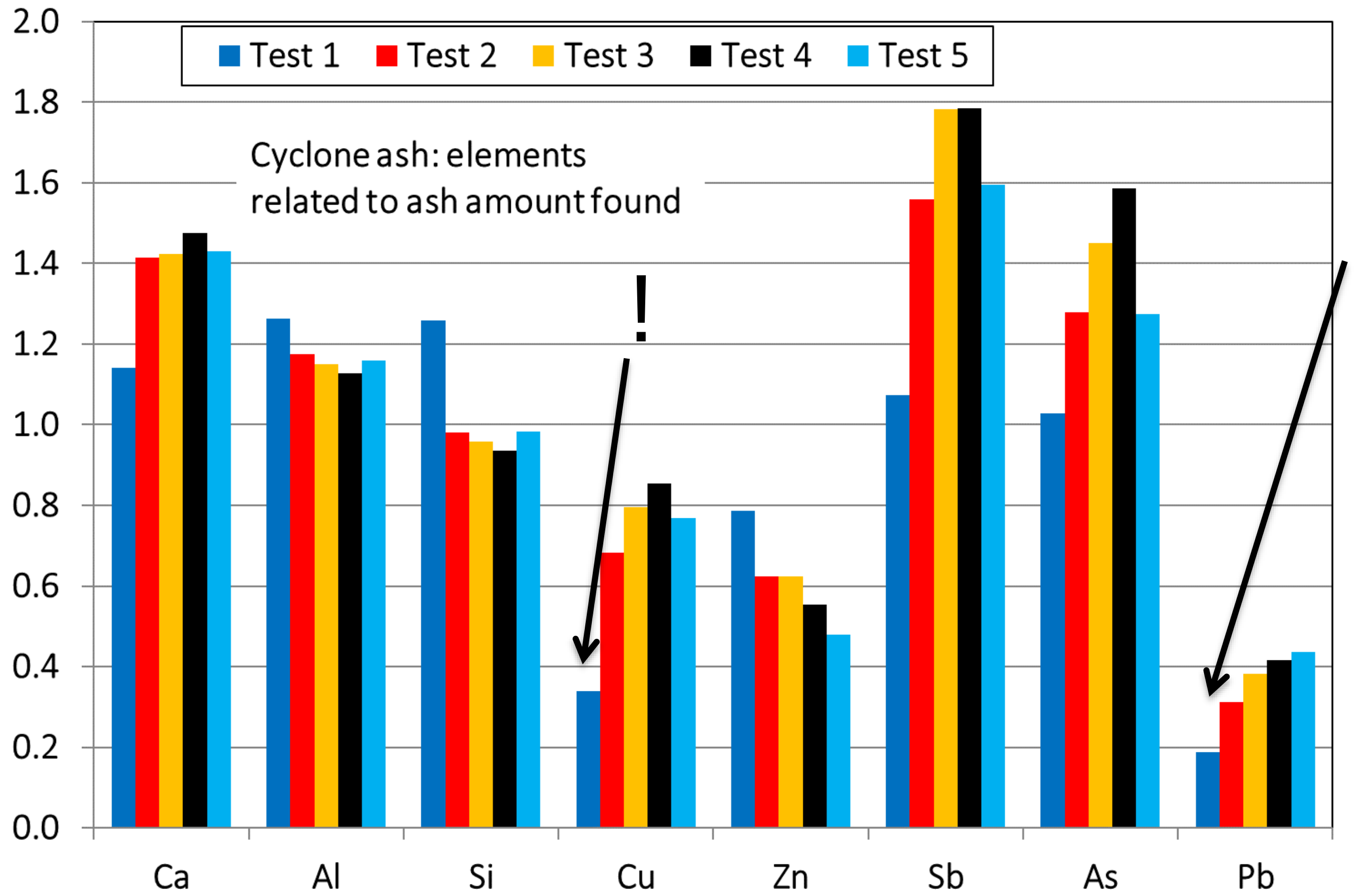
Mass flow of each element / mass flow of ash to cyclone > 1 enrichment, < 1 = cleaning (a portion passes through)



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Conclusions

- Two fuels were tested to know if hot cyclone has use to fly ash cleaning and if important elements can be enriched somewhere
- It was possible to reduce Pb concentration up to 79% and Cu concentration up to 65% in the fuel ash in a hot cyclone. No reduction in Sb concentration was found.
- Enrichment factors up to 12.3 for Pb, 6.5 for Sb and 5.0 for Cu were measured in filter ash. So, recovery can be possible from a selected fly ash fraction of a power plant. This prevails especially for Sb (as a valuable element)
- Modelling predicted behaviour of Pb and Cu in the hot cyclone in a satisfactory level, but failed with Sb. Other phenomena than chemistry such as surface adsorption dominated with Sb.

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Conclusions

- Knowledge of heavy metal behaviour in fluidized bed combustion is important
  - Emissions
  - Boiler design
  - Ash quality

- Improvement of ash quality prediction
  - Process and fuel optimisation also form ash quality point of view
  - Optimal handling of different ash fractions
  - Disposal cost / Utilization value

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