

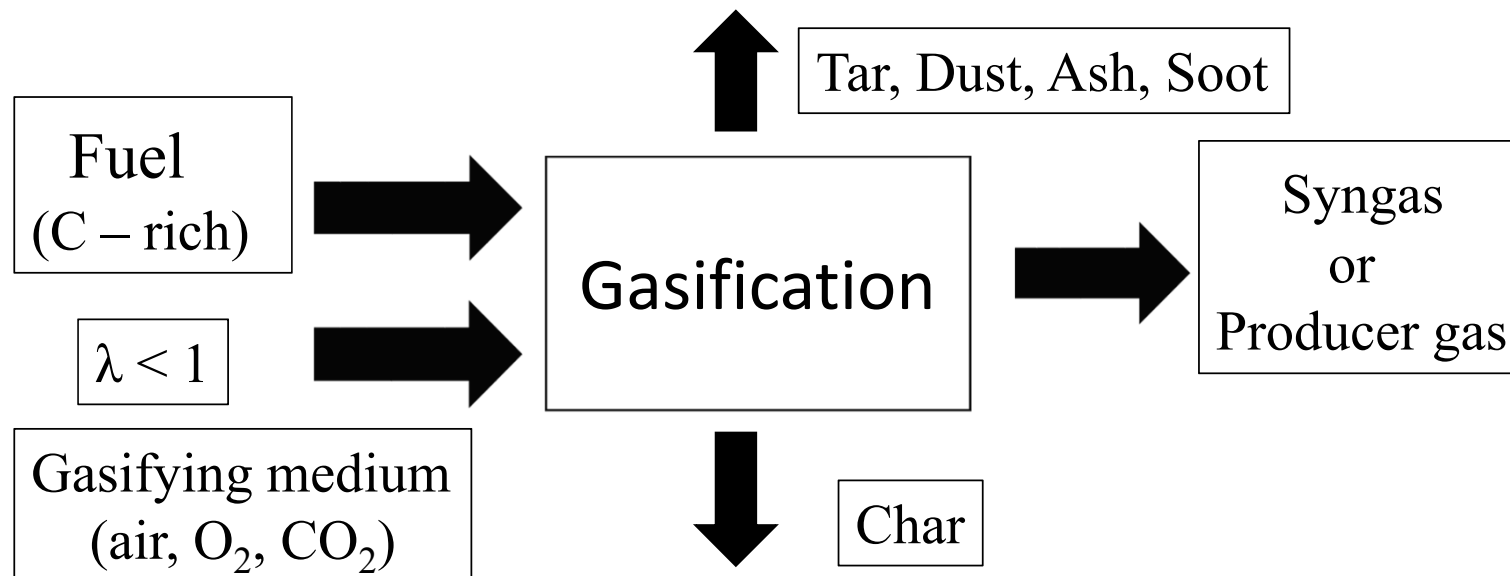
Thermodynamic modelling of potassium in the after-burner of a biomass gasifier

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Concept of gasification

Gasification is a thermal process which under sub- stoichiometric conditions “packs” energy into chemical bonds



Syngas - Producer gas

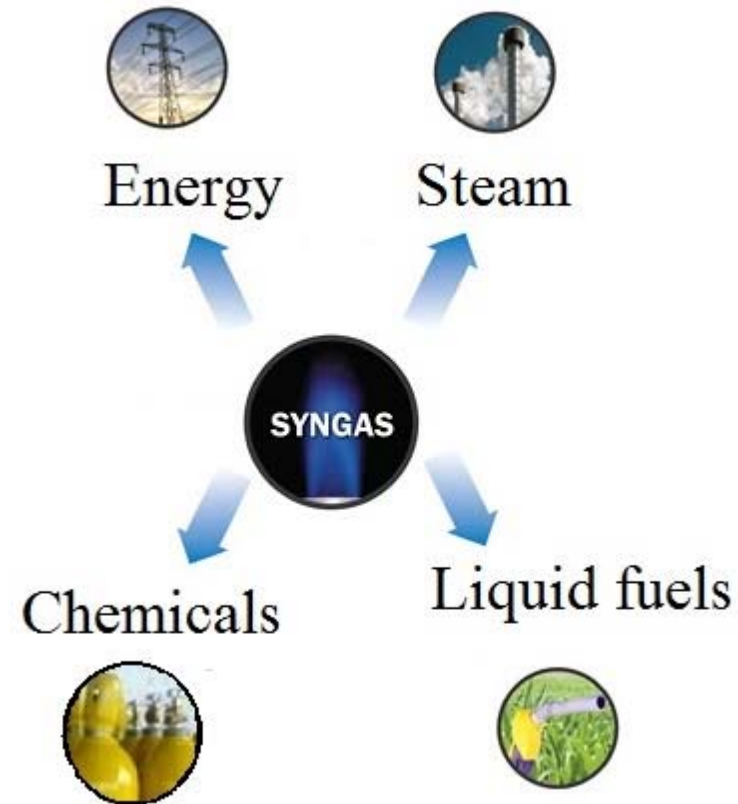
Syngas

CO, H₂

Producer gas

CO , H₂ , CO₂, CH₄

but also N₂

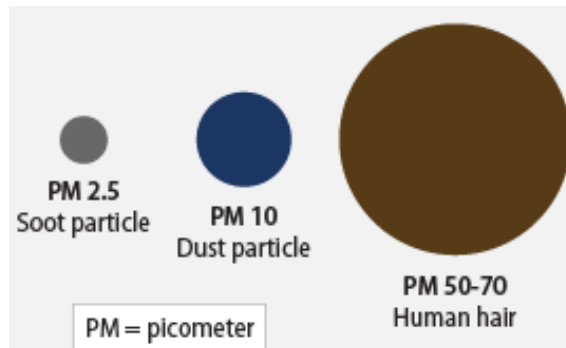


Other by-products

Tar - heavy organic compounds



Dust - Soot



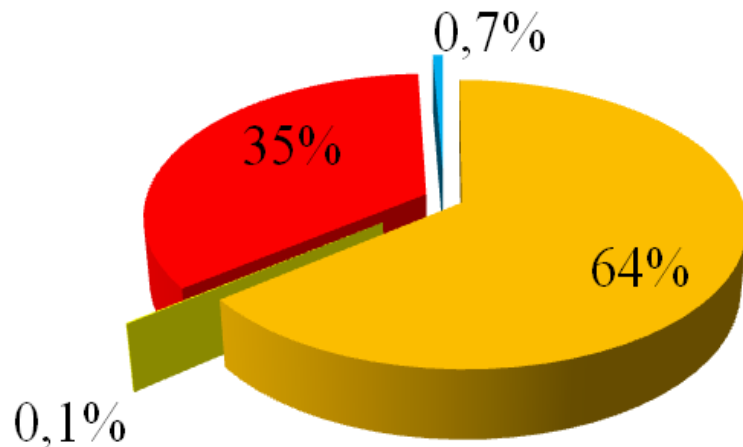
Char – high in carbon
Ash – inert minerals



Char characteristics and management

Char is a carbon rich material and its structure is similar to graphite

■ C ■ N ■ Ash ■ H



Management of the residue char remains an important problem in the small scale gasification sector.

The main reason is the concentration of heavy metals.

Solutions to the problem should be developed on a local level or even better onsite, since the amount of produced char from small scale gasifiers is not sufficient in order to provide incentives for more centralized projects.

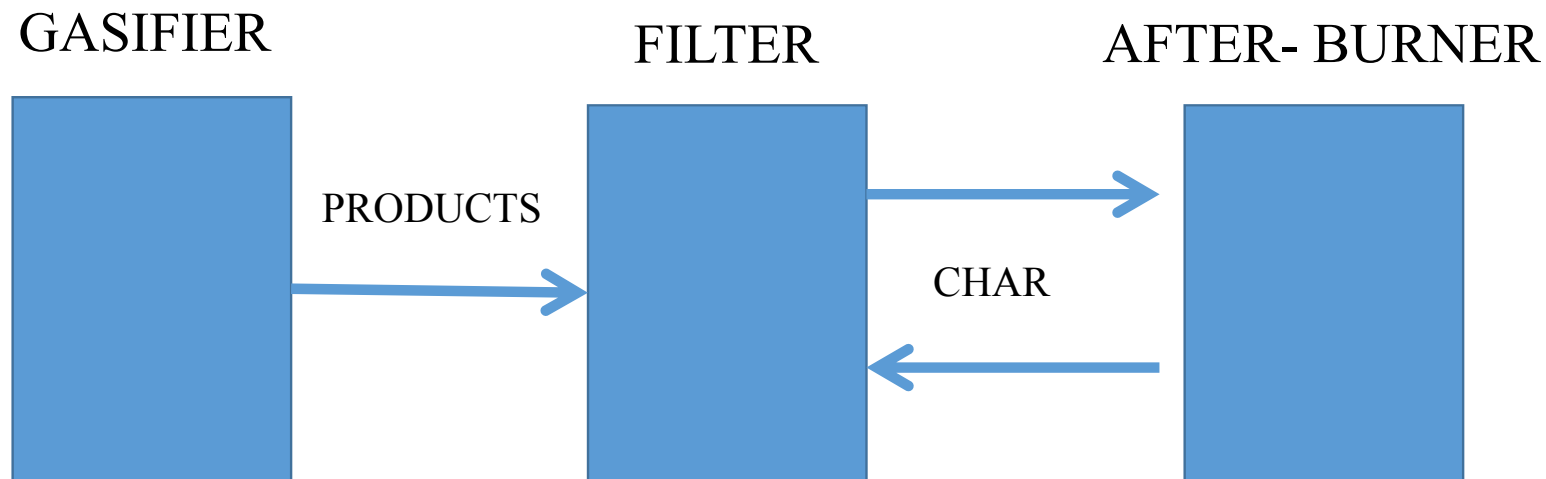
Gasifier with an onsite application



- Joos gasifier
- Two separate vessels
- 30 kWe, 80 kWth
- Main product: producer gas
- 23 – 25 % el. Efficiency
- 70 % CHP efficiency
- 2 – 5 % char as by - product

Source: Spanner RE website

The introduction of an after- burner



Char reacts on a secondary stage with air at an elevated temperature (450 °C – 750 °C). The scope is the distribution of heavy metals between the gaseous and the solid phase. Usually a reduction > 20 % is sufficient for reduction into accepted environmental limits.

Benefits of after-burner integration

The content of heavy metals is correlated to the quality of the input.

After gasification their concentration increases by orders of magnitude.

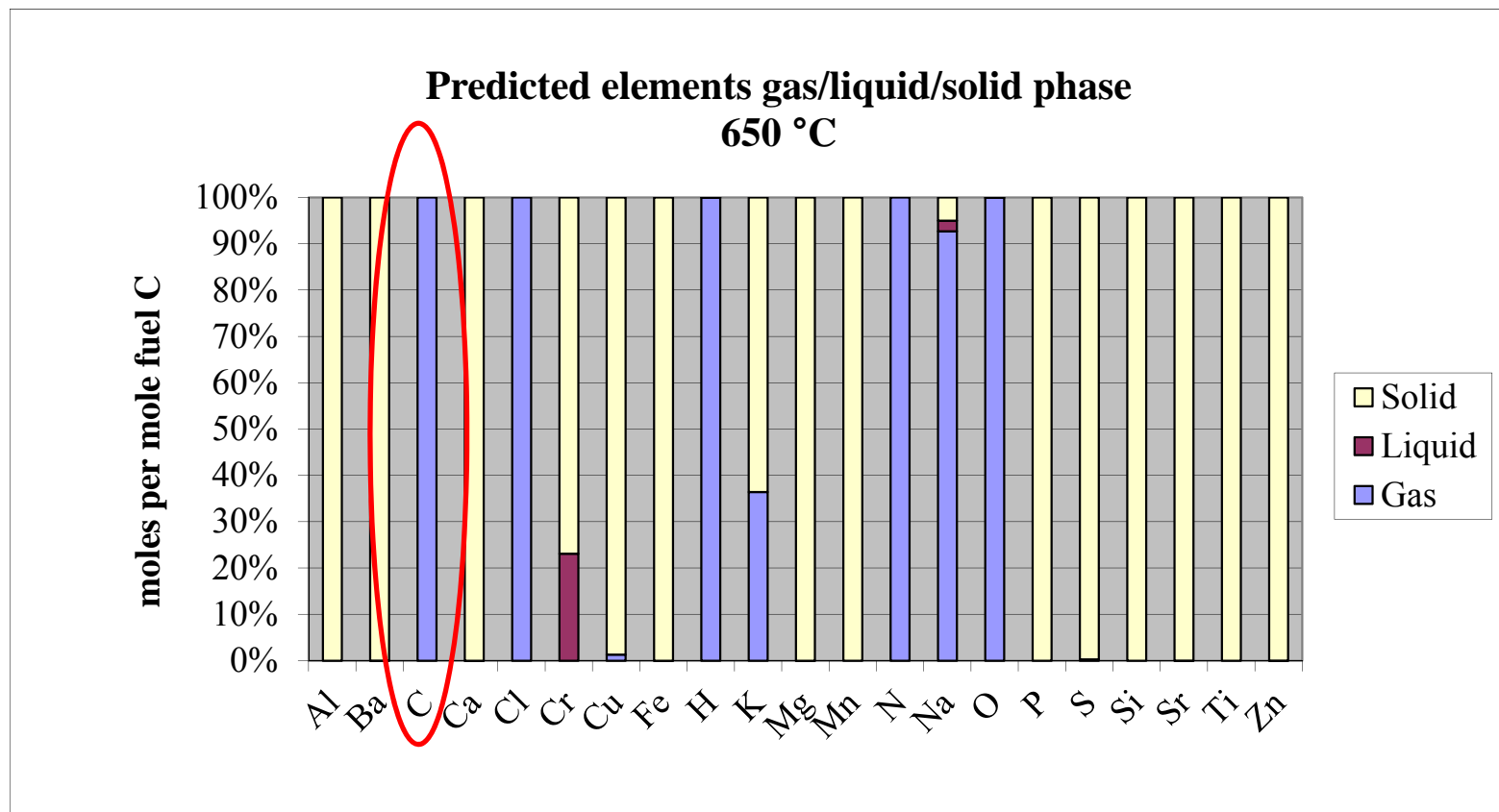
As a result, char may be potentially treated as hazardous waste. The integration of an after-burner assists:

- Reduction of char volume
- Reduction of heavy metals and alkali metals content
- Reduction of tar compounds trapped in the solid residue

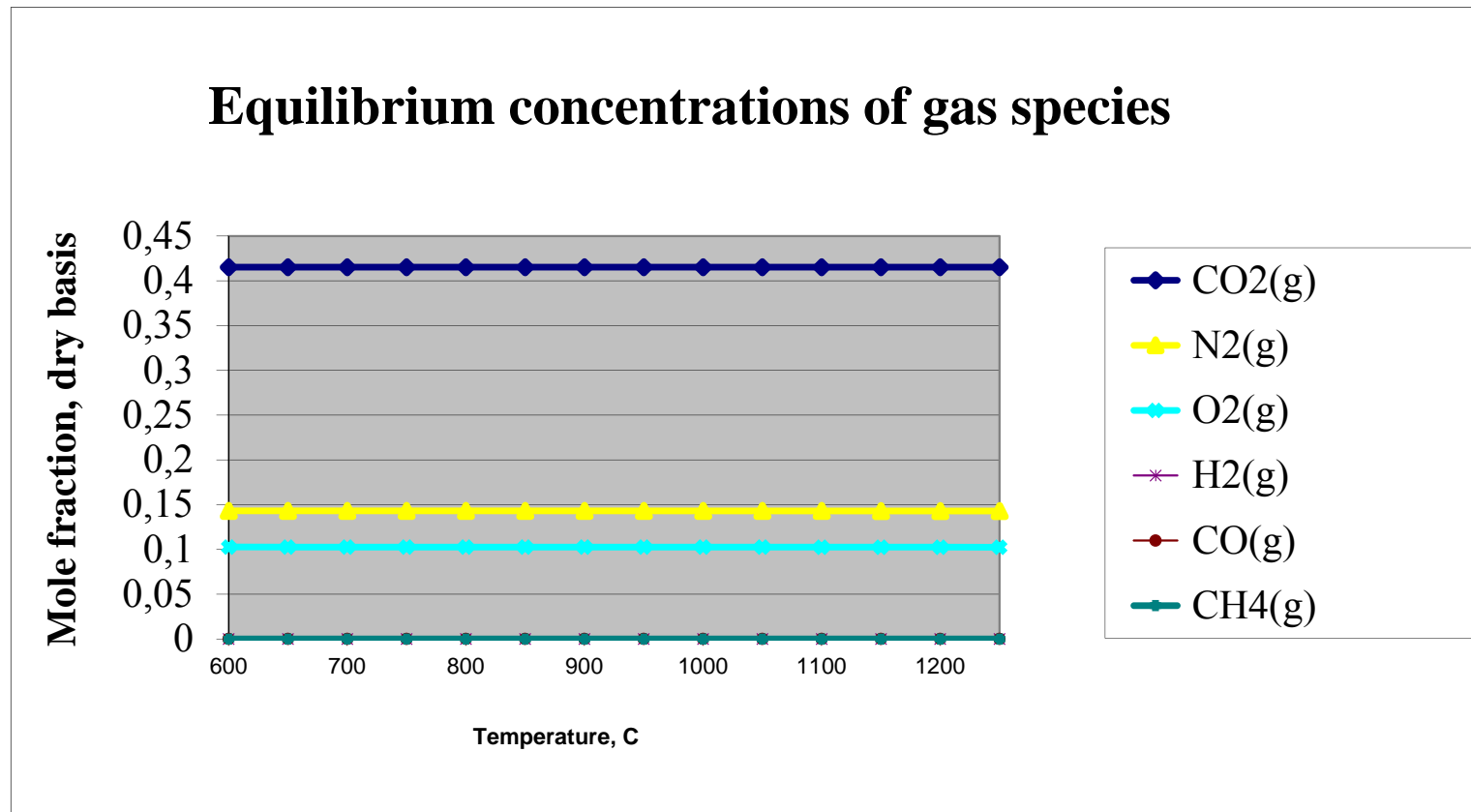
Modelling the after - burner

- Optimization of the after – burner has the scope to minimize simultaneously char - tar – metals contents
- A commercial software was utilized for modelling the equilibriums of heavy and alkali metals. (Master Thesis of Barbora Zezulova)
- The commercial software provided very interesting results concerning the thermodynamic equilibriums of all the investigated heavy and alkali metals.
- Nonetheless, **several issues** had to be taken into consideration for the case of the after-burner.

Issue 1 - Yield of carbon



Issue 2 – Gas composition

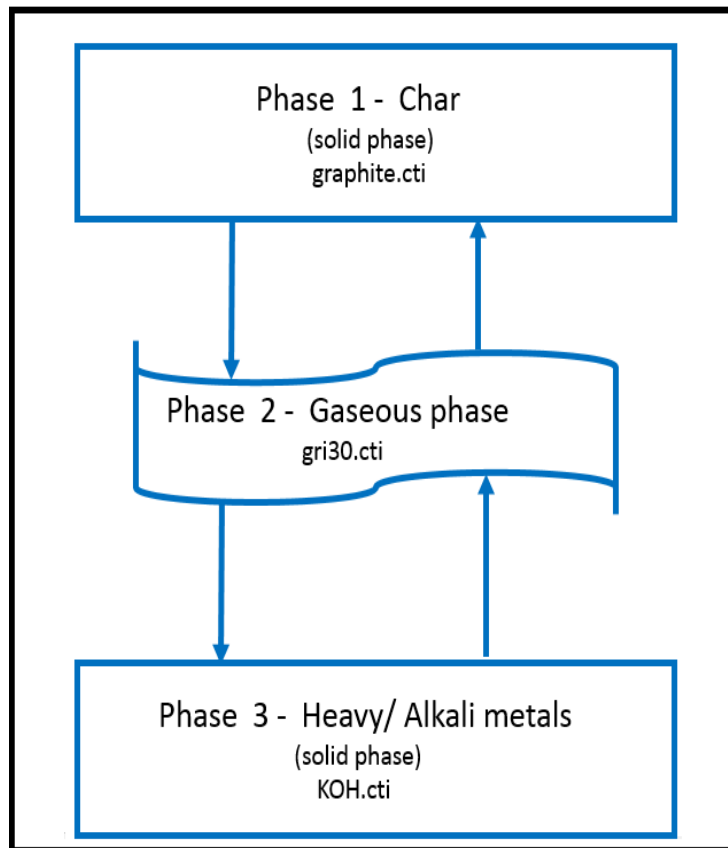


Issue 3 – Air input in the after-burner



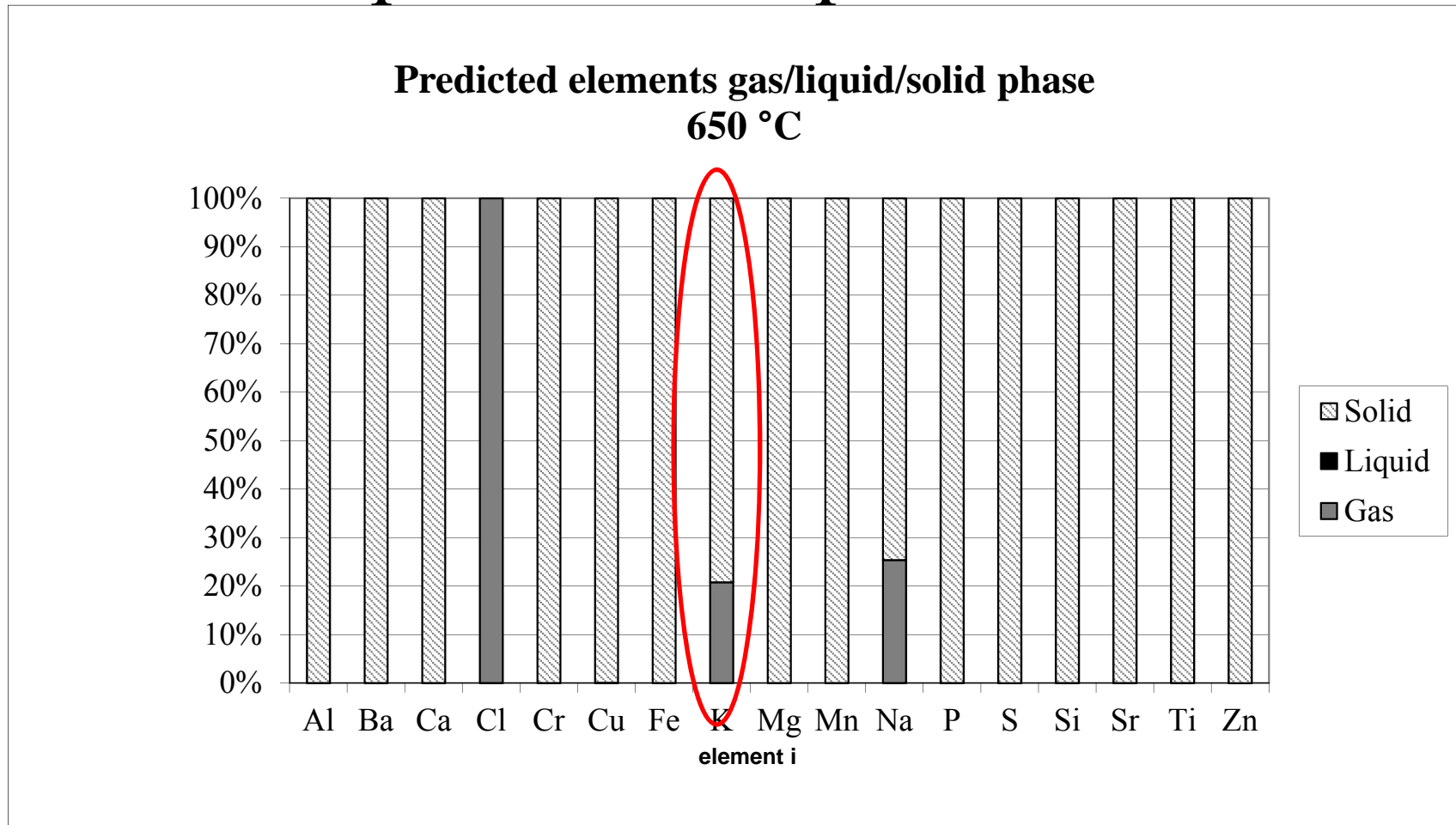
Air input can be measured by means of a Pitot tube. Nonetheless, the input is separated in two streams in order to cover the operation of the gasifier and the operation the after-burner. The air that enters the after- burner can be only indirectly calculated.

Introduction of thermodynamic model



- MATLAB/ Cantera model
- Databases: GRI-Mech, NASA
- Mechanisms: KOH.cti., graphite.cti, gri30.cti
- 3-phase model with char phase represented by graphite and potassium/ potassium oxides is represented by the KOH.cti

Solid – Liquid – Gas equilibria of metals



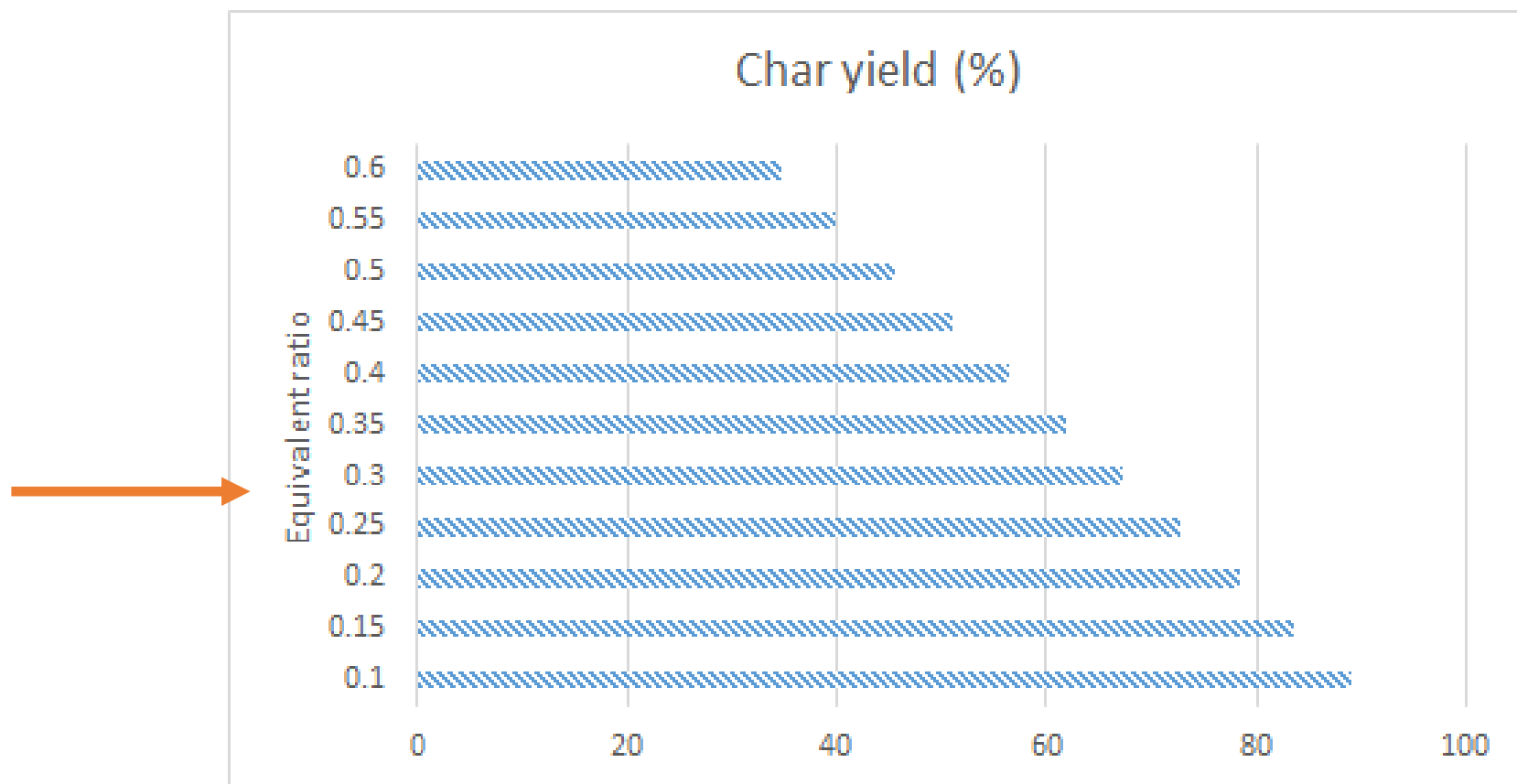
Fundamental concept of the model

- The balance of char is used as a control variable in order to assess the amount of reactive oxygen.
- Potassium yield is calculated for different temperatures.
- Gaseous species are calculated in accordance

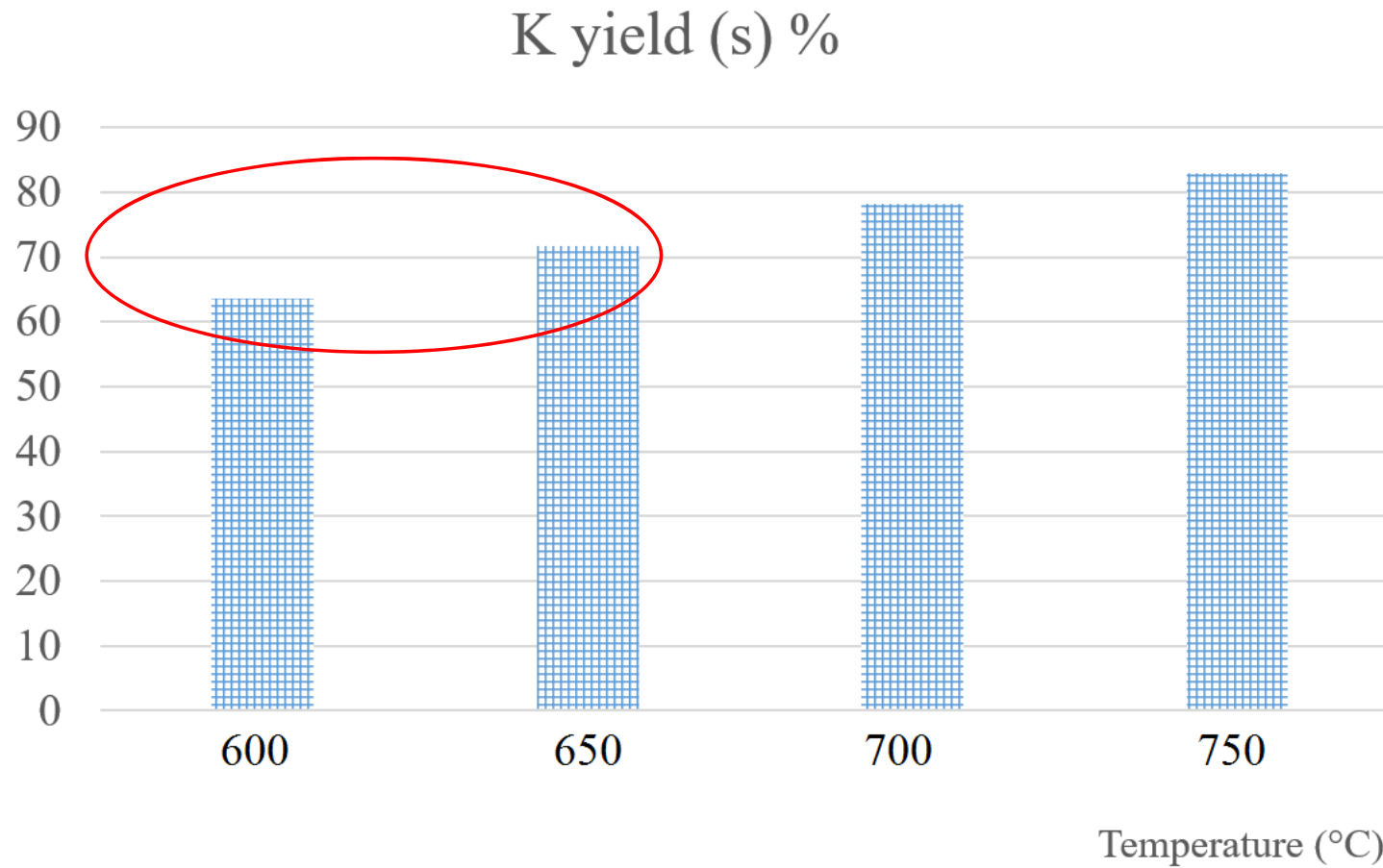
Monitoring of a Spanner gasifier was used for verification of results

- Spanner HK30
- Hochschule Zittau/ Görlitz
- Measurements follow the ‘Recommendation CTI 13‘

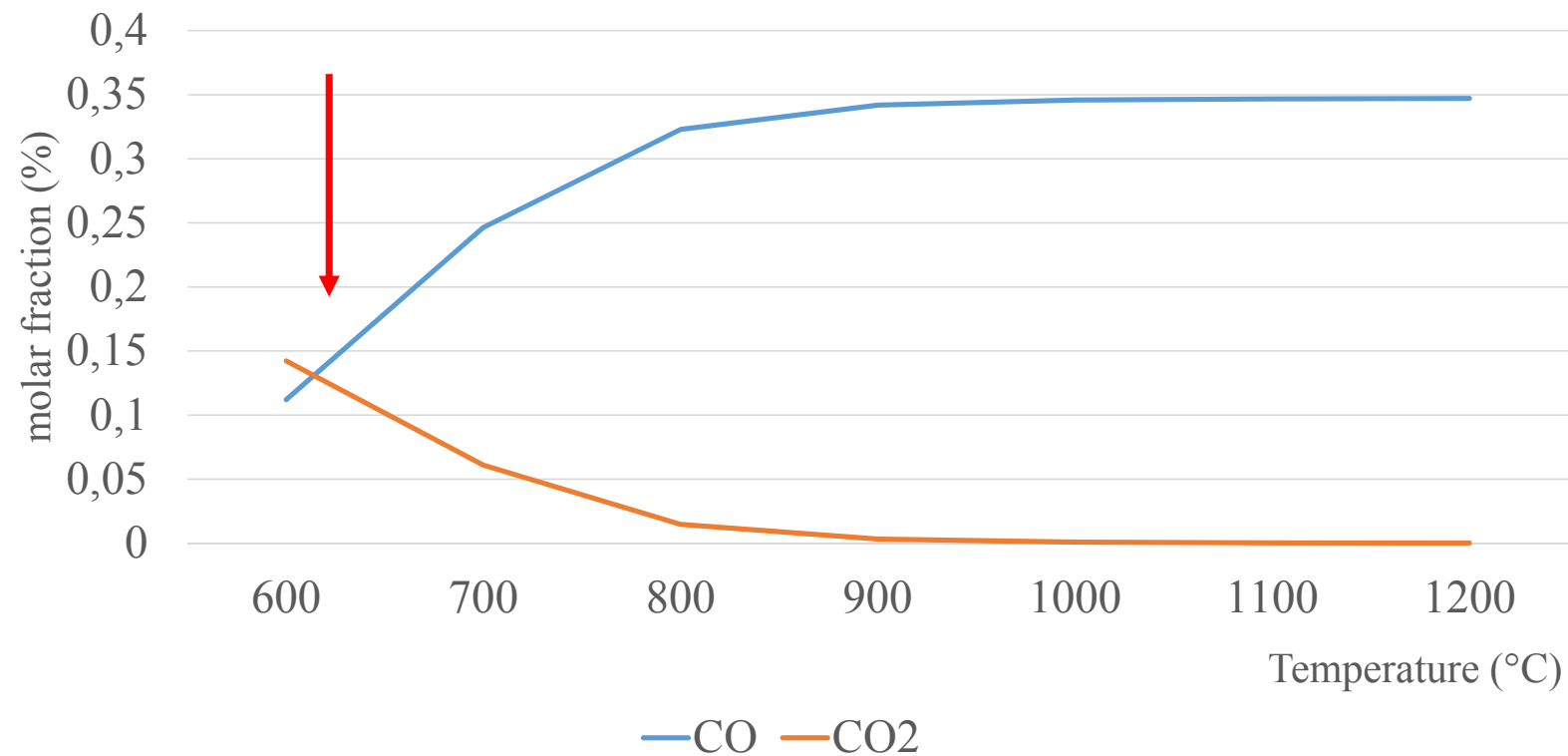
Results – Char residue yield



Results- Solid pottasium (K) yield



Results - Gaseous species (ER 0.25)



Comparison of results (at 650 °C/ 0.25 ER)

	Commercial software	Cantera model	Case study
Char Yield	0%	75 %	79.5 %
Potassium Yield	78 %	72 %	70.2 %
Gaseous Species	Primarily carbon dioxide at all temperatures	Transition to carbon monoxide above 700 °C	n.a.

Conclusions

- The utilization of an after-burner is a unique commercial application that is financially sustainable.
- Modelling the after-burner may result to the optimization of the process
- The Cantera model was able to return more reliable results for the estimated char yield, potassium yield and the composition of the main gaseous species in comparison to the commercial software.
- It should be denoted that this model aims only to assist and not to replace commercial softwares.

THANK YOU FOR YOUR ATTENTION!

For further info:

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