Solid fuels operation in a 150 kW_{th} CFB-based Chemical Looping Combustion pilot unit

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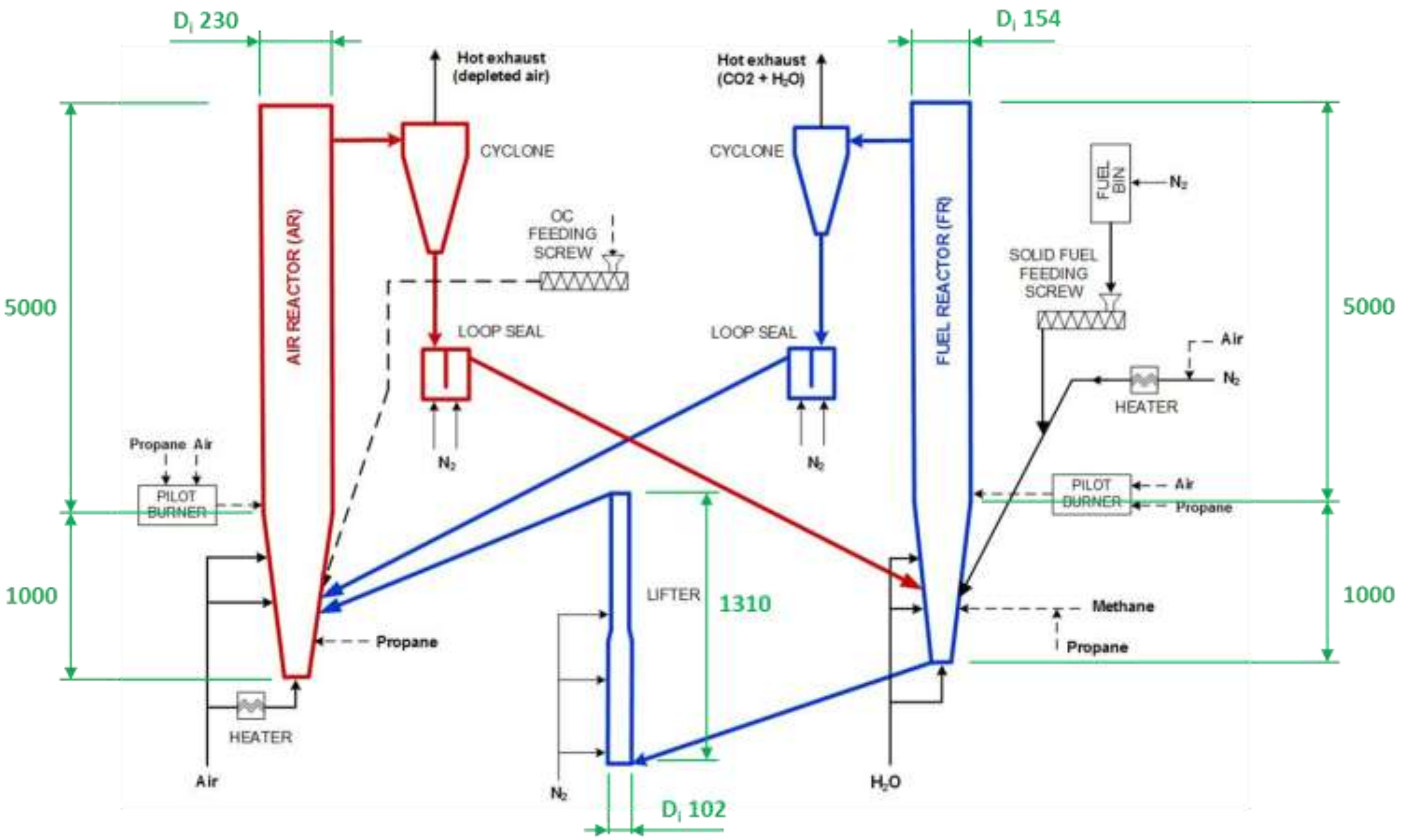
Outline

- Reactor system
- CLC performance parameters
- Typical operation sequence
- Fuels tested
- Results
- Conclusions

Reactor system based on circulating fluidised beds (CFB)



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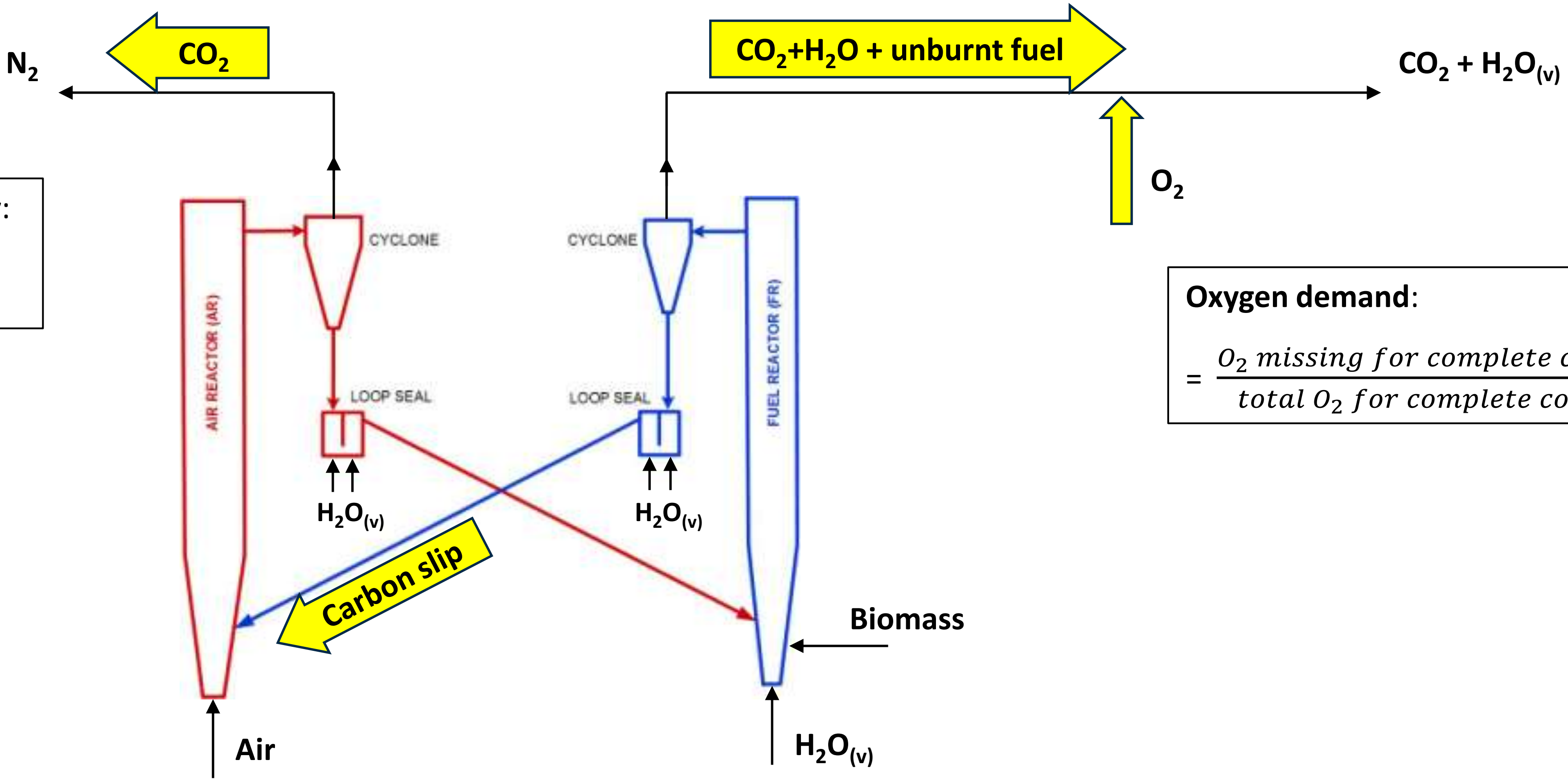
Reactor system

Two important performance parameters

Carbon capture efficiency:

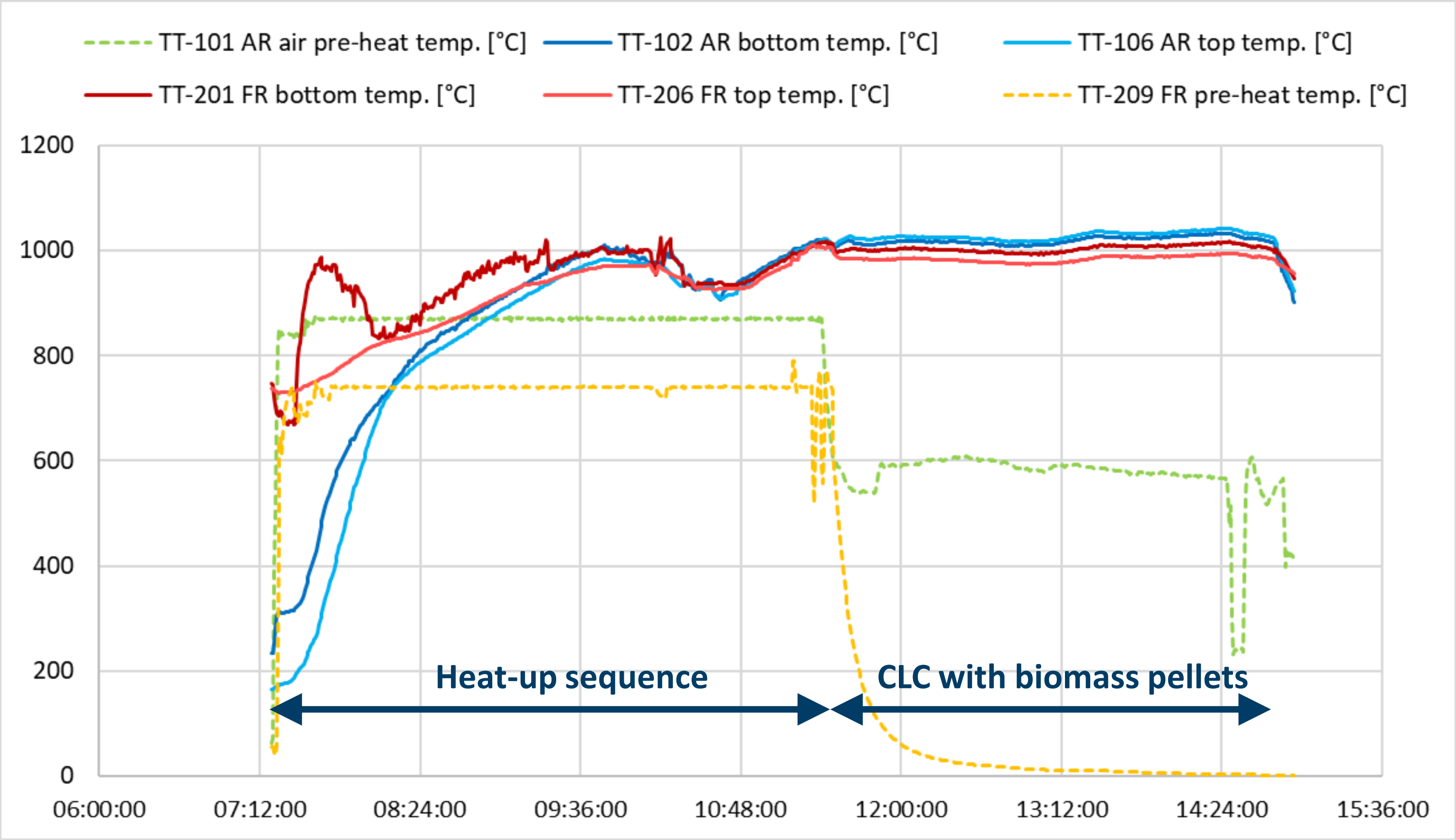
$$= \frac{carbon\ captured}{carbon\ introduced}$$



Oxygen demand:

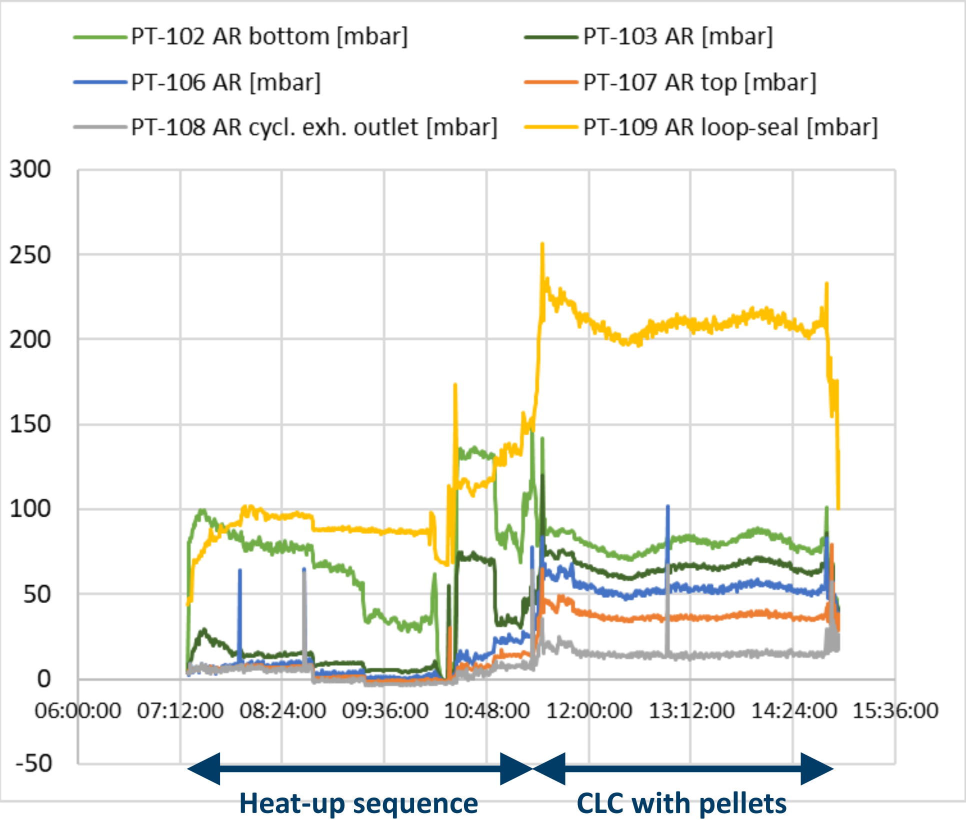
$$= \frac{O_2\ missing\ for\ complete\ combustion}{total\ O_2\ for\ complete\ combustion}$$

Typical temperature sequence

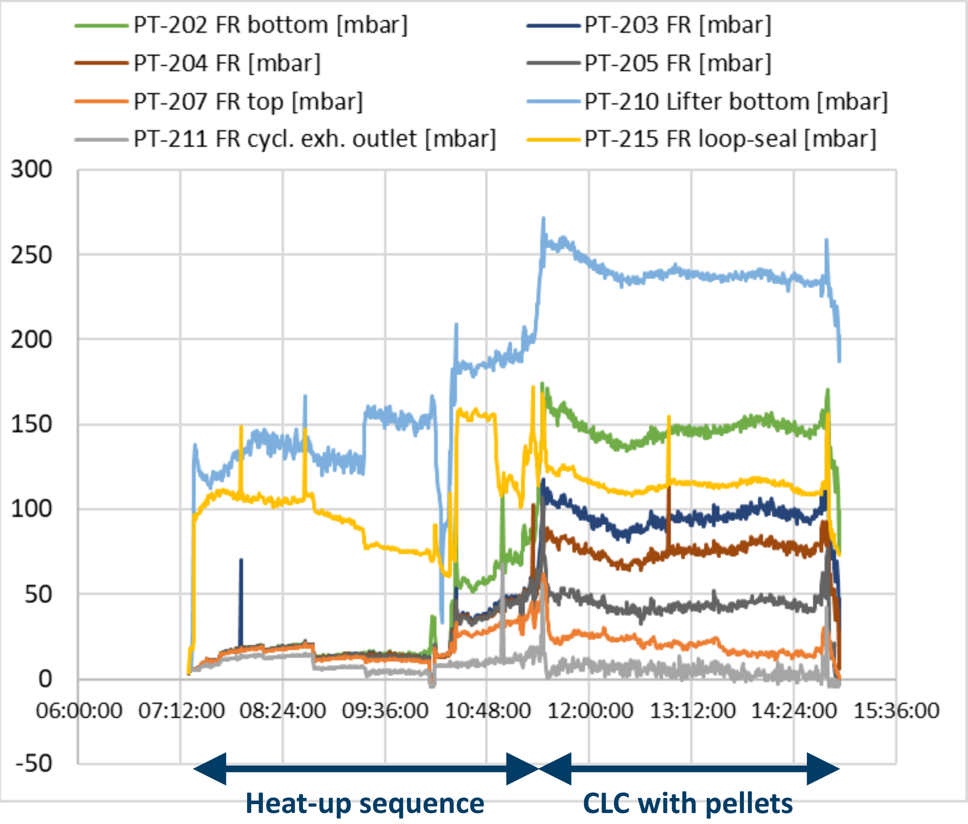


Typical pressure profiles

Air reactor



Fuel reactor



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Fuels tested

A. Biomass pellets, steam exploded, from Arbaflame in Norway

B. Same pellets, but crushed and sieved (> 800 µm)

C. Petcoke, from China, low-sulphur, particle size 315 – 500 µm

D. Mix of crushed/milled biomass pellets and petcoke, 50/50 wt-%

E. Mix of crushed/milled biomass pellets and petcoke, 75/25 wt-%

Fuels tested

Petcoke

Pellets

Crushed and sieved pellets

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Oxygen carrier: Ilmenite

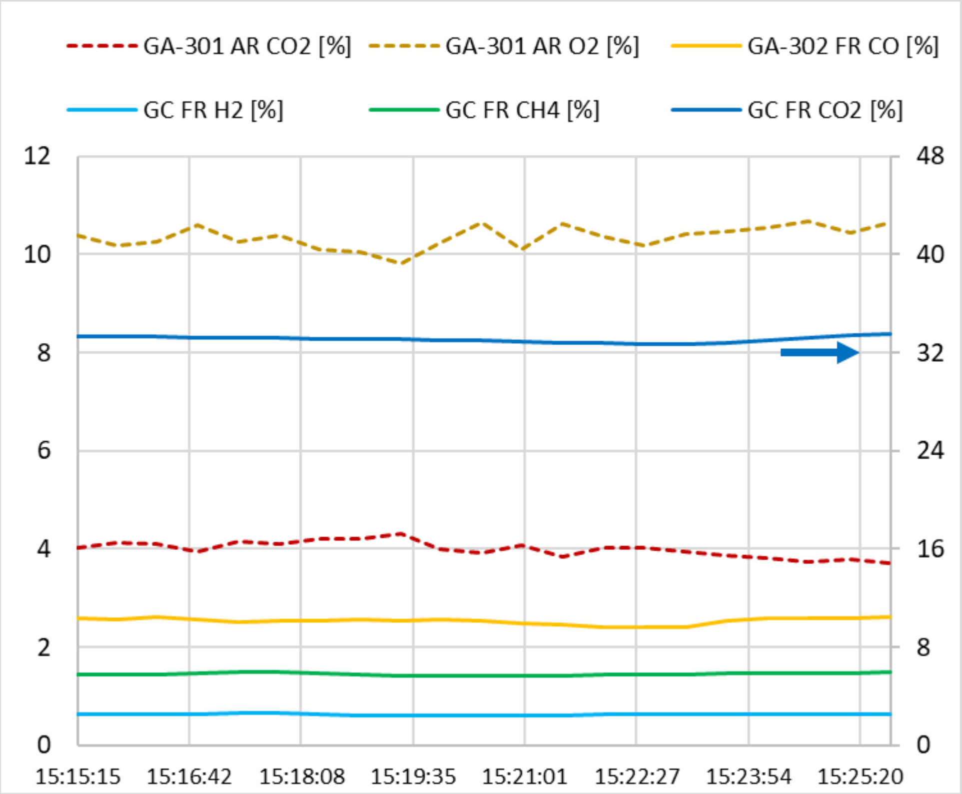
Ilmenite from Titania in Norway, particle size 40 – 120 µm

Fresh

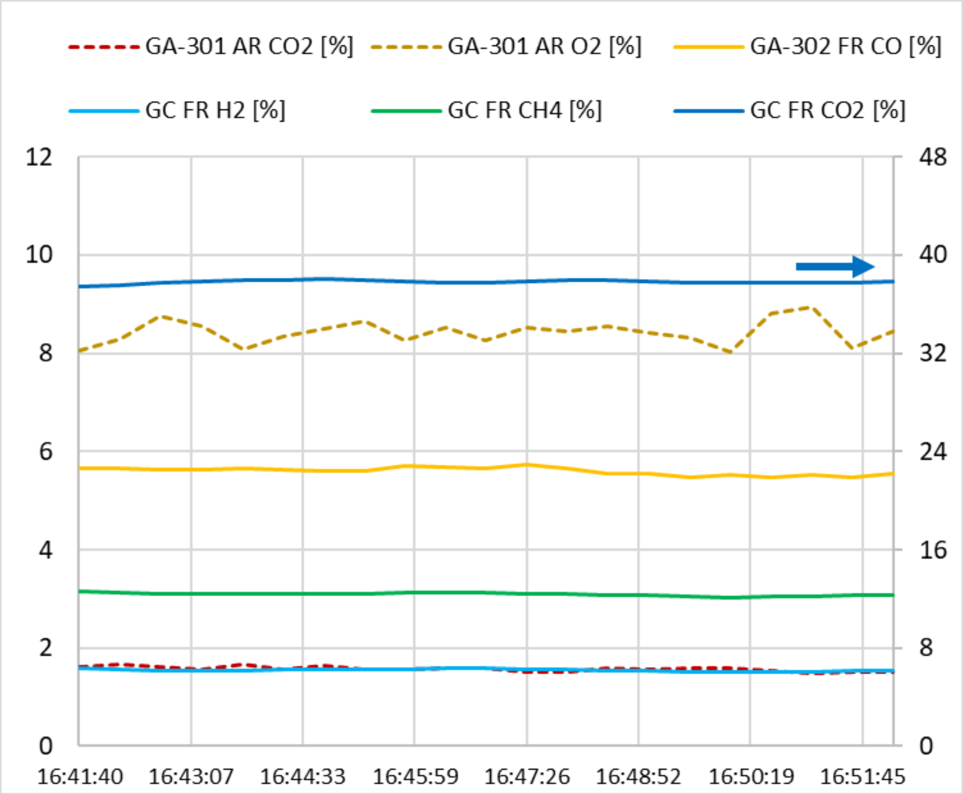
Used from
fuel reactor

Used from
air reactor

Mixed fuel vs biomass, gas analysis



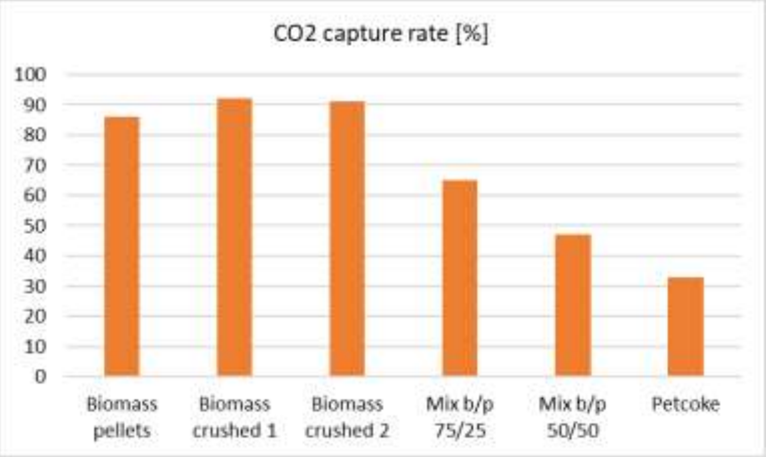
Mix 75/25 biomass/petcoke

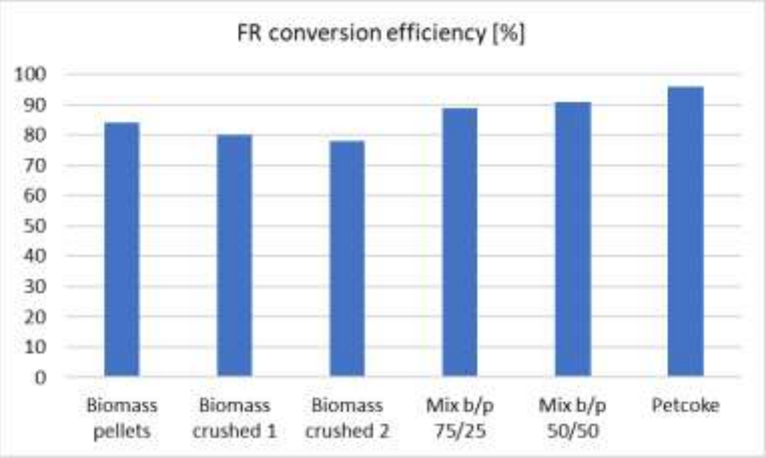


Biomass (crushed pellets)

Main results so far

	Biomass pellets	Biomass crushed 1	Biomass crushed 2	Mix b/p 75/25	Mix b/p 50/50	Petcoke
Fuel power (approx.) [kW]	108	99	113	80	93	126 (?)
FR temperature [°C]	988	967	952	966	966	1002
CO_2 capture rate [%]	86	92	91	65	47	33
FR conversion efficiency [%]	84	80	78	89	91	96
FR oxygen demand [%]	16	20	22	11	9	4





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Conclusions

- High fuel conversion and carbon capture rate obtained with biomass as fuel
- Limited capture rate obtained with petcoke as fuel, because of low fuel reactivity and that the pilot unit is not optimally designed for this.
- Stable operation for biomass pellets and the petcoke-containing fuels.
- Instabilities when using the crushed biomass pellets due to rapid devolatilization.

- Much longer residence time in FR needed, e.g. by using a "carbon stripper".
- Oxygen carrier with more "CLOU" effect would also improve some of the results.
- A smaller and more accurate fuel feed screw will improve operation (to be mounted soon)
- Much higher fuel conversion and capture rate can be expected in a large industrial unit, as residence times will be much higher

- All in all, CLC is a promising technology for carbon capture from solid fuels

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Thank you for your attention !