# Two years experience with an innovative 100 kWth dual fluidized bed gasifier: the results of BLAZE Project

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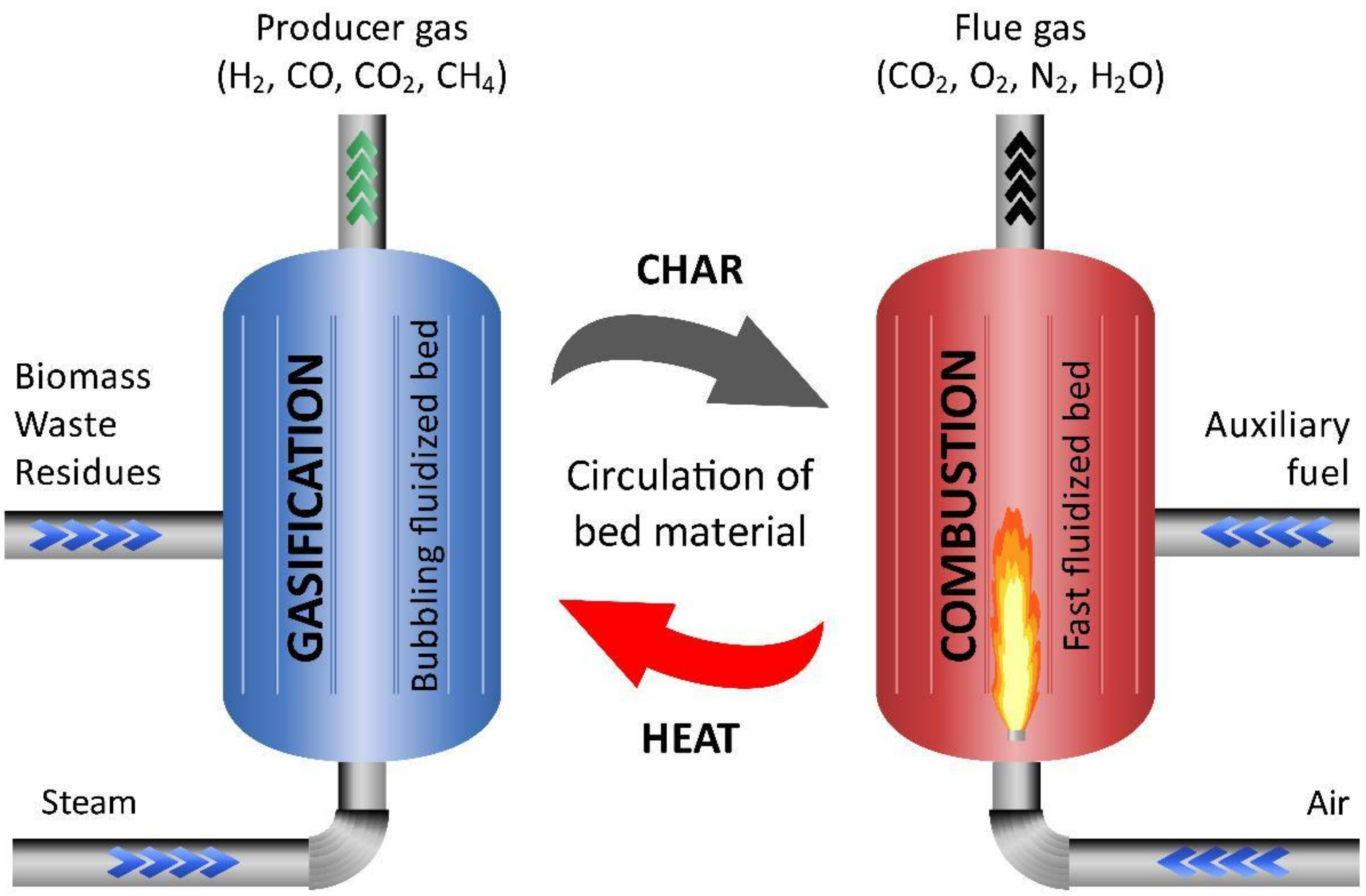
EUBCE
31st European Biomass Conference & Exhibition

# Steam gasification - DFB gasifier




- Gasification and combustion zones separation
- Residual char and auxiliary fuel combustion provide the heat
- Bed materials as heat carrier
- Loop seal to avoid gas mixing
- $H_2$-rich gas (low nitrogen content)



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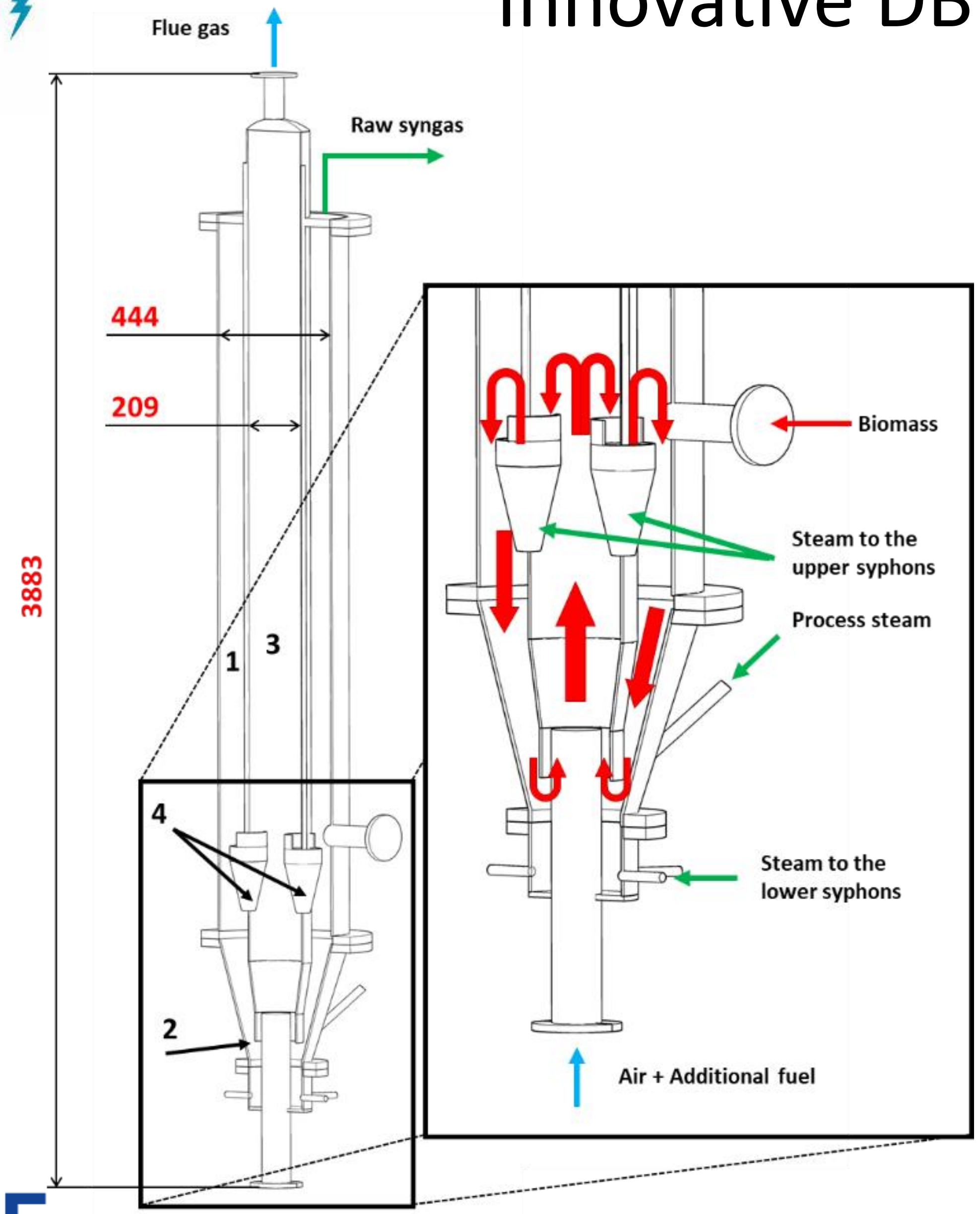
# Innovative DBFB gasifier




- **Two concentric** cylindrical reactors in a **single vessel**
- External gasification reactor – **Slow bed** (1.5 – 3 umf)
- Internal combustion reactor – **Fast bed** (5 – 10 umf)
- Heat exchange occurs both through the bed circulation and heat transfer through the wall between the chambers
- Compact reactor suitable for small-to medium scale applications (0.1 – 10 MW as biomass input)

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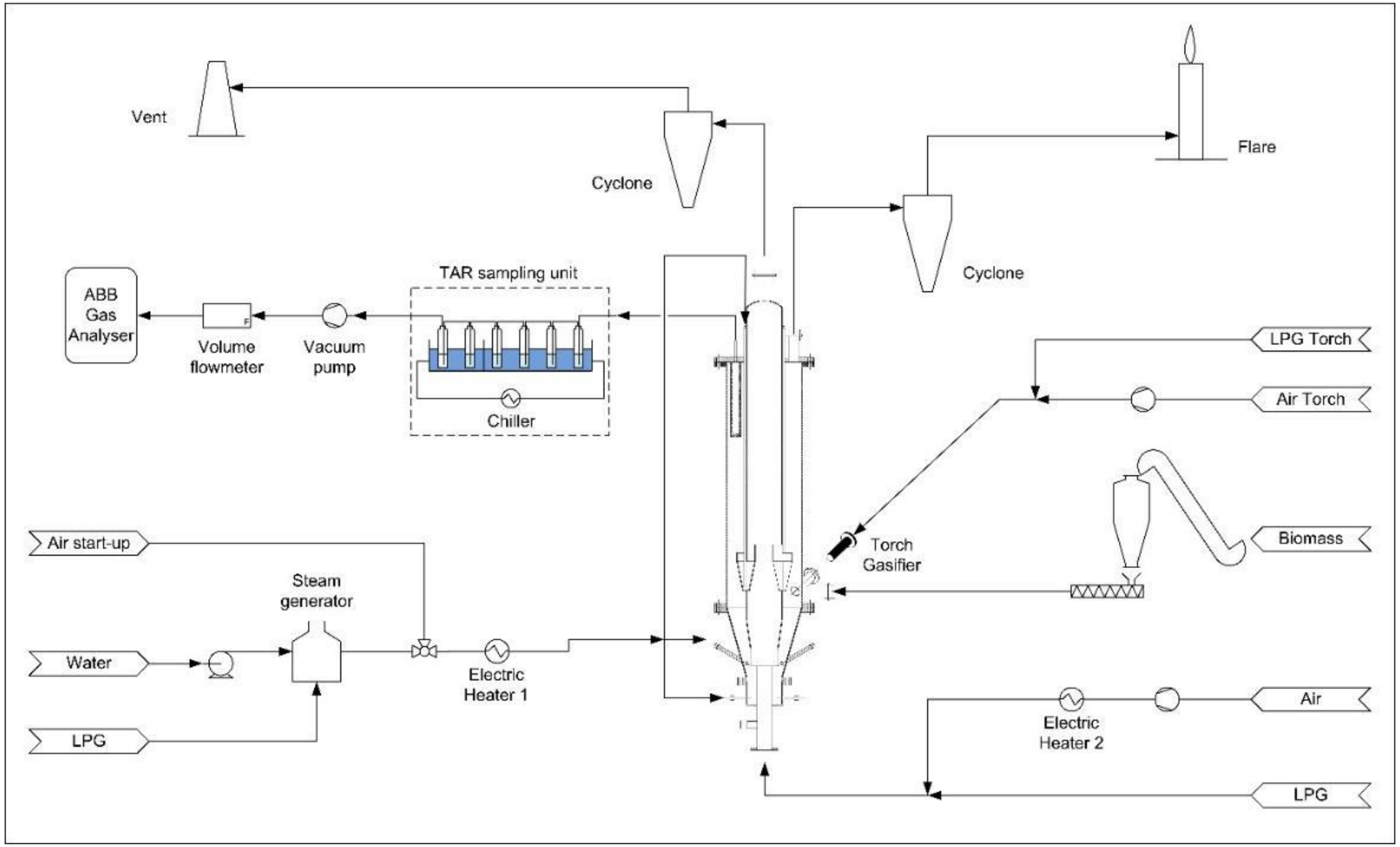
# The gasifier pilot plant




The dual bubbling fluidized bed gasifier is designed to process up to 20 kg/h of biomass (100 kWth).

Biomass Gasification is carried out using just steam (S/B=0.5-1).

Air and additional fuel (LPG) feed the combustor. Air and LPG flowrate are adjusted to control the gasifier temperature: 30-50 kg/h and 1-2 kg/h respectively

One ceramic candle can be inserted in the freeboard of the gasifier.

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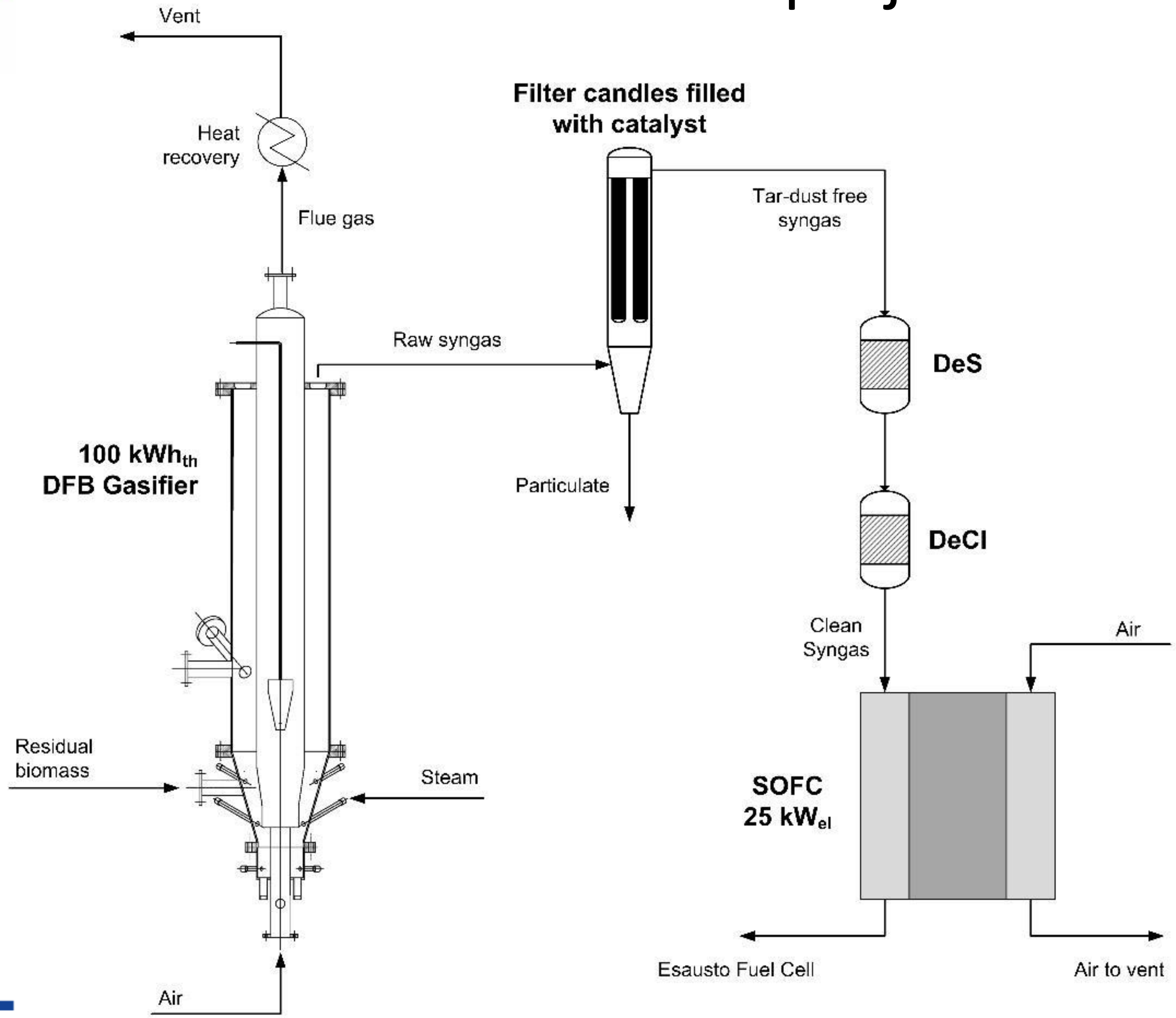
# BLAZE project




The BLAZE project will demonstrate the use of an **integrated biomass gasifier and fuel cell CHP plant**, as cost-effective way to produce **renewable electricity and heat** from residual biomass.

The aim of the project is to develop an innovative, highly efficient and fuel-flexible technology.

*High efficiency and low emissions CHP technologies from biogenic residues*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BLAZE

# Pilot plant

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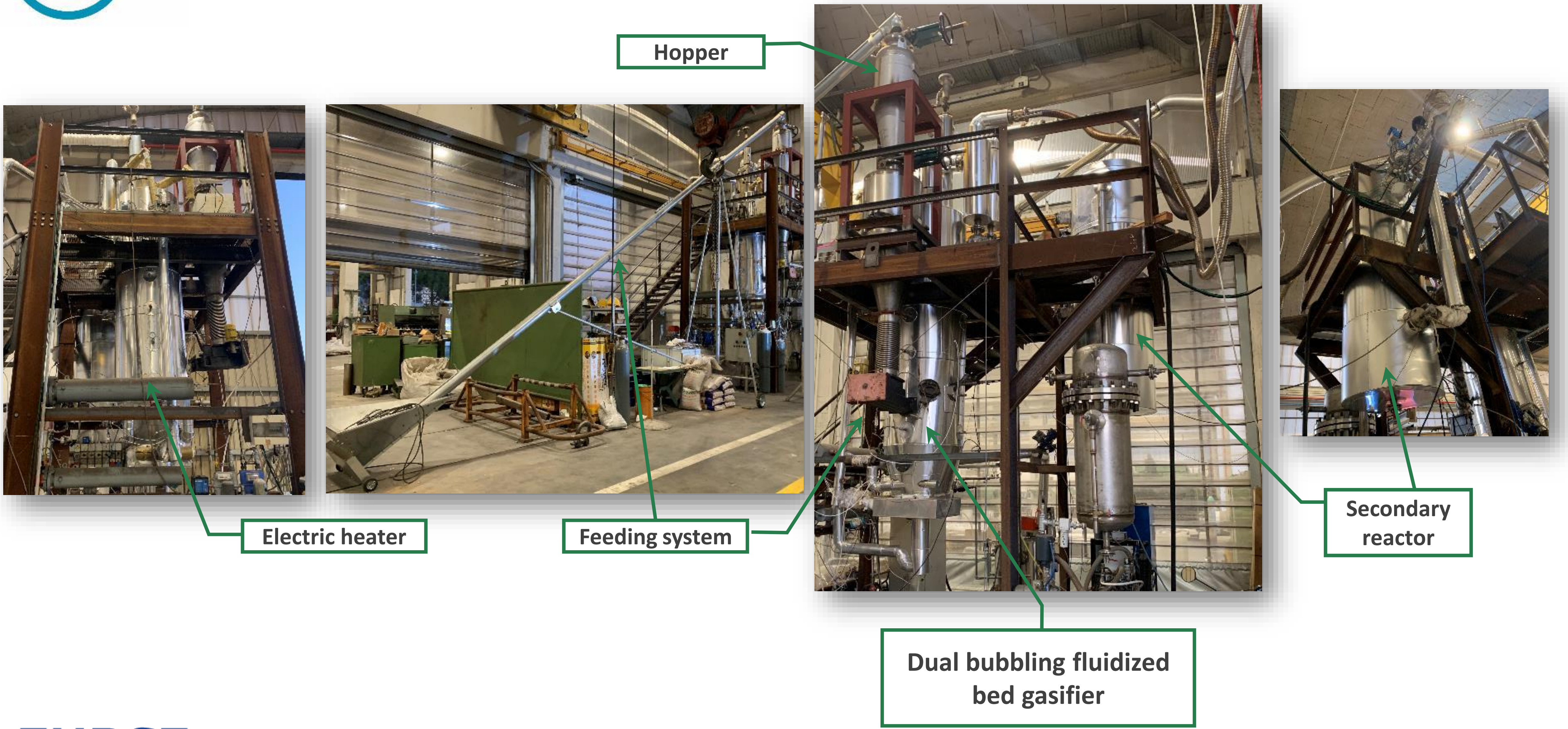




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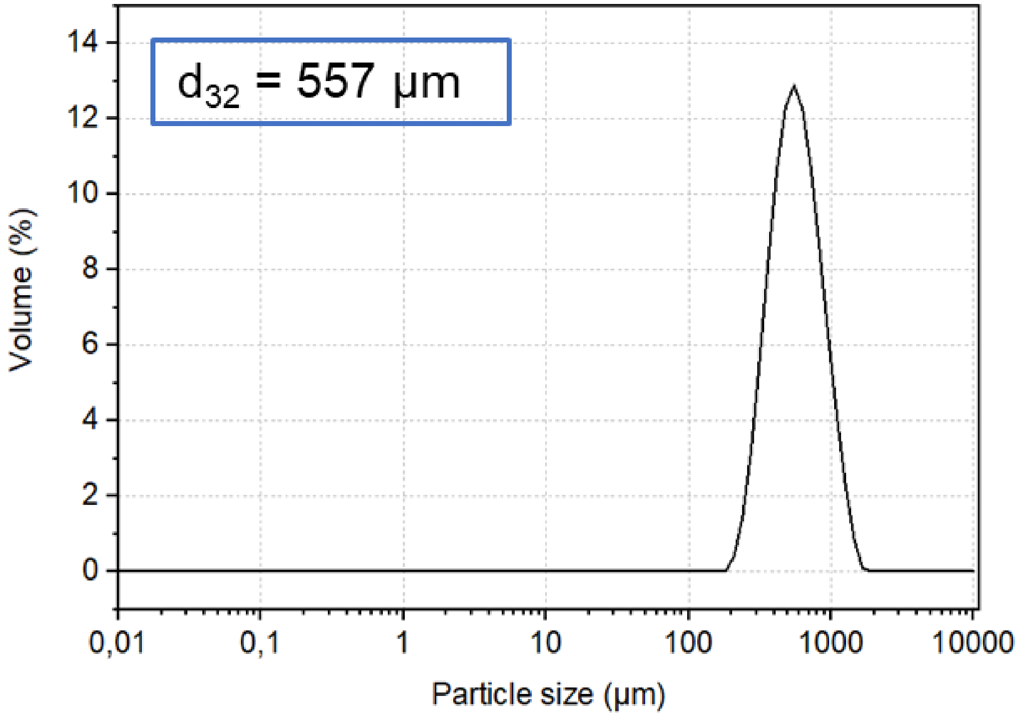
# Materials

## Shells

| Proximate and ultimate analysis | |
|---|---|
| **Ash ($wt\%_{,db}$)** | 1.2 |
| **Volatile Matter($wt\%_{,db}$)** | 75.5 |
| **Fixed Carbon($wt\%_{,db}$)** | 23.3 |
| **Moisture ($wt\%_{,ar}$)** | 8 |
| **C ($wt\%_{,db}$)** | 50.96 |
| **H ($wt\%_{,db}$)** | 5.72 |
| **N ($wt\%_{,db}$)** | 0.42 |
| **S ($wt\%_{,db}$)** | 0.03 |
| **O ($wt\%_{,db}$)*** | 41.67 |
| **HHV (MJ/kg)** | 19.9 |
| **LHV (MJ/kg)** | 18.1 |

*%O=100-( %C+%H+%N+%S+%ash), dry basis

## Olivine sand




$$d_{3,2} = \frac{1}{\sum_{i=1}^{n}\left(\frac{x_i}{d_i}\right)}$$



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# Start-up procedure

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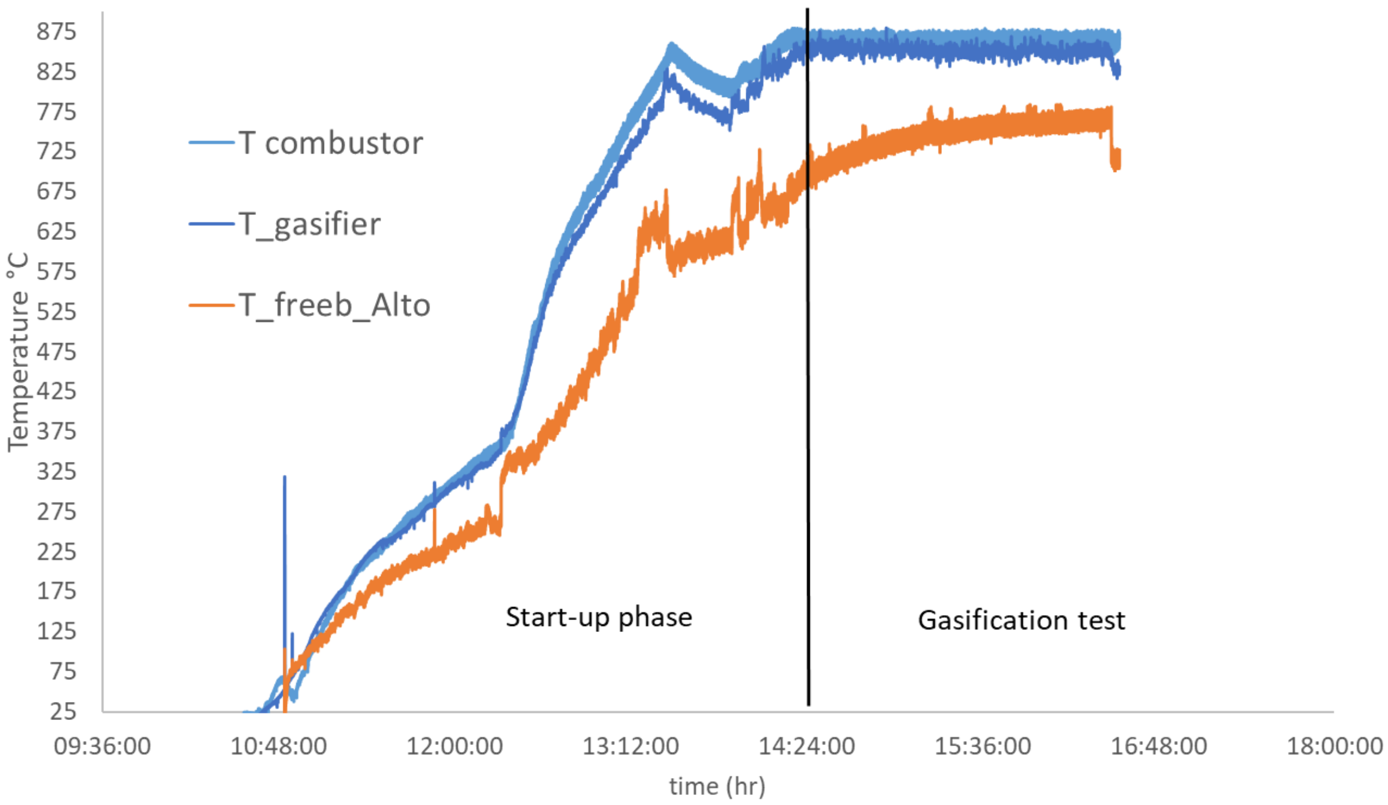


Air was fed in both chambers

$T_{gasifier}$ = 25 °C → 300°C (2 °C/min)

Pre-heated air (200 °C)

LPG burner 20 kW in the gasifier

$T_{gasifier}$ = 300 °C → 850°C (6,5 °C/min)

Pre-heated air (200 °C) – reduced flow rate

LPG burner 20 kW in the gasifier

Biomass for combustion in the gasifier

Approximately **4h** to reach operating temperature



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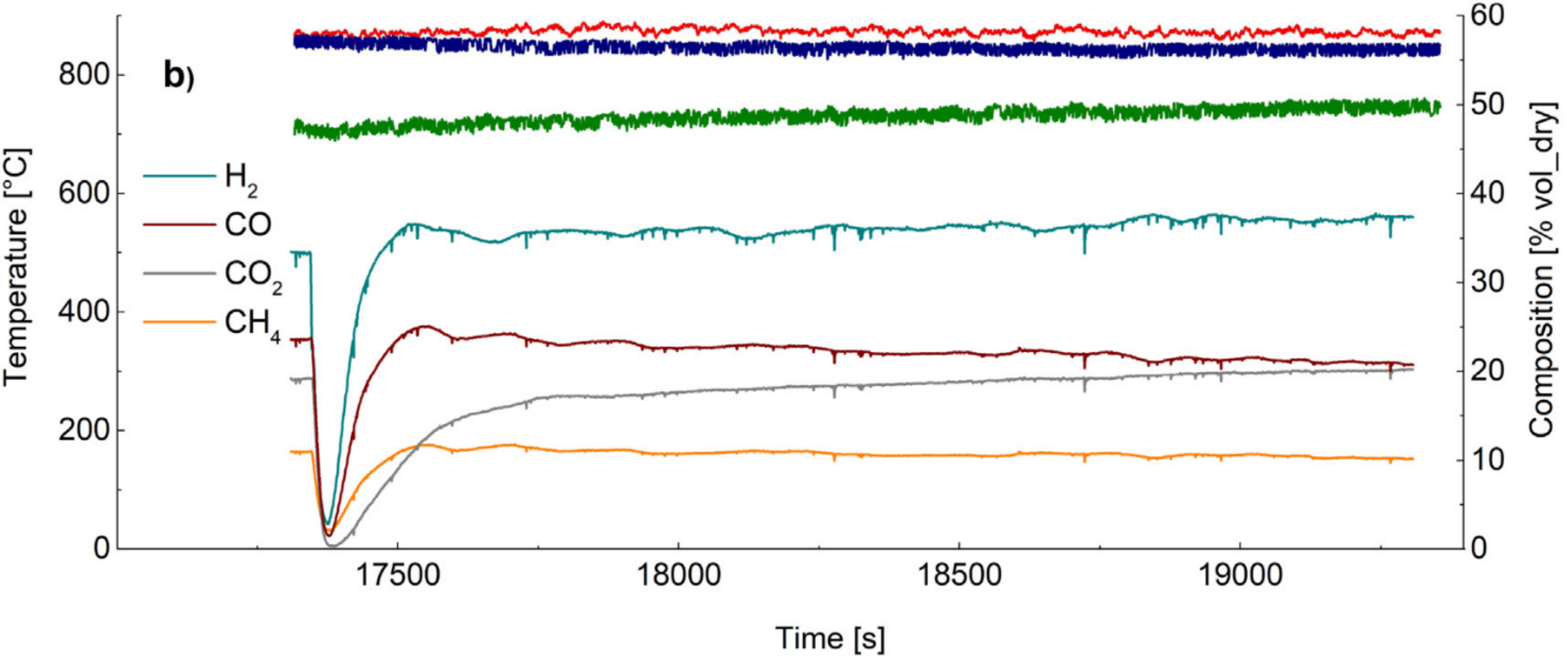
# Gasification test




Gas composition and temperature during the sampling phase

**Reactor maintained at the steady state** changing air and LPG flow rates

Air flow rate in the combustor was studied to verify its influences on the temperature of the reactor and on the leakages between the two chambers

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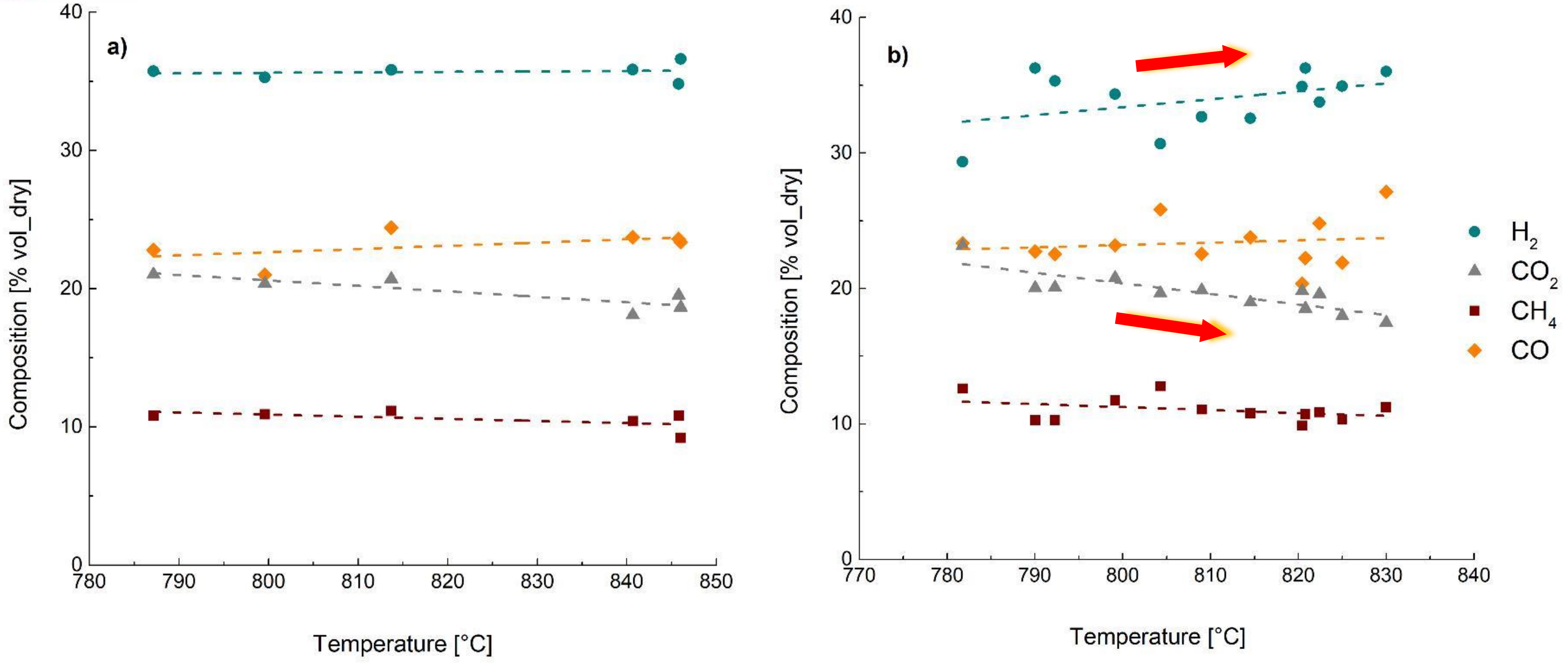
# Gasification tests - Results




15 kg/h

$N_2$ content 5-10 %

20 kg/h

*High efficiency and low emissions CHP technologies from biogenic residues*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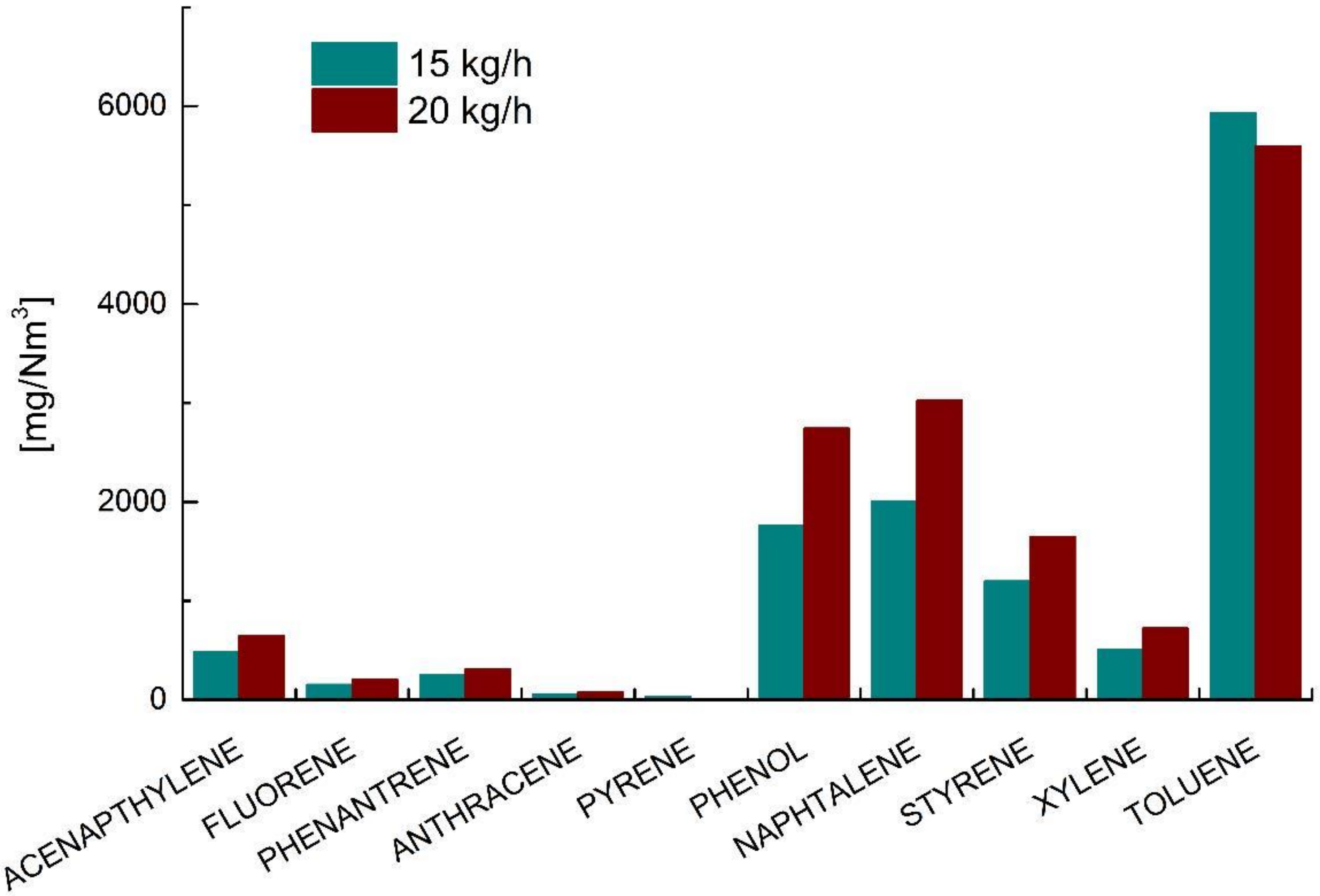
# Tar concentrations




Temperature, in the range investigated, does not affect significantly the tar content (Mean value is reported)

15 kg/h → 12.4 g/$Nm^3$

20 kg/h → 15 g/$Nm^3$

Lower tar content at higher S/B

TAR content too high for SOFC

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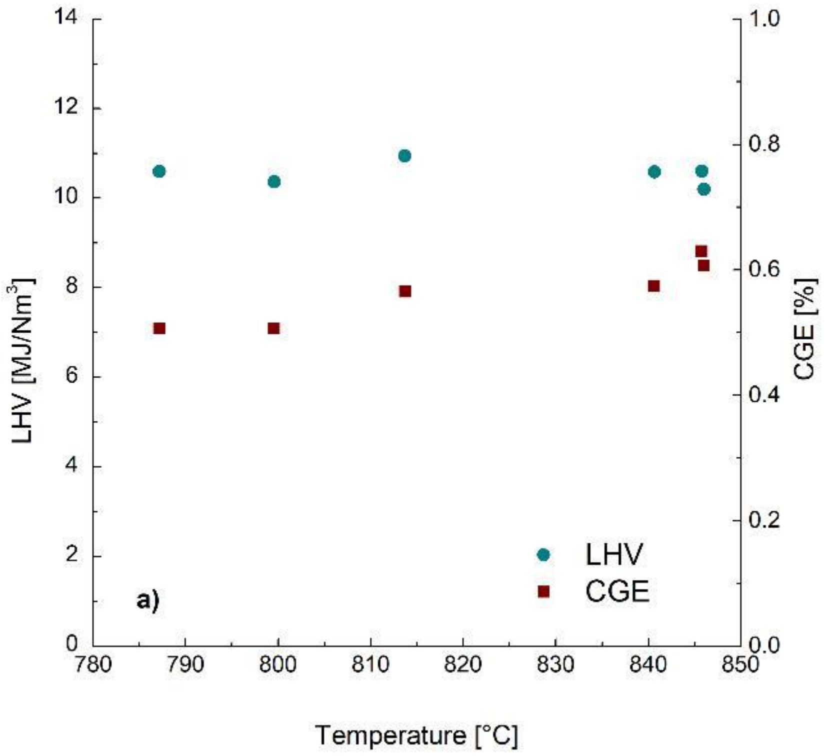
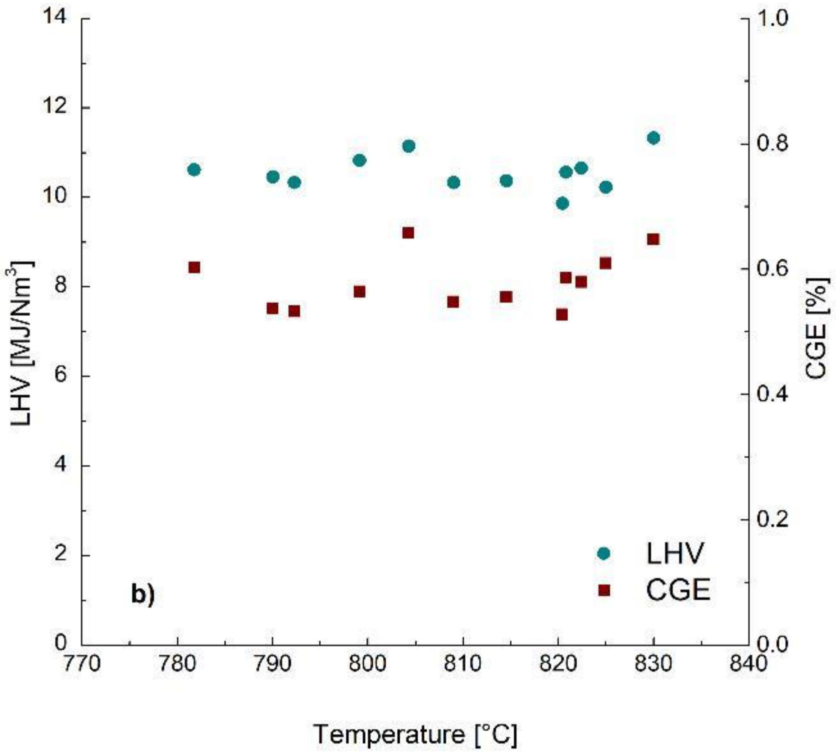
# Gasification tests - Results




15 kg/h




20 kg/h

$$CGE\ (\%) = \frac{Q_{Syngas} \cdot LHV_{Syngas}}{\dot{m}_{Bio} \cdot LHV_{Bio} + \dot{m}_{LPG} \cdot LHV_{LPG}} \cdot 100$$

Increase in LPG in some tests does not lead to a rise in temperature

Unfavourable operating conditions:

- Lower excess of air
- Reduced heat exchange chambers

**Optimal LPG/Biomass ratio** in terms of energy input is 20 % with an air excess of 30 %.

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# Hot gas cleaning and conditioning



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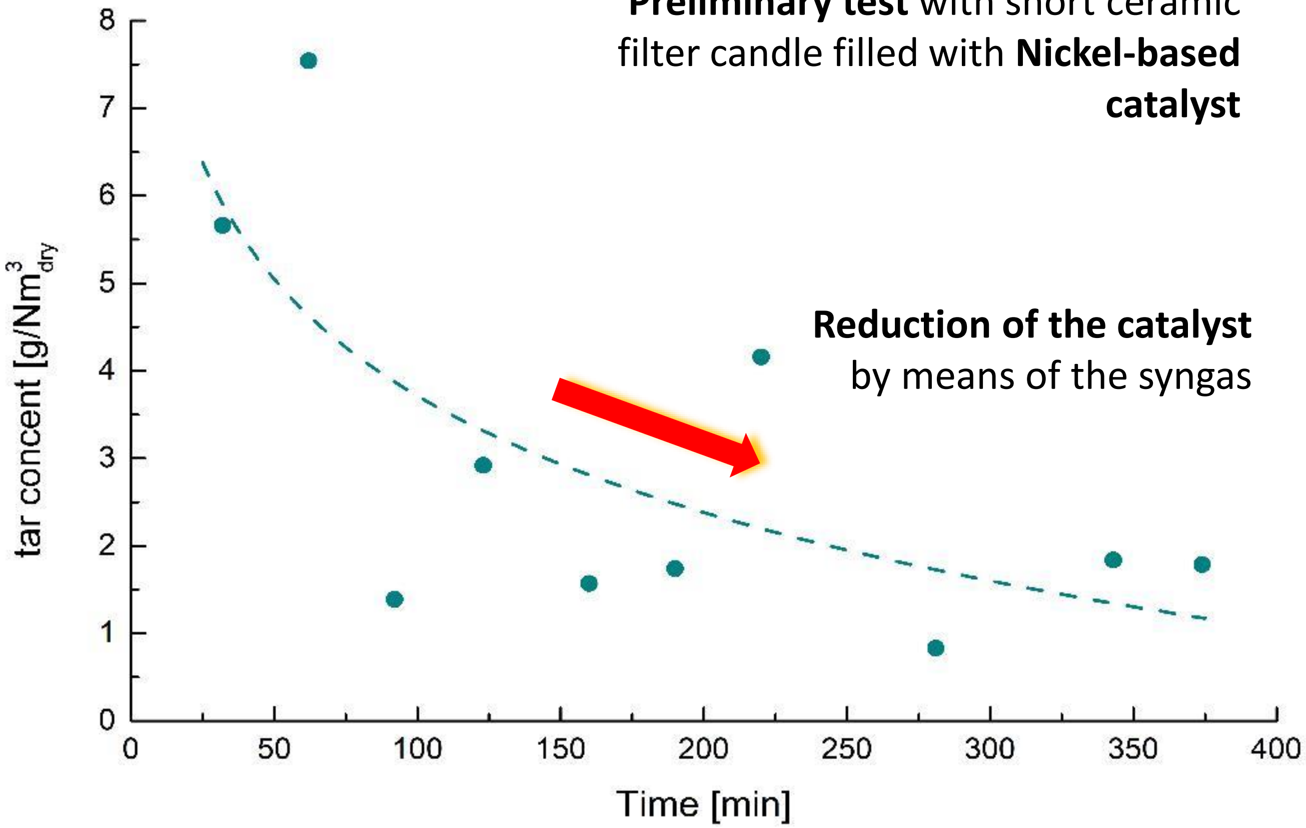
**Preliminary test** with short ceramic filter candle filled with **Nickel-based catalyst**




**Reduction of the catalyst** by means of the syngas


<u>The temperature of the freeboard is always lower than that of the gasifier (100 °C); tests will be carried out to increase this temperature and improve the performance of the catalyst (Enriched Air injections in the freeboard)</u>



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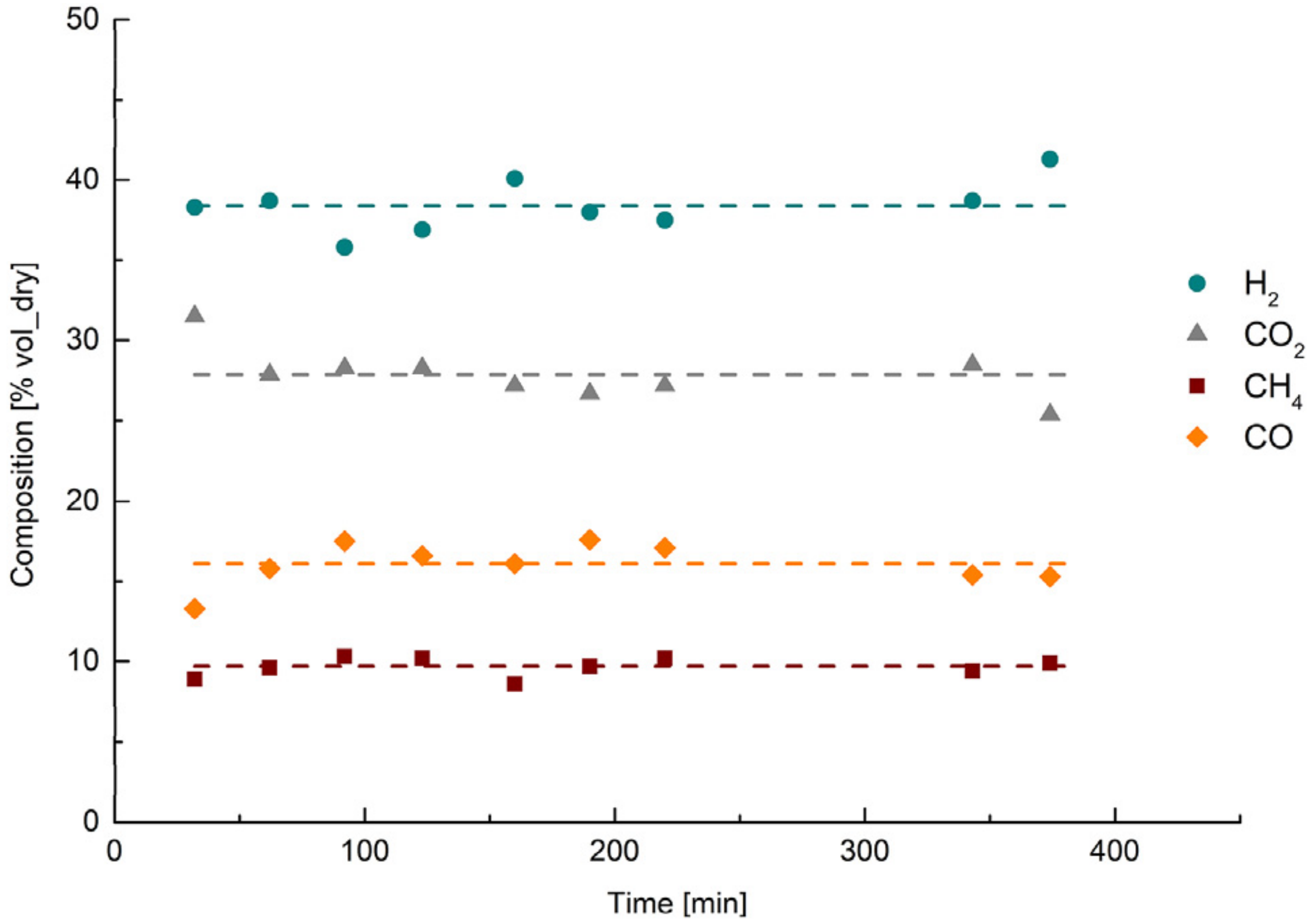
# Hot gas cleaning and conditioning:Gas composition




The syngas composition shows a higher content of $H_2$ and $CO_2$ and lower content of CO highlighting the effect of WGS reaction.

Gas yield obtained is **1.4 Nm$^3$/kgBio$_{,dry,ash\ free}$.**
**CGE=71.2%**

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# Conclusions

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- The analysis of the producer gas varying several process parameters showed the reliability of the system.
- The highest operating temperature levels are obtained with LPG/Biomass ratio of approx. 20% in terms of energy input.
- The hydrogen concentration increases with temperature and S/B (up to 36.6 %). The tar content of the raw syngas was 12 g/Nm$^3$
- The syngas produced, for all tested conditions, has a LHV of 10.6 MJ/Nm$^3$, with low content of nitrogen.
- The test long run with ceramic filter candle filled with catalyst showed that the tar content dropped to about 2 g/Nm$^3$ and the H2 concentration was increased up to 41 %, confirming the activity of the catalyst.
- **Future test campaigns are planned on the pilot plant to further reduce the tar content of the syngas and to evaluate the behavior of the gasifier using different biomass feedstocks.**



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# Thank you
# for your attention

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