

The new Research-Gasifier at Chalmers

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CHALMERS

 *Göteborg Energi*

 **metso**


AKADEMISKA HUS

 *Swedish
Energy Agency*

Aim

Produce a Product Gas from Solid Biomass
as Energy and Cost Efficient as Possible!

Concept

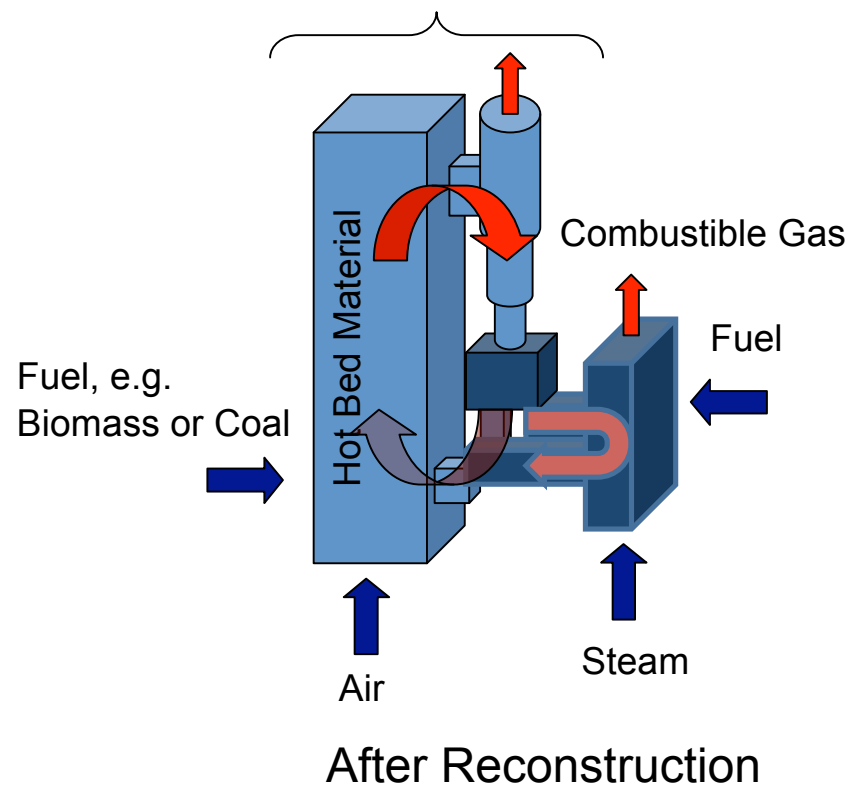
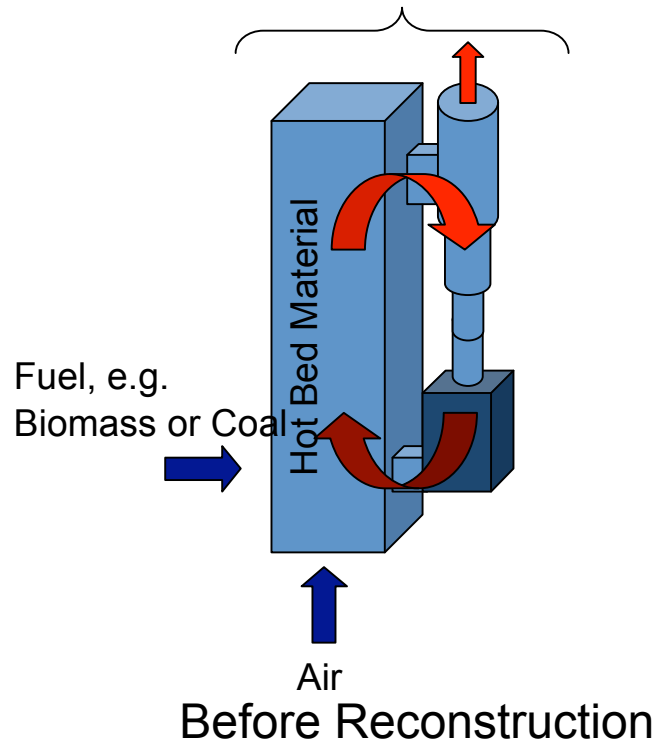
Use **Existing Boiler Infrastructure** for solid fuels, which at present produce heat and power **to also produce gas**



Concept

Circulating fluidized bed (CFB)

Heat, Electricity, Steam

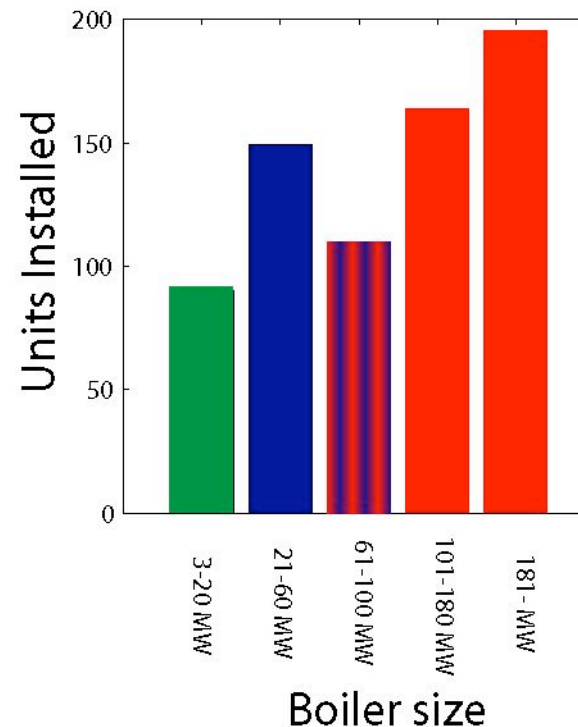
Heat, Electricity, Steam



-  Circulating bed
-  Bubbling beds

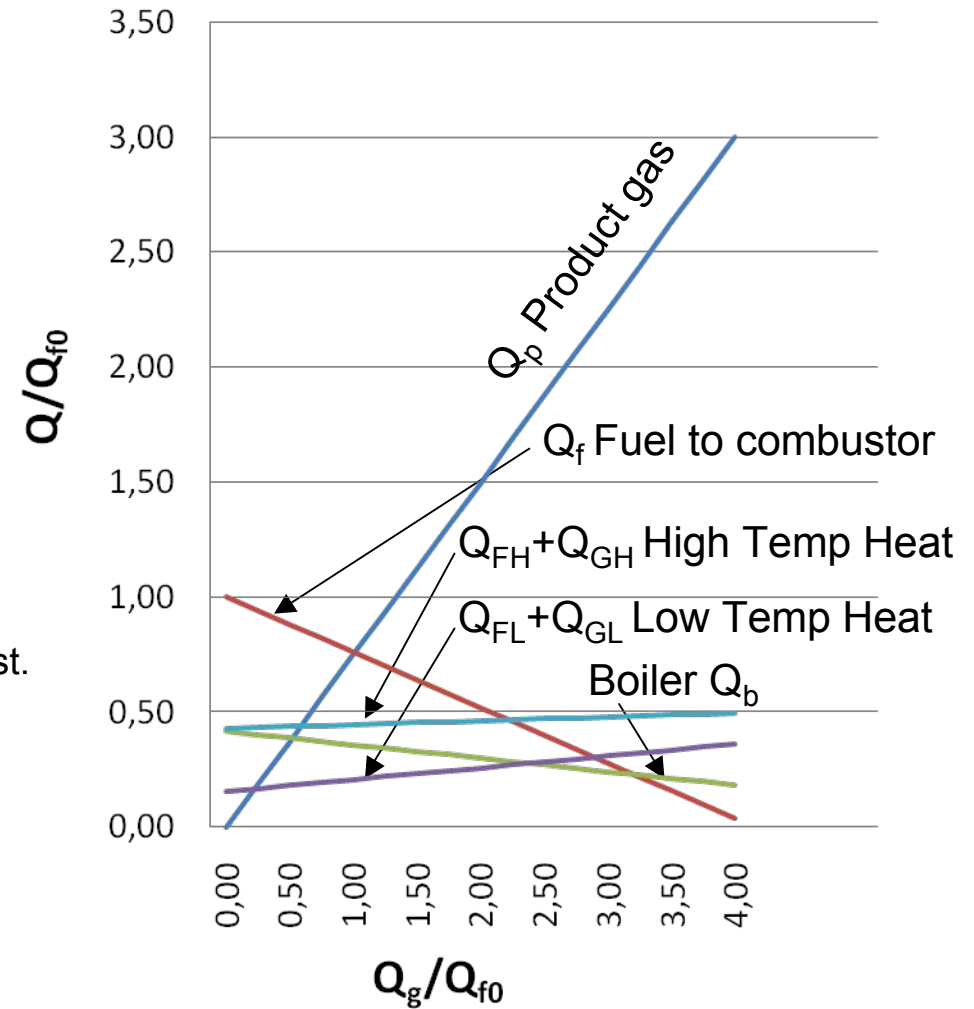
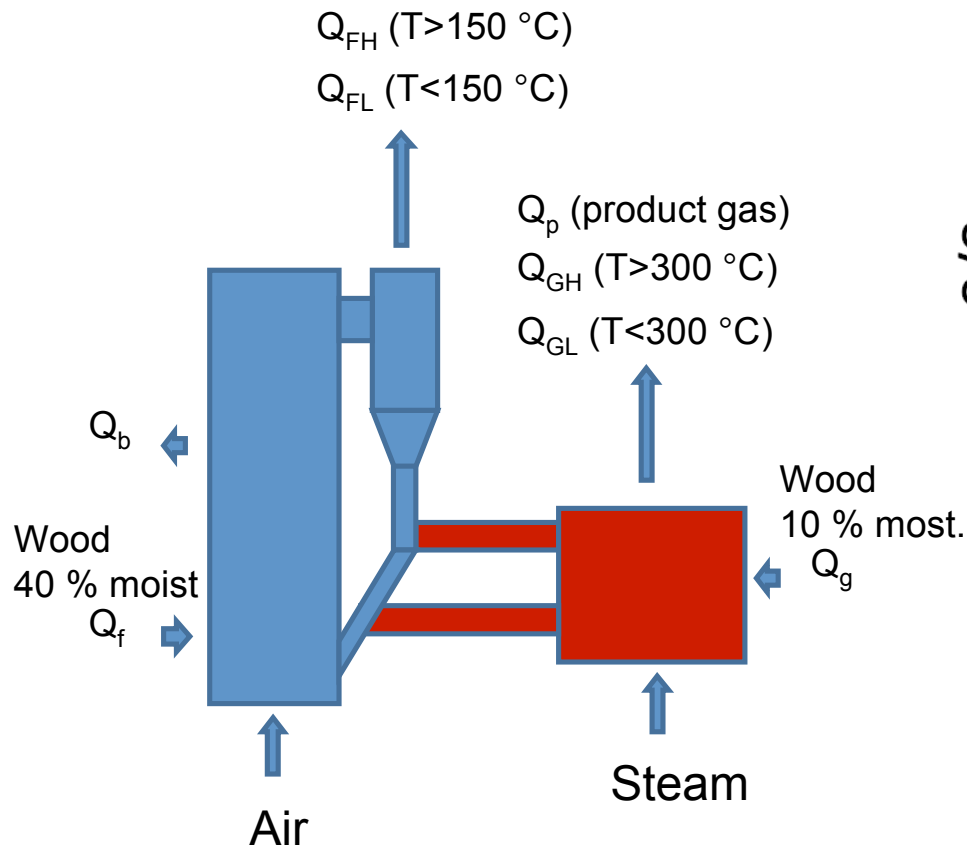
Potential for retrofitting FB boilers* in Europe and North America

Many more FB boilers exist in China and India
Installed capacity ~ Potential for gasification



*Delivered boilers from Metso Power, Foster Wheeler and Alstom until year 2007

Heat Balance for a Poly-Generation Unit



Conversion Efficiency

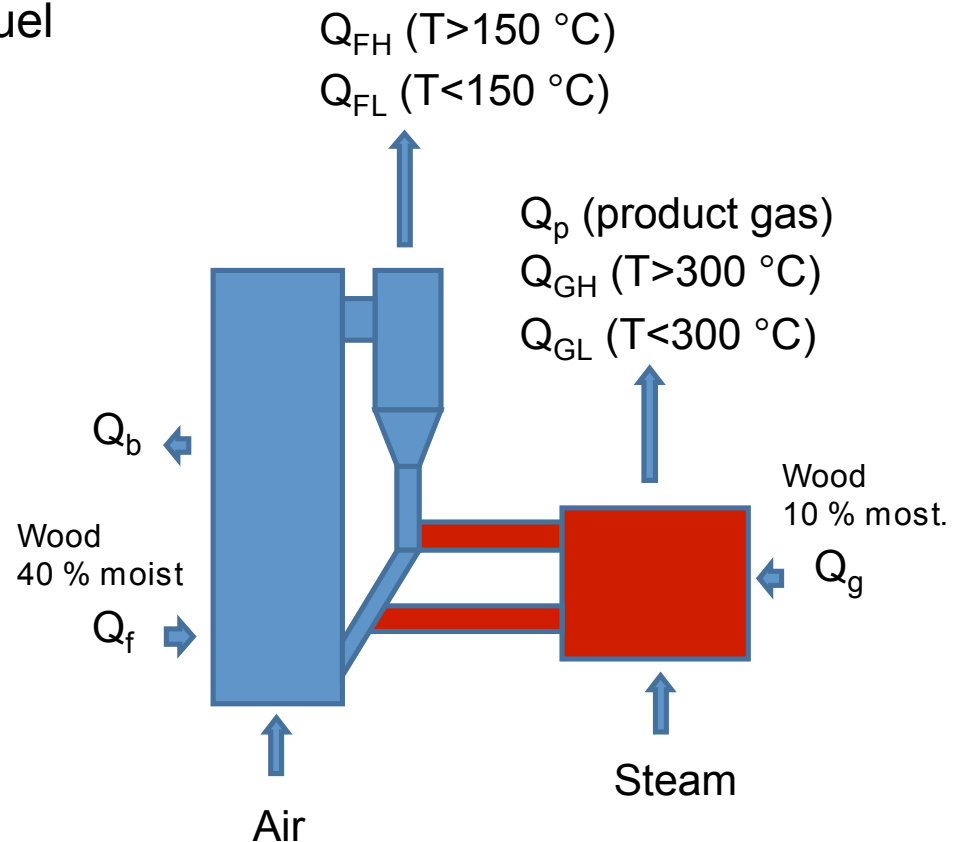
Efficiency based on LHV of received fuel

$$Q_{evap,f} = m_{f,daf} \frac{X_{mf} H_{evap}}{1 - X_{mf} H_i}$$

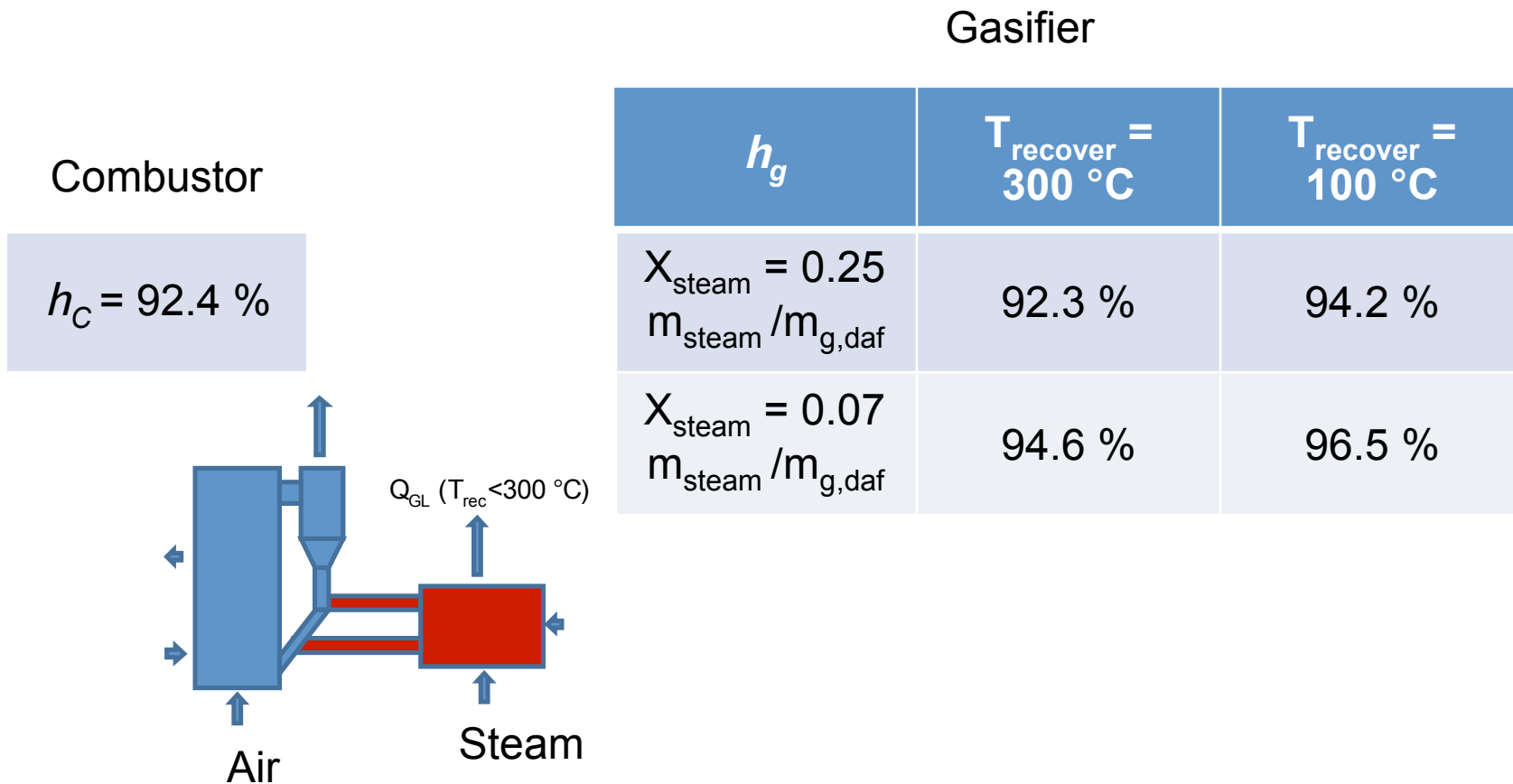
$$\eta_C = \frac{Q_b + Q_{FH}}{Q_f - Q_{evap,f}}$$

$$Q_{evap,g} = m_{g,daf} \frac{X_{mg} H_{evap}}{1 - X_{mg} H_i}$$

$$\eta_g = \frac{Q_P + Q_b + Q_{FH} + Q_{GH}}{Q_g - Q_{evap,g}}$$

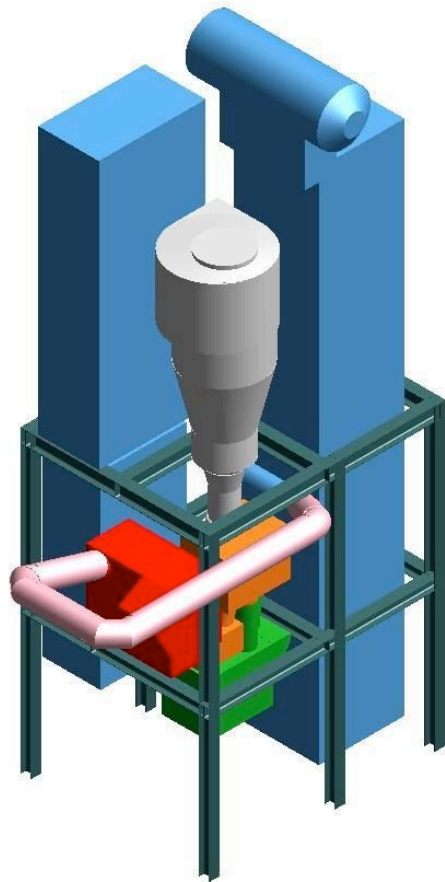


Conversion Efficiency

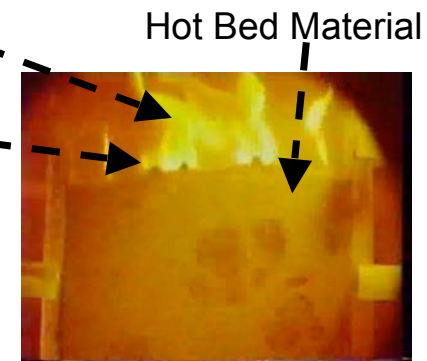
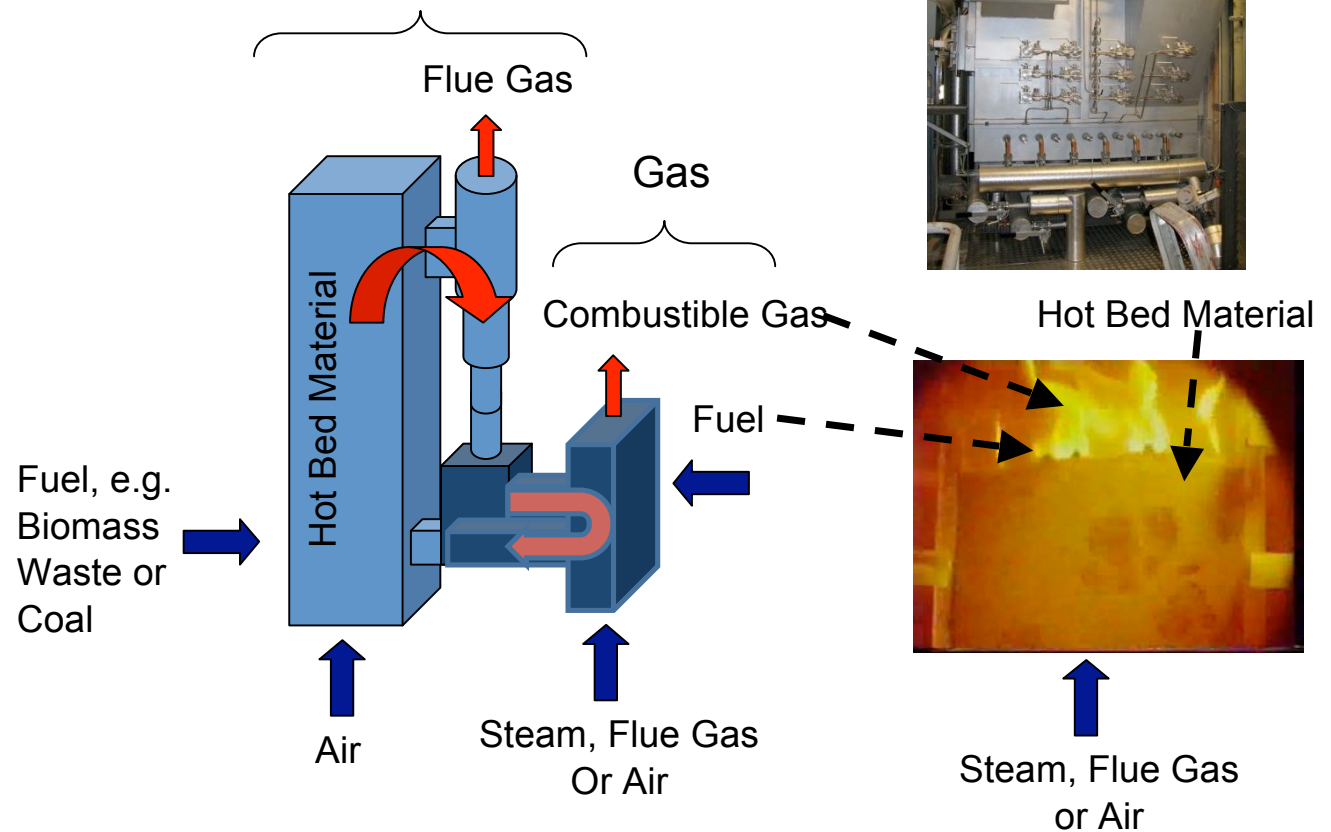


The new Research-Gasifier at Chalmers

Chalmers
12 MW CFB boiler



Heat, Electricity, Steam



Specification of gasifier

Variation possibilities

- Fuel load 0 – 4 MW (tested: 0-2.3 MW)
- Optional fluidization media
 - Steam
 - Flue gases
 - Air (not yet tested)
- Temperature in Gasifier 550-950 °C (tested 725 - 860 °C)
- Residence time
 - Adjustable solid flux
 - Adjustable bed height (Not yet applied)
- Fuel
 - Dry pellets (tested: Wood and Bark)
 - Wet biomass (tested: Wood chips)
- Bed material (tested: silica sand)

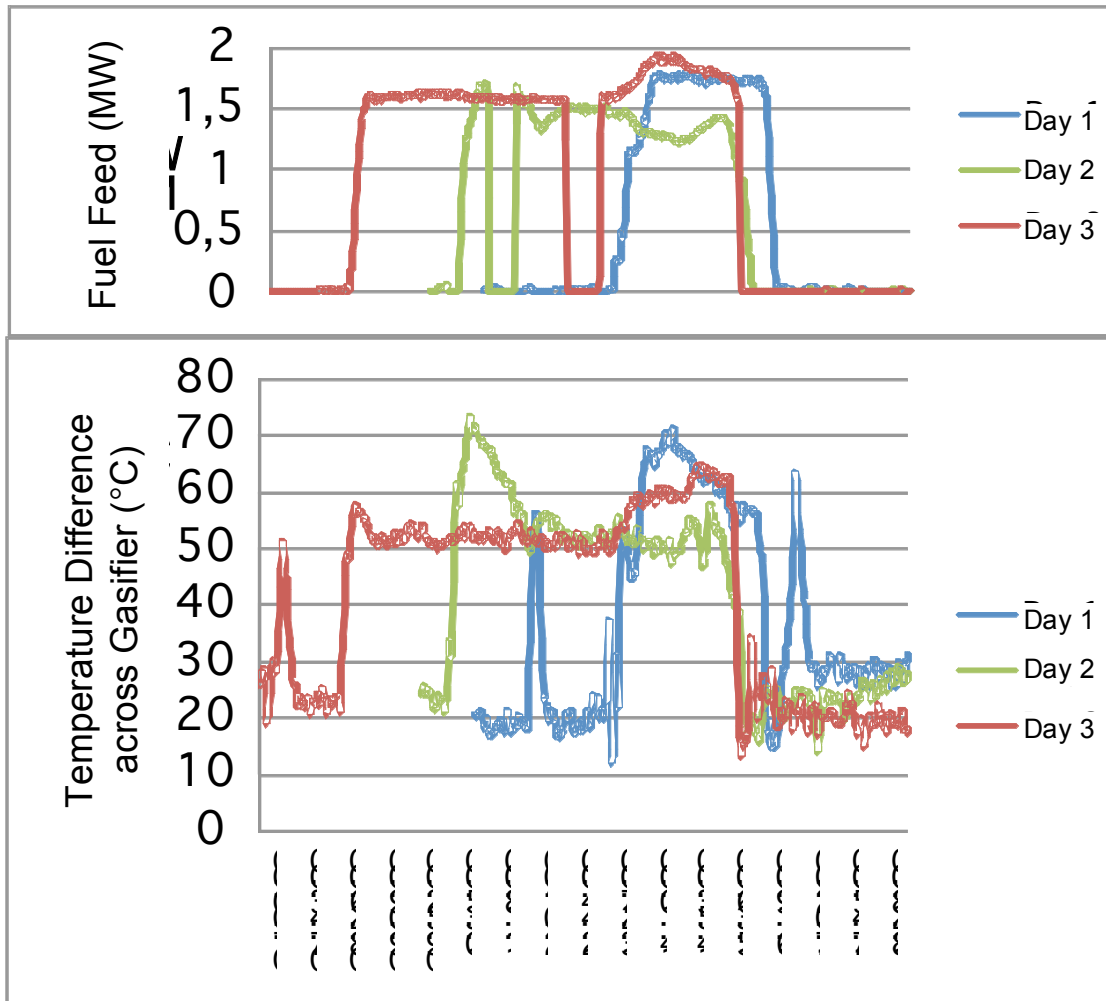
Measurements

- Product gas composition
- Solid flux
- Fuel feed
- Temperatures
- Pressures
- In plant gas and bed sampling
- Extraction of gas slip flow

Accumulated Time of Operation

with fuel ~250 h without fuel ~1800 h

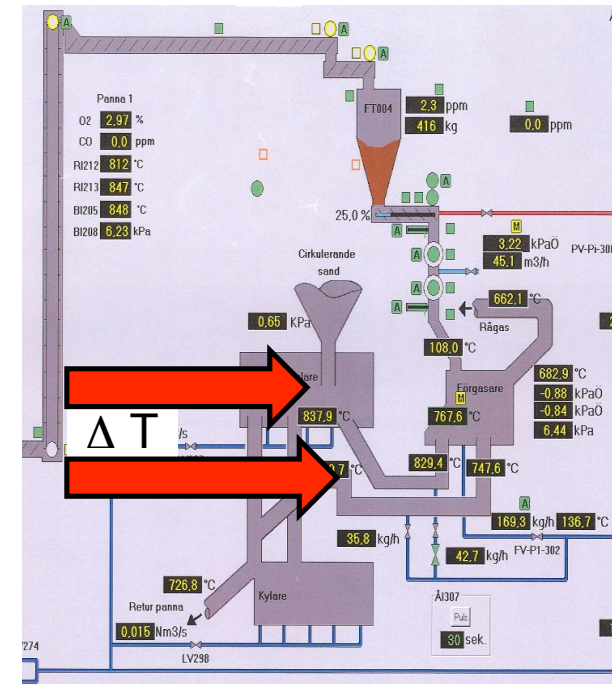
Examples of Operation



Temperature in distributor ~ 870 °C

Temperature reduction in gasifier ~ 20 °C / MW_{dry wood}

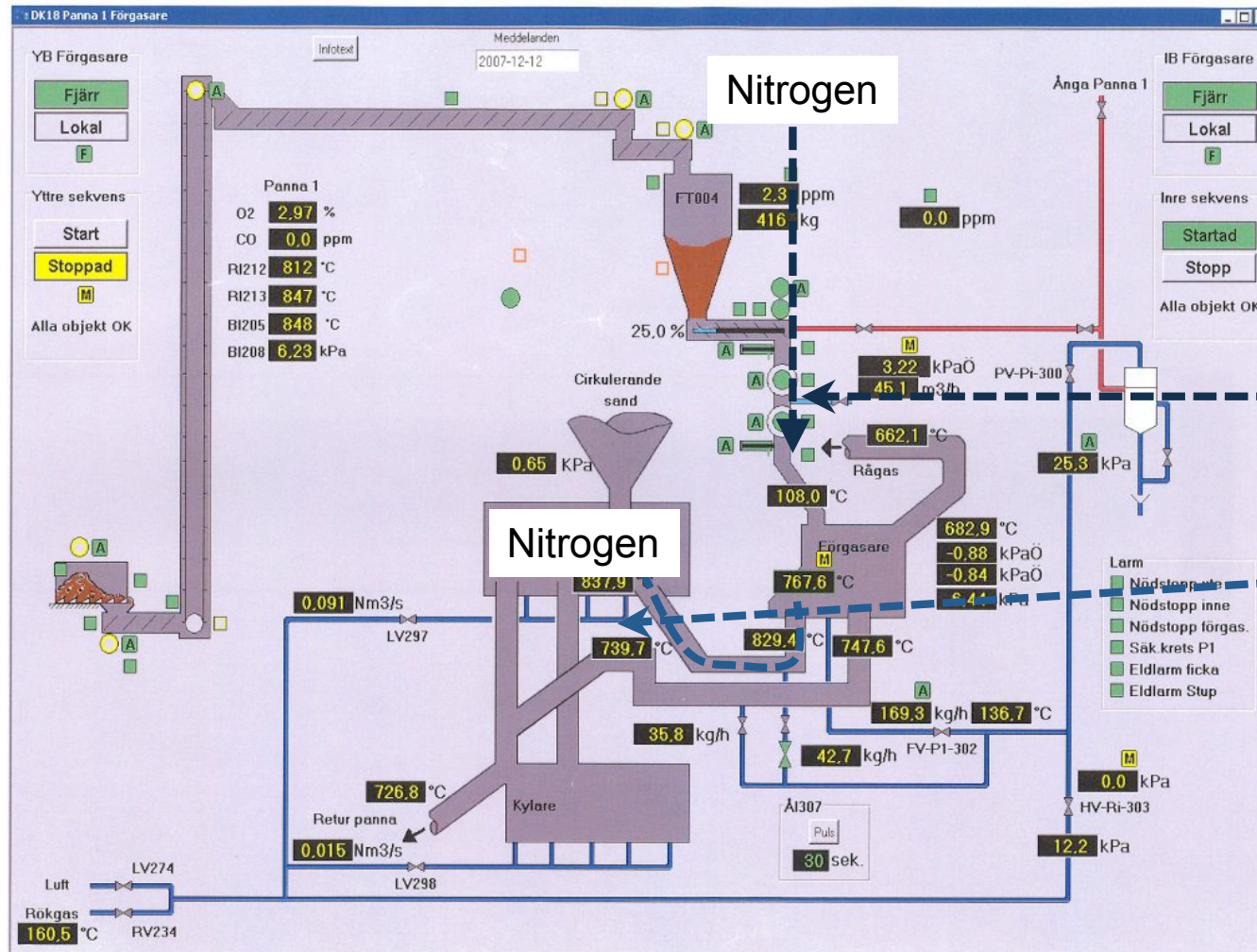
Residence time in gasifier ~ 220 s



Dry Gas Composition

Gas	27. March wood pellets 327 kg/h @812 °C	Heating Value (Calc. Dry Gas)
H ₂ [mol%]	25.1 [mol%]	13.7 MJ/nm ³ or 14.1 MJ/kg
CO [mol%]	33.1 [mol%]	
CO ₂ [mol%]	14.8 [mol%]	
CH ₄ [mol%]	11.8 [mol%]	
C ₂ H ₄ [mol%]	4.2 [mol%]	
C ₂ H ₆ [mol%]	0.4 [mol%]	
N ₂	9.3 [mol%]	
Tars (Gravimetric tar analysis)	7.8 g/nm ³	

Inflow of Nitrogen



Ongoing measures to reduce inflow of Nitrogen:

Reduce pressure at fuel inlet

Fluidize particle distributor with steam instead of flue gases

Conclusions

- Poly-generation of gas with heat and power production from solid biomass by retrofitting fluidized bed boilers is very cost and energy efficient
- Initial calculation and operating experience indicate that the this solution provides a very flexible poly-generation scheme
- The energy efficiency is most effected by:
 - how low in temperature heat recovery of the product gas can be managed
 - the amount of steam needed to fluidize the gasifier
- Chalmers 12 MW_{th} research CFB-boiler has successfully been retrofitted with a 2 MW_{fuel} gasifier according to this concept and has been operated more than 1800 hours, whereof 250 hours with fuel
- So far there is no negative effect on the functionality of the CFB boiler; combustion only mode is still possible
- The fuel feeding system and particle seal are at present sources of nitrogen in the product gas
- The layout of the gasifier has been proven to be very suitable for all sorts of in plant measurements with probes