New thermal processes for tomorrow´s energy system

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Fluidized bed technology and development

Chalmers involved in the development since the 70th

Flue gases

Fuel

Chalmers 16 MW BFB 1982
(12 MW CFB since 1989)

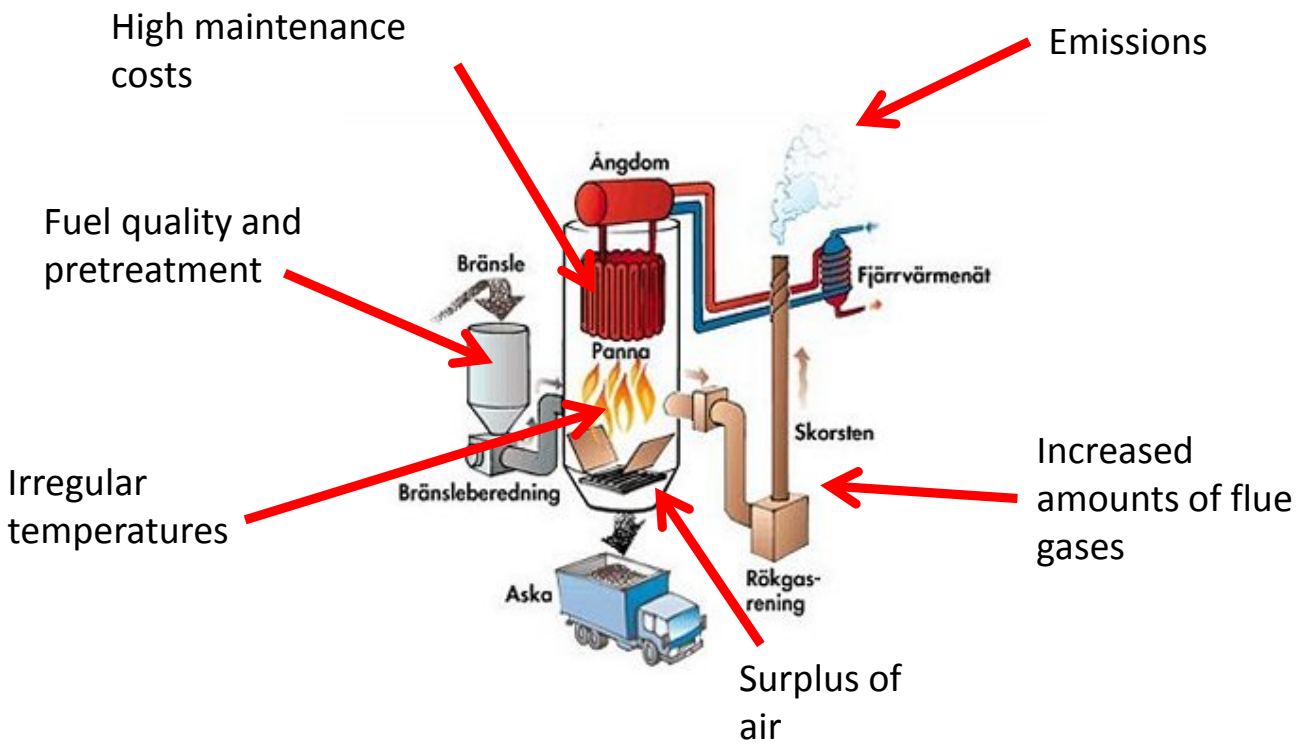
Thermal processes covered in this presentation

- OCAC oxygen carrier aided combustion
- Indirect gasification
- Chemical Looping Combustion

Experimental Facilities

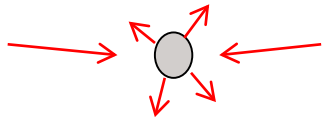
Oxygen Carrier Aided Combustion (OCAC)

Issues to address to improve performance and efficiencies of biomass boilers and waste incinerators



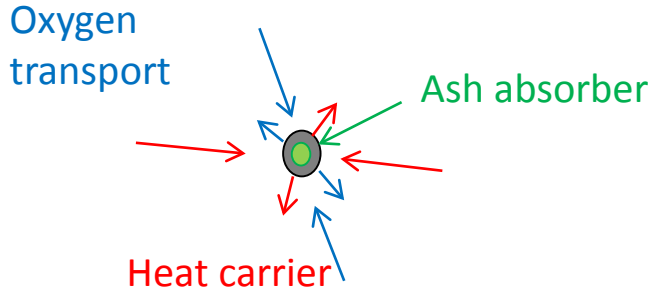
Principal of new combustion concept

Silica-sand is a conventionally adopted material with a single function



Heat carrier

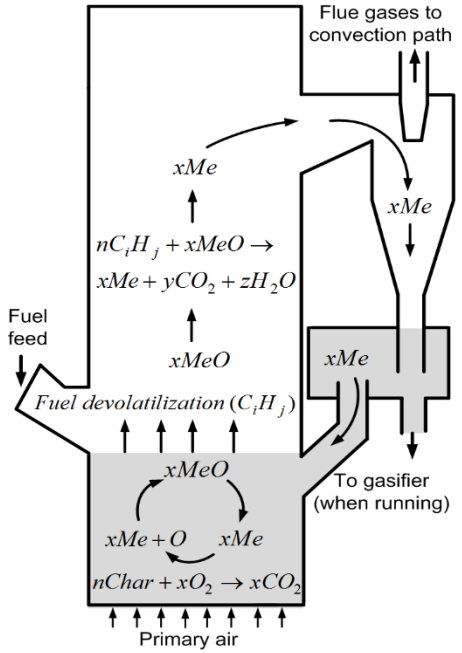
Metal-oxides provides several functions with synergy effects and exists as natural ores

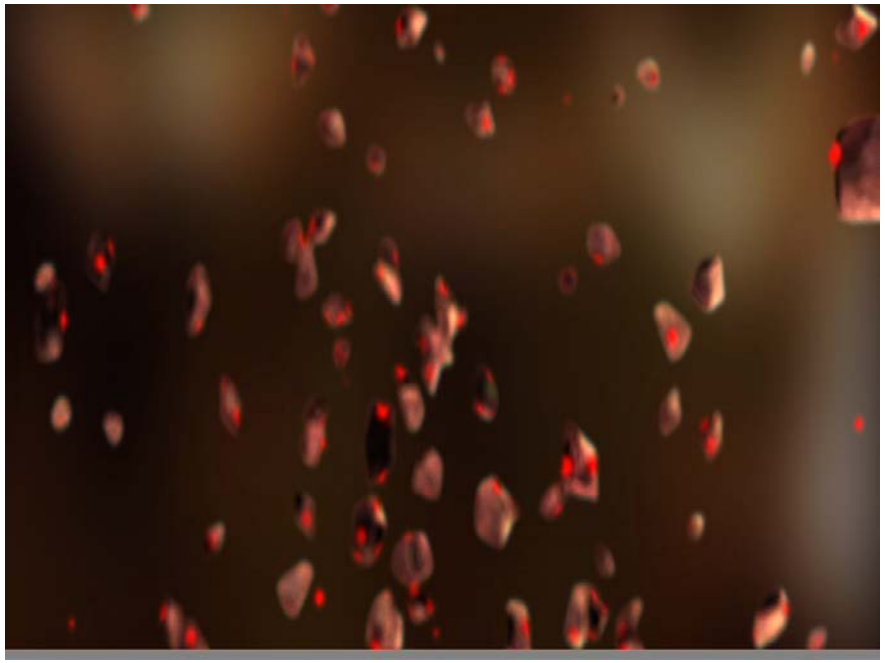


Benefits

- Combusting more complex fuels
- Heat is absorbed in the bed material
- Oxygen-carrying properties, double effect

Principal of new combustion concept





Thunman, H. ; Lind, F. ; Breitholtz, C. et al. (2013). Using an oxygen-carrier as bed material for combustion of biomass in a 12-MWth circulating fluidized-bed boiler. *Fuel*. 113 s. 300-309.

Commercialization (100% switch of bed material)

2013

Lab scale reactor

2014

CTH-boiler 12MW$_{th}$

2014-

Händelöverket 75 – 80 MW$_{th}$

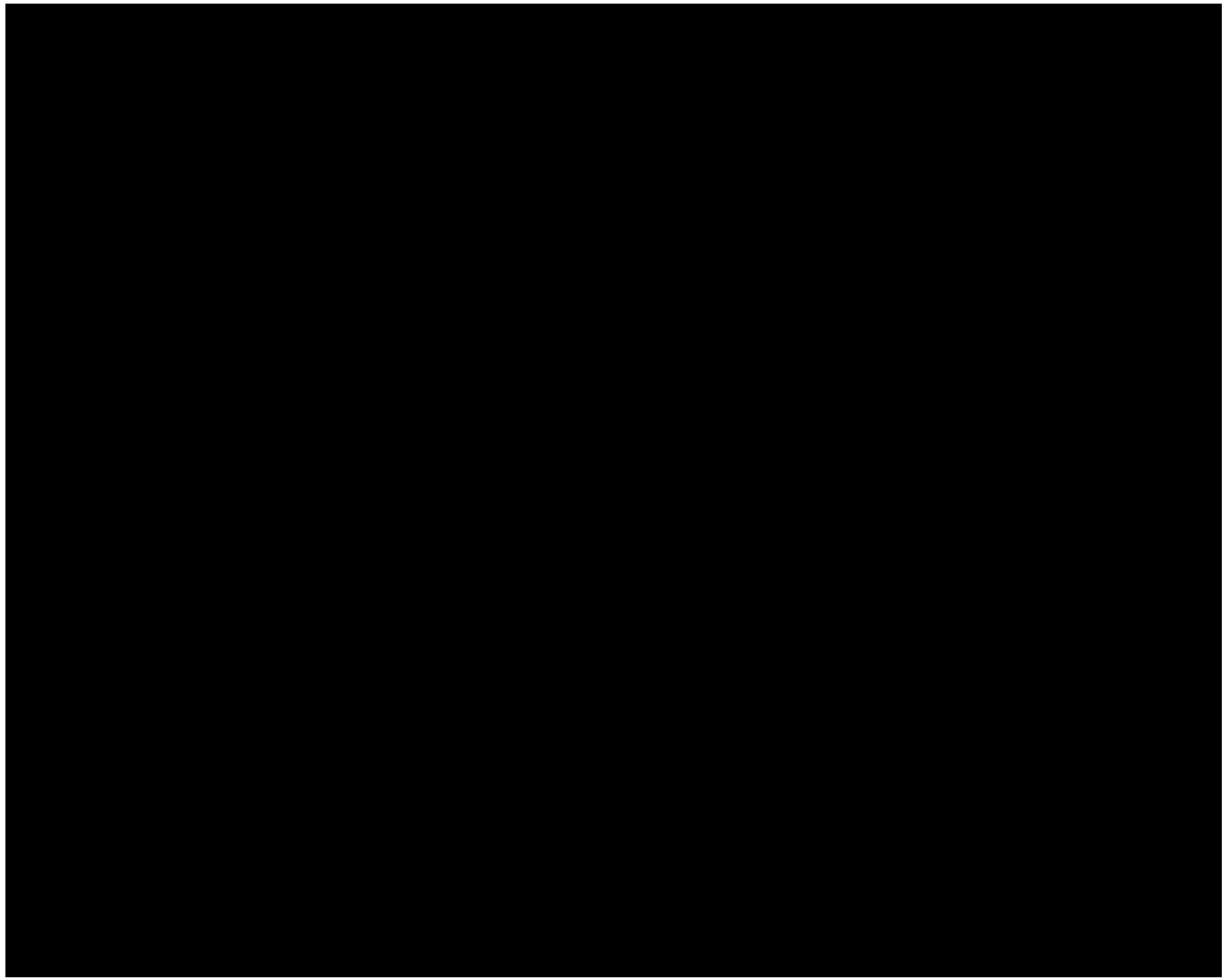
Waste incinerator

2015

Improbed

Contact: Lars Bierlein
lars.bierlein@eon.se

How do a 1 MW pulse look like?



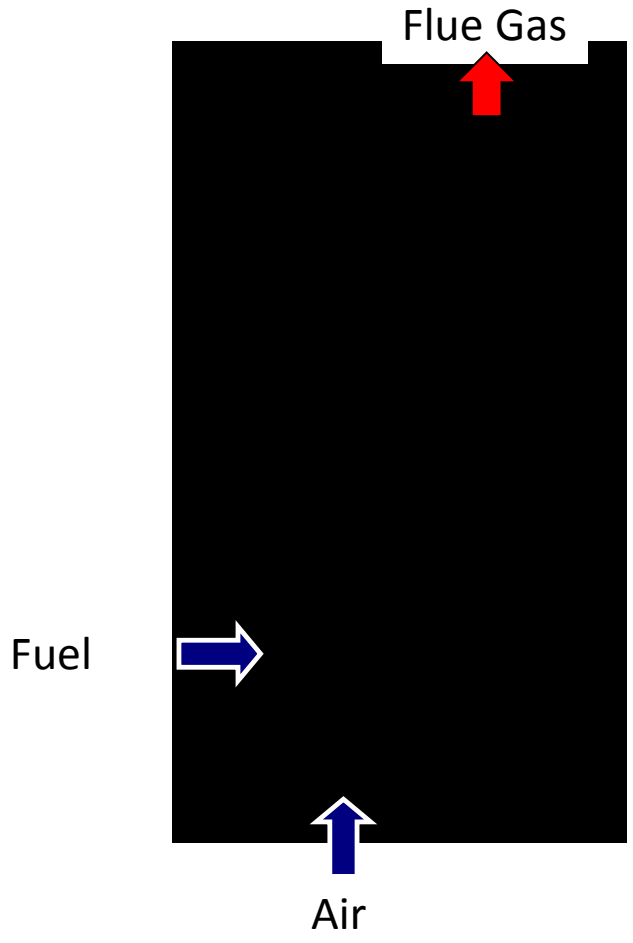
Oxygen balance Chalmers's boiler

Pulse of 3 kg wood pellets consume
In total appr. 4,5 kg oxygen or in average
0,5 kg/s during 9 s

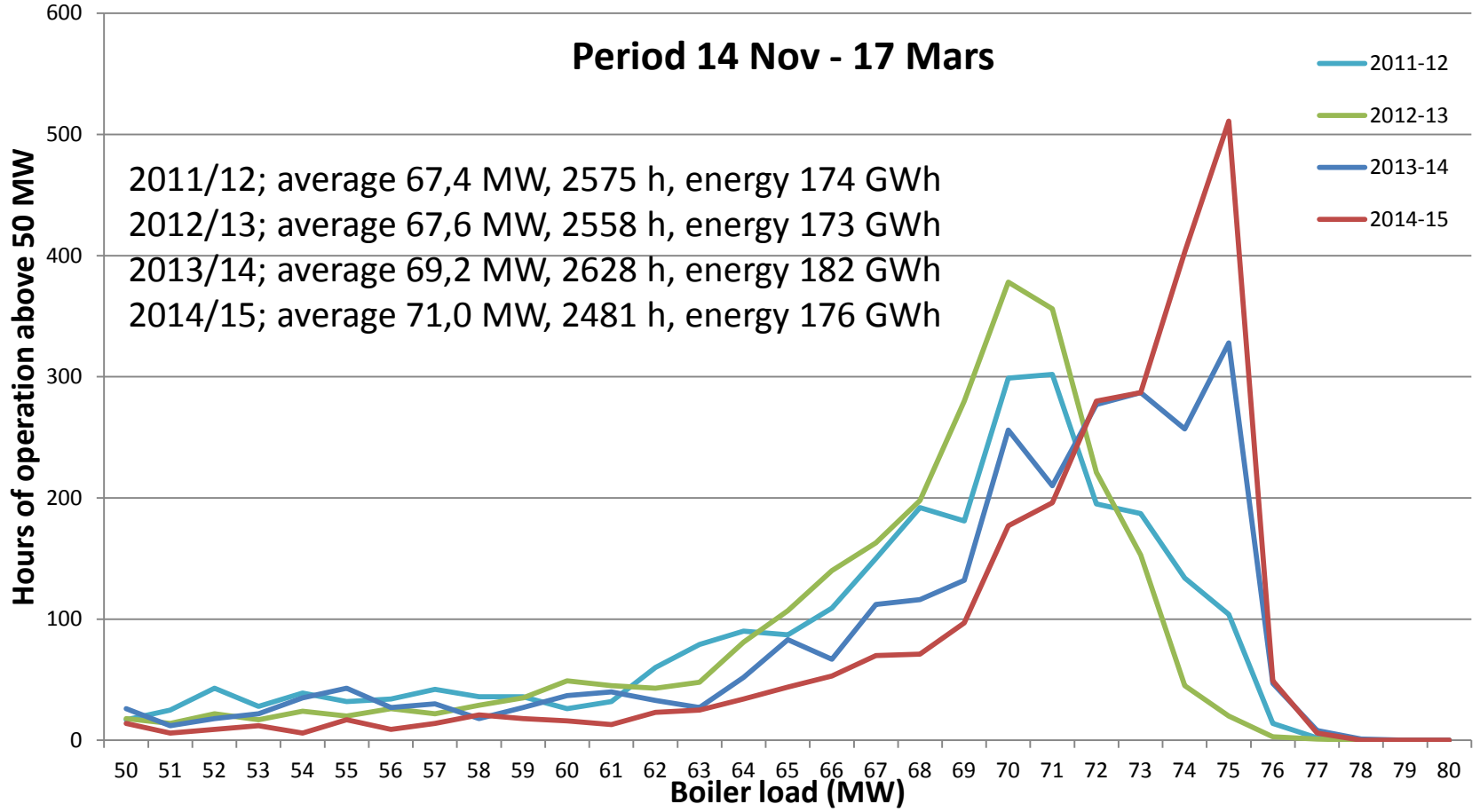
- Oxygen i gas phase
  - 1 kg free oxygen in boiler
  - 0,5 kg/s added as air
  - 0,1 kg/s in excess
- Oxygen stored in bed material
  - 100 kg

⇒ Increase available oxygen with 10 000 %

Circulating fluidized bed boiler
Heat and Power production



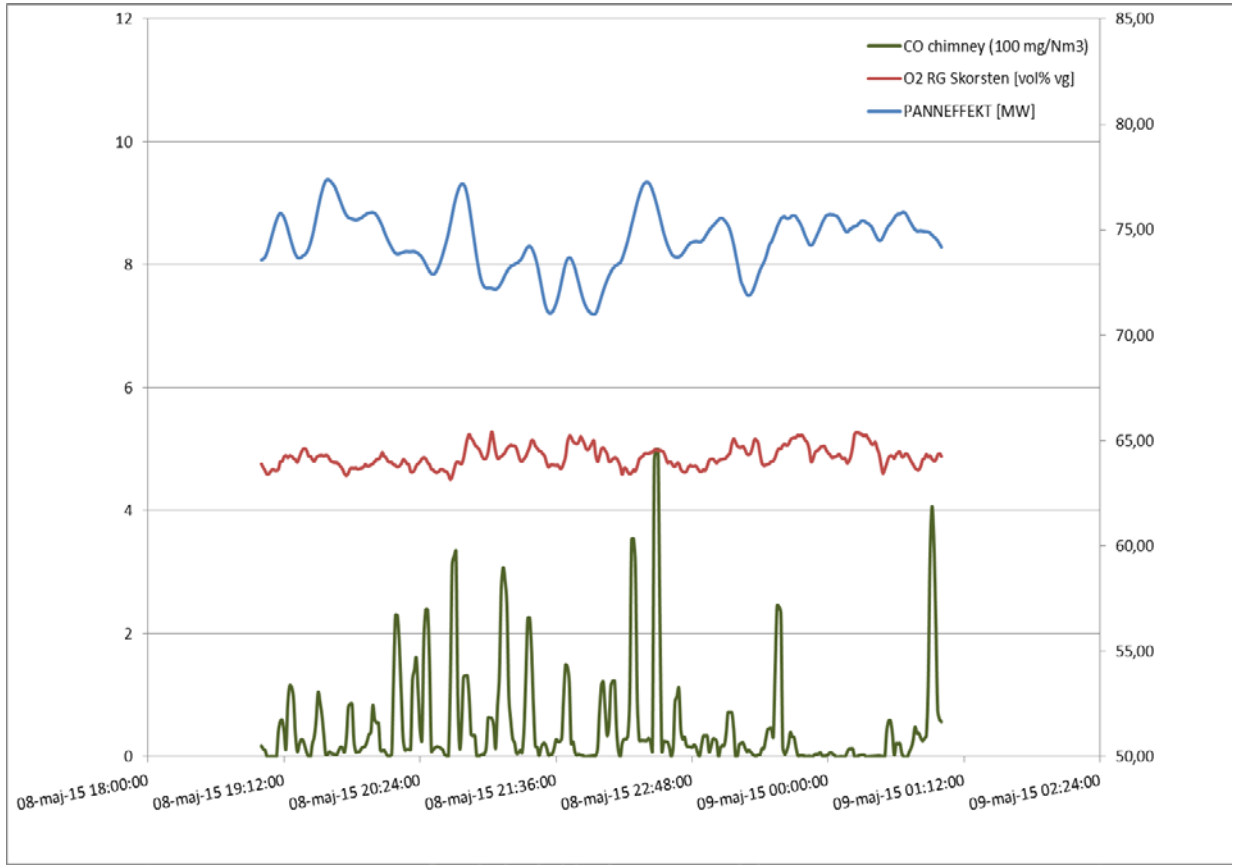
Improbed – Results boiler load 2014 - 15



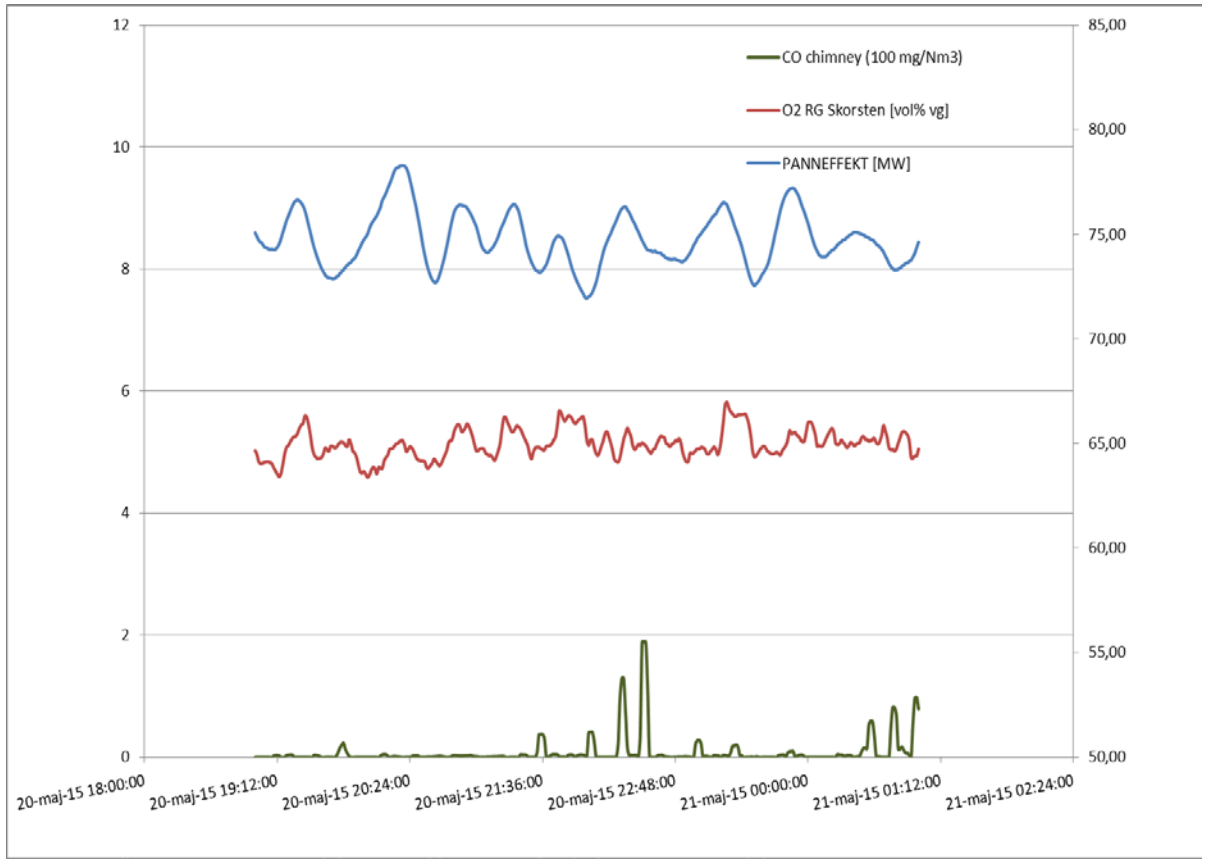
- Average load increased by more than 4% compared to earlier seasons

CO emissions 75 MW waste boiler

Silica Sand operation



Ilmenite operation



- 75 MW – 5% O2 – CO emissions

Indirect Gasification

Vision for research

Demonstrate how to produce:

1. A gas that can substitute natural gas with a thermal efficiency of 85% (+10-15% units higher than today)

2. Electricity from biomass with an efficiency above 50% (+10-15% units higher than today)

Theoretical limitations from methane produced from biomass

- Biomass ~ CH_2O

- Efficiency to methane based on elemental composition
  - CH_2O => ½ CH4 + ½ CO2

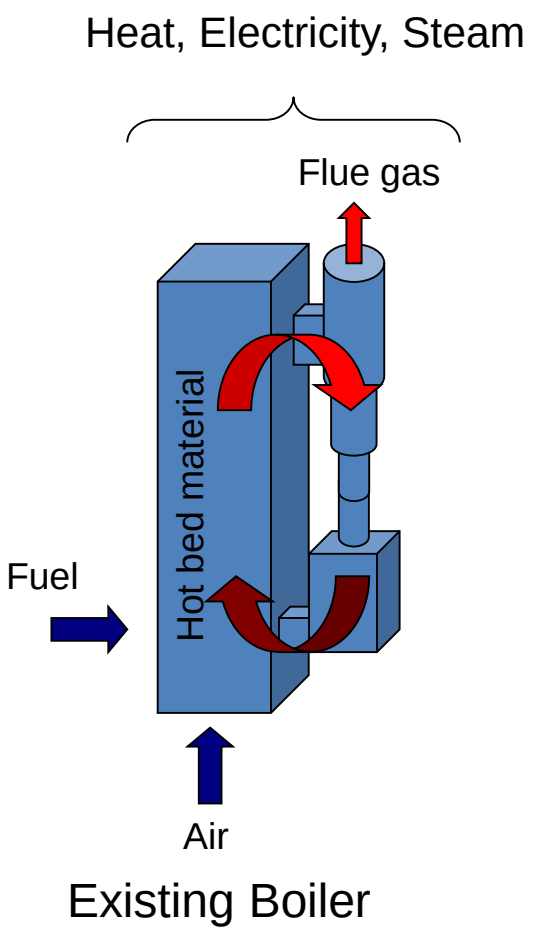
  Theoretical efficiency ½ * 800 / (2*223) = 90%

  Based on lower heating value of received fuel (biomass 50% moisture), standard definition of efficiency heat and power plants in Europe

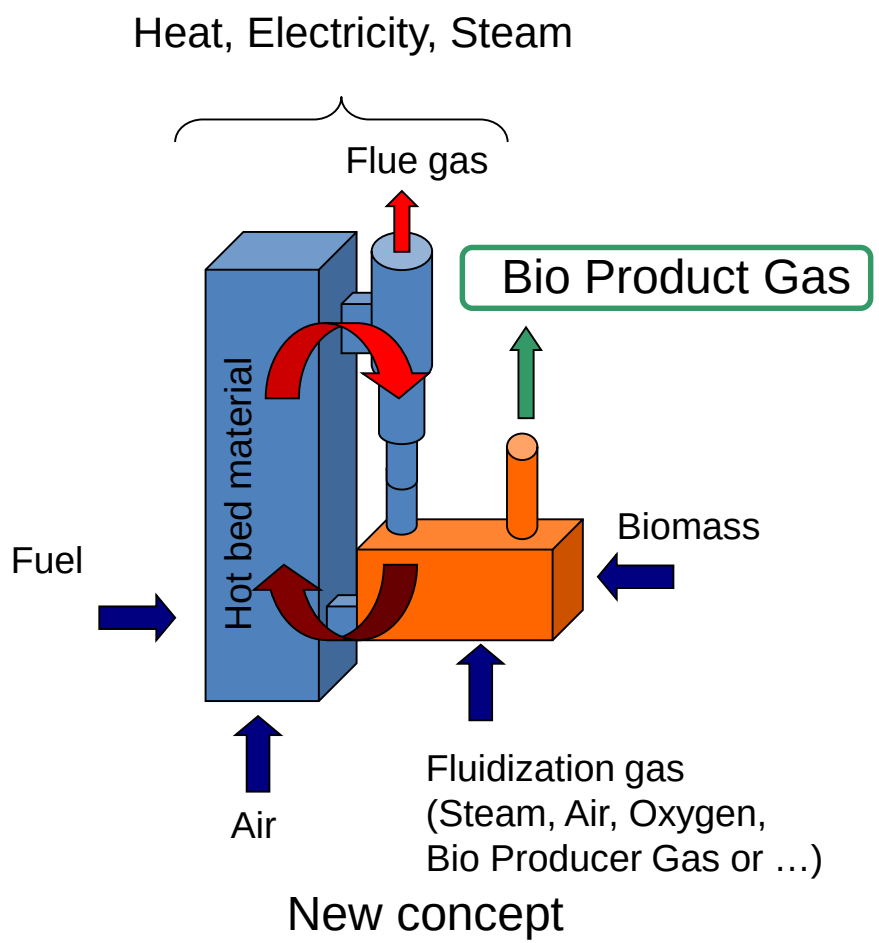
  Theoretical efficiency = 18.6/((18.6 *0.5/(1-0.5)*2.4)*0.9 = 103 %

  (85% as given by vision correspond to 82% of theoretical)

Integration with traditional boiler



Existing Boiler

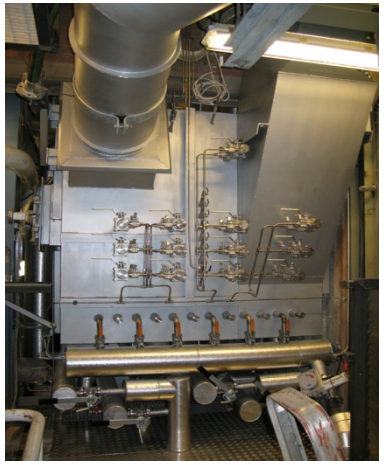


New concept

Outline of demonstration

Chalmers lab reactor

Chalmers
2-4 MW Raw Gas
Pilot Plant



1.6 M$

GoBiGas Phase 1 Hisingen
20 MW Biomethane
Demonstration Plant
Göteborg Energi

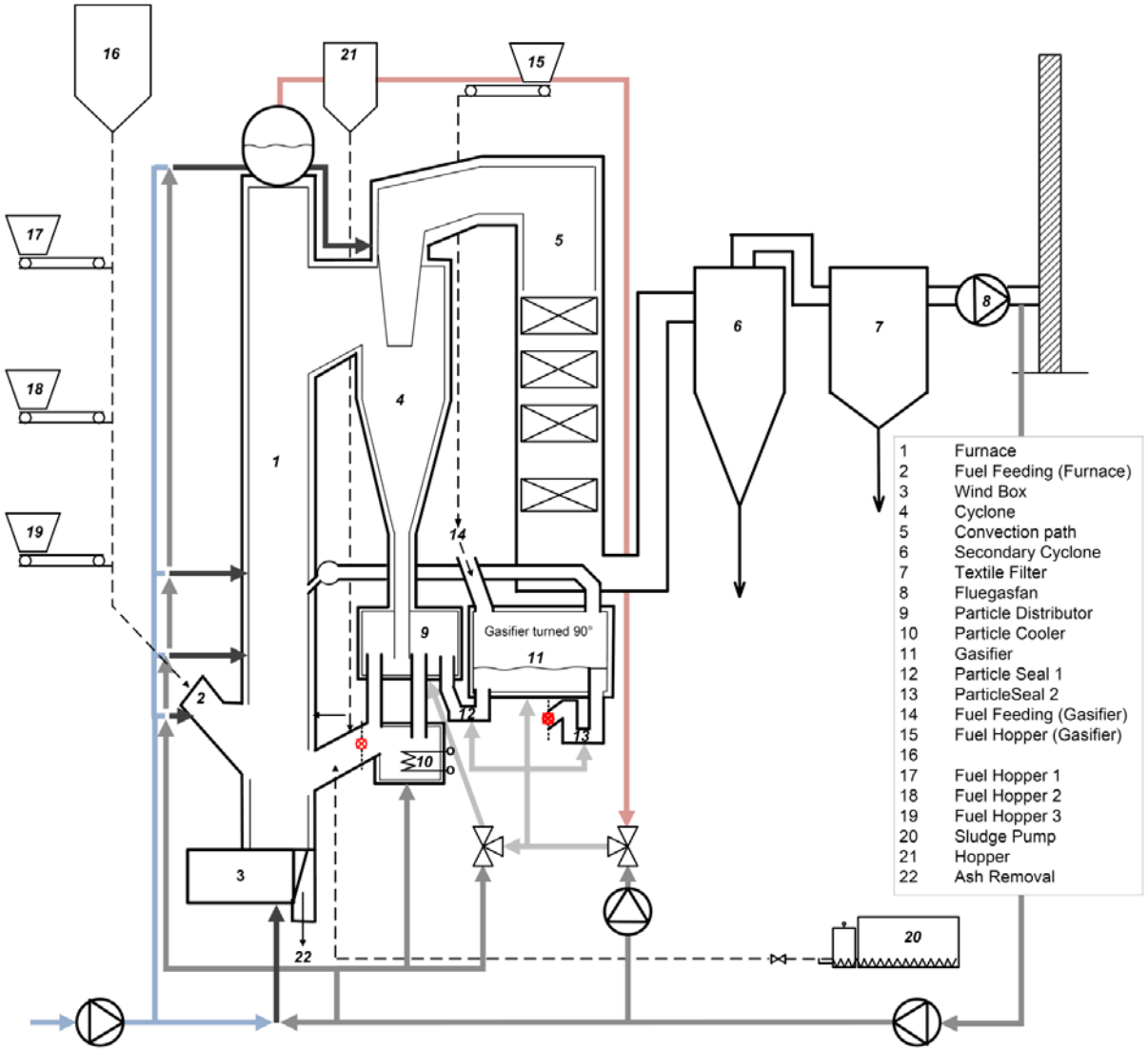
180 M$

GoBiGas Phase 2
Hisingen
80-100 MW Biomethane
Commercial Plant
Göteborg Energi

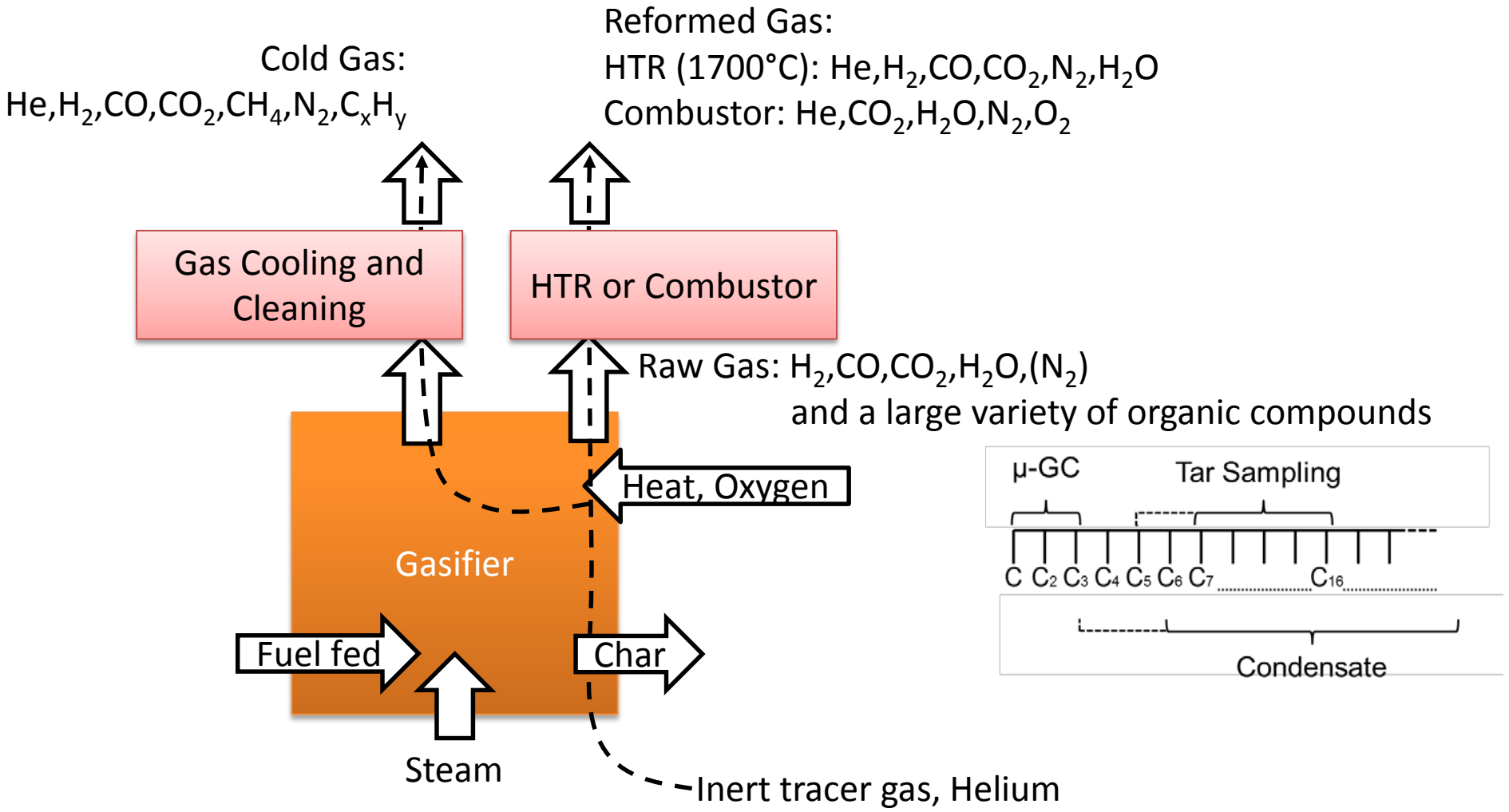
420 M$

2008 2013 2017

Chalmers 12 MW CFB boiler with a 2-4 MW Gasifier



Quantification of Gas Products

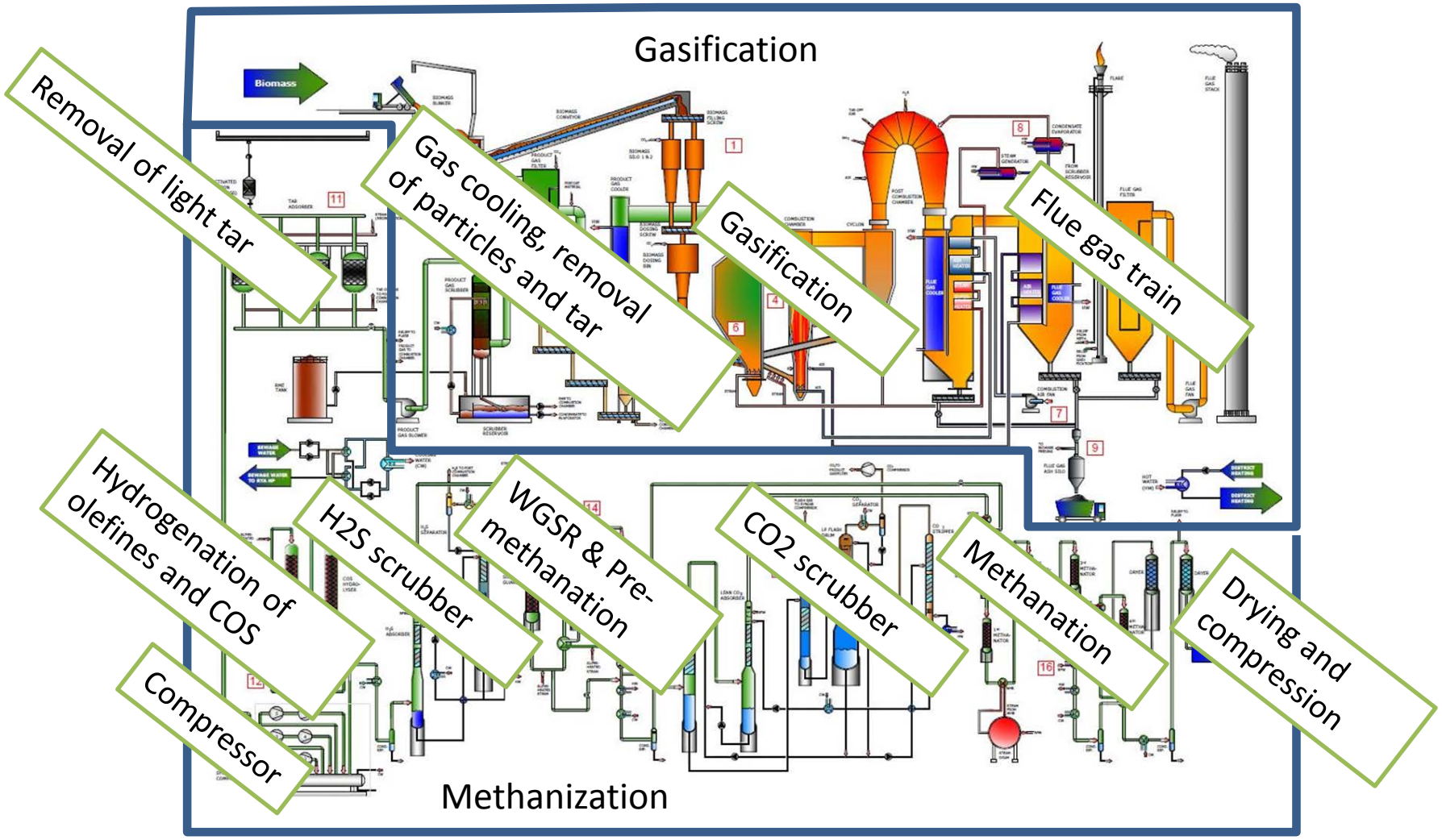


Fluidized Beds

Gasification from above:

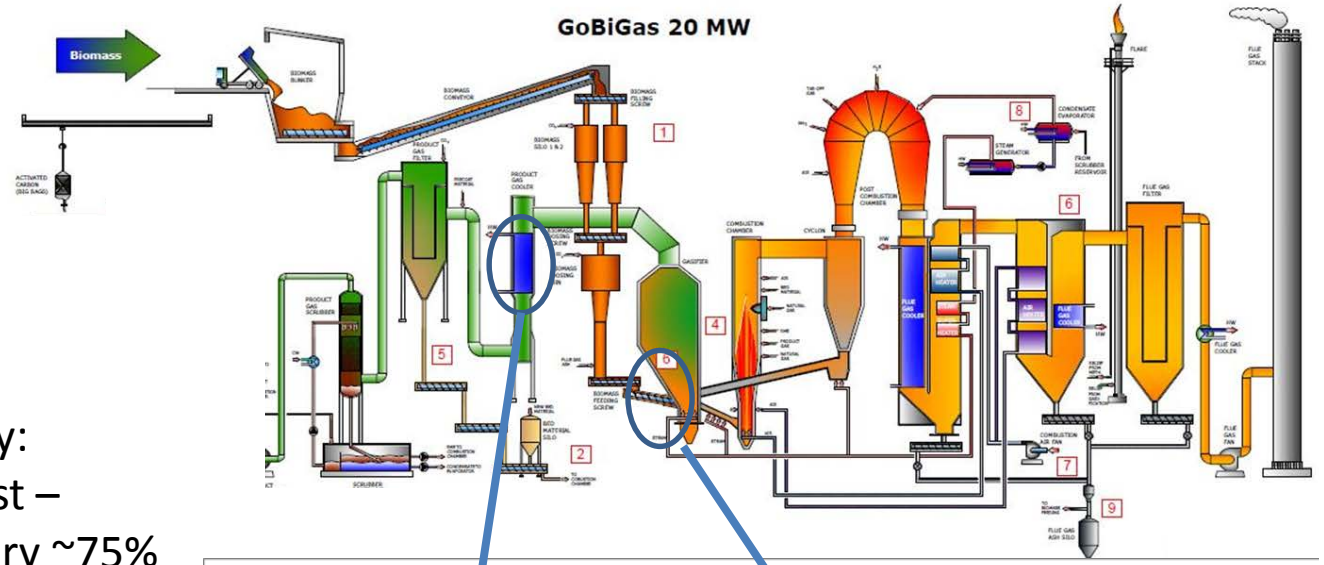
By: Erik Sette and Rustan Marberg

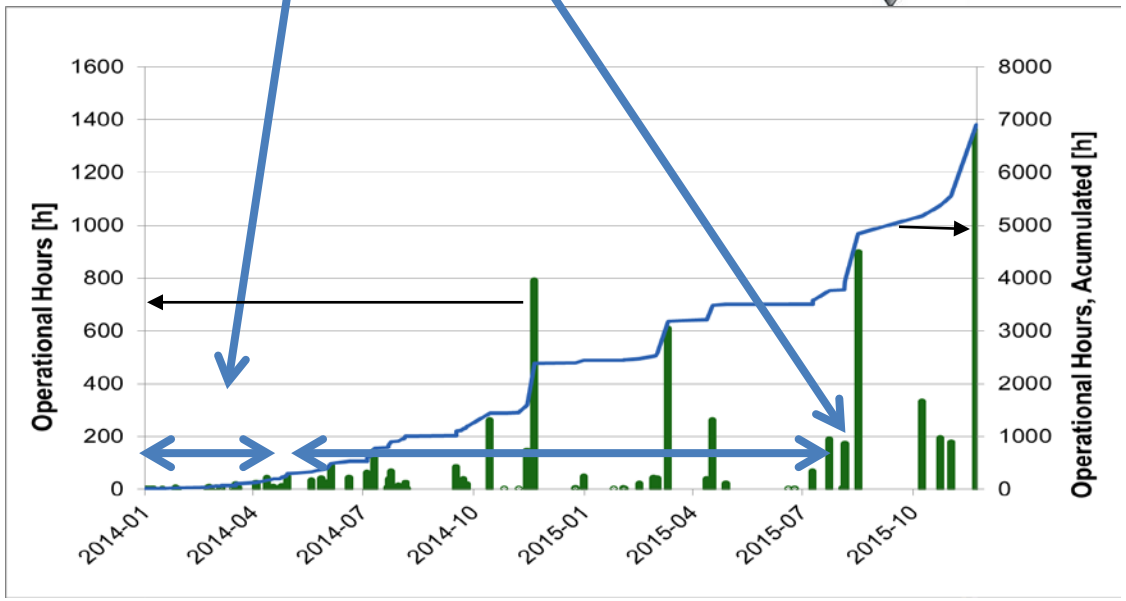
Schematic overview of the GoBiGas-plant



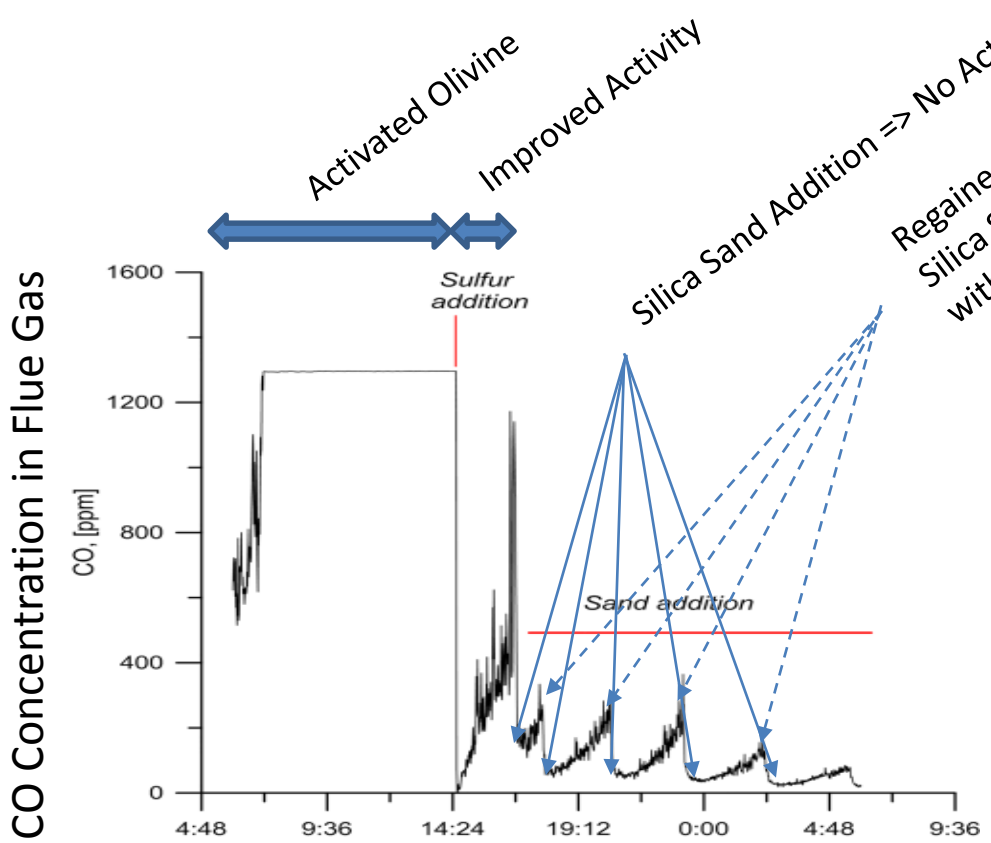
Commissioning of gasifier

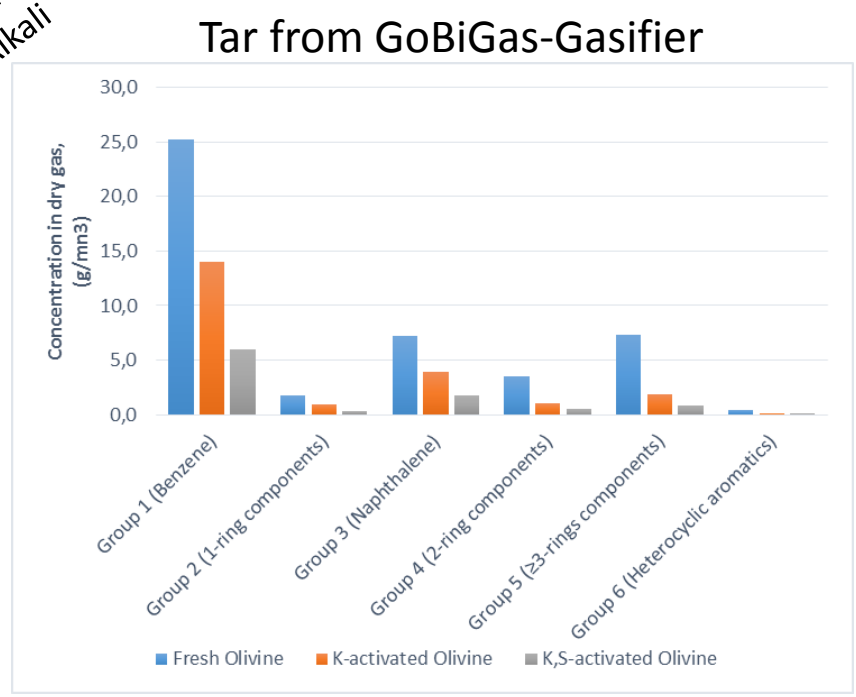
Availability:
mid August –
mid January ~75%





Effect of Alkali on the Activation of Olivine



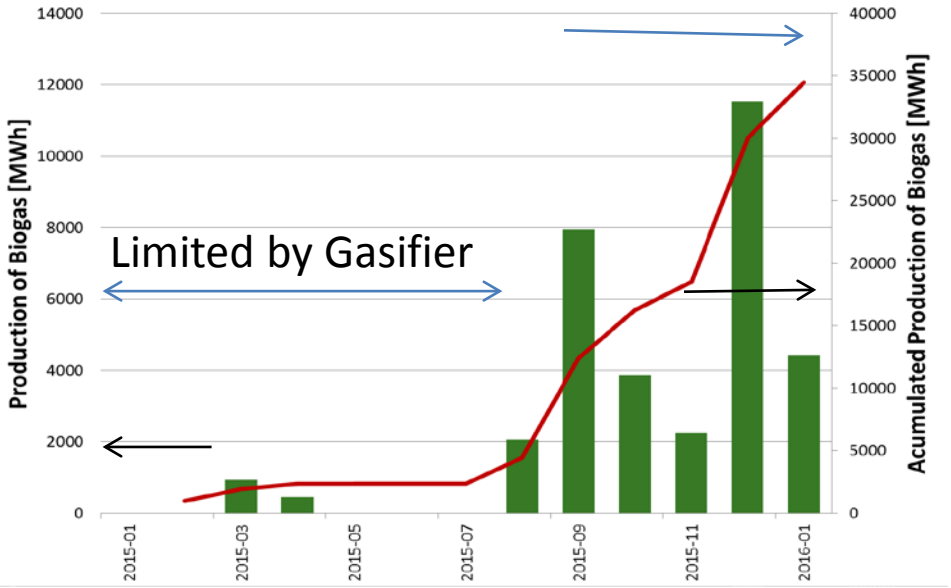


Reference: Jelena Marinkovic, Henrik Thunman, Pavleta Knutsson, Martin Seemann, Characteristics of olivine as a bed material in an indirect biomass gasifier, Chemical Engineering Journal (1385-8947). Vol. 279 (2015), p. 555-566.
ISSN: 13858947

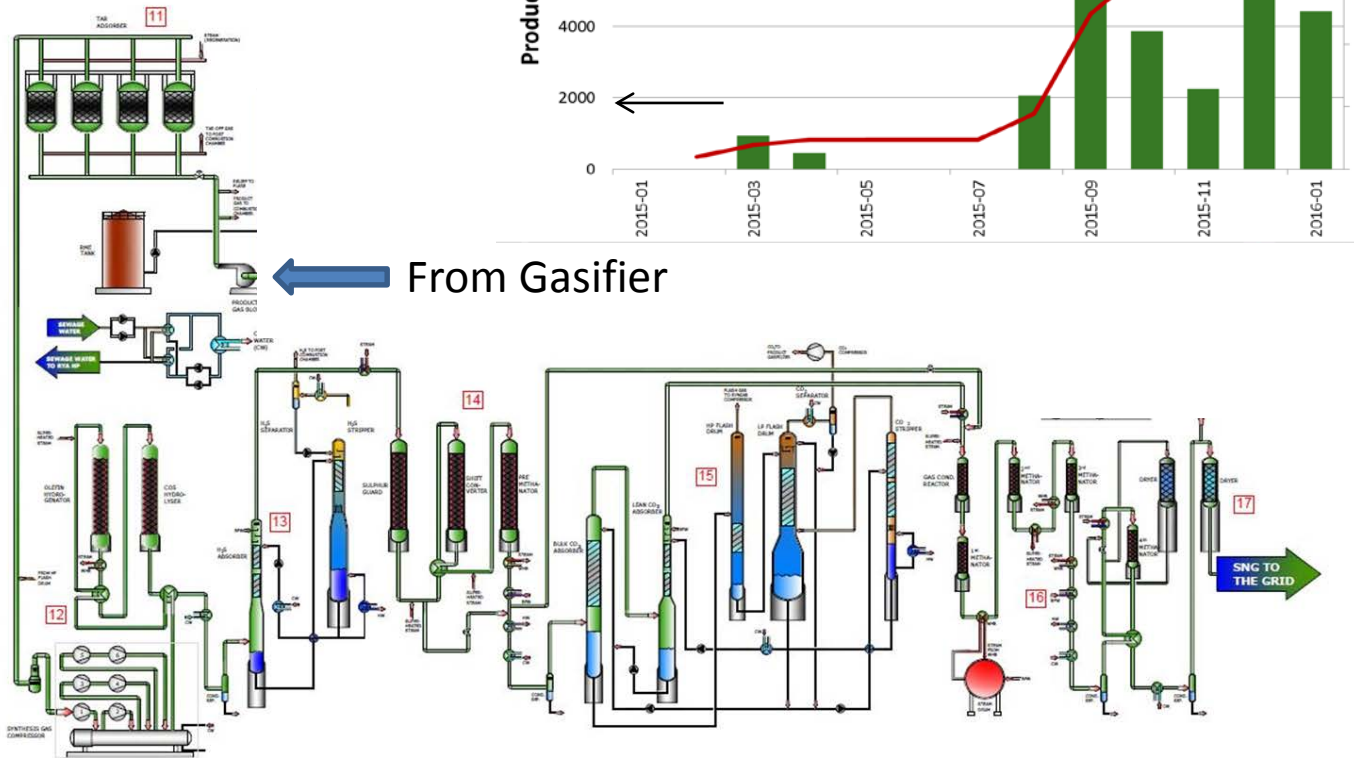
Commissioning of Methanization

Limited by Carbon beds

Up to day 35 GWh ~ 2400 h
Availability:
mid August – mid January ~65%



From Gasifier



Chemical Looping Combustion

OCAC + Indirect Gasification = Chemical Looping Combustion

Chemical Looping Combustion