

# Power generation and hydrogen production from biomass and plastic waste gasification

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Sotacarbo S.p.A.

## Sotacarbo: Società Tecnologie Avanzate Low Carbon

Shareholders:

- Regional Government of Sardinia
- ENEA

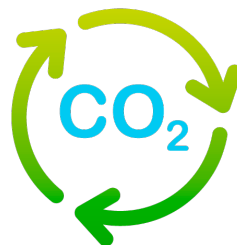
Established: 1987



biomass / waste  
gasification



CO<sub>2</sub>  
capture



CO<sub>2</sub>  
utilization



CO<sub>2</sub>  
storage



energy  
efficiency



- **approach**
- moving-bed updraft
- moving-bed downdraft
- bubbling fluidised-bed
- conclusions

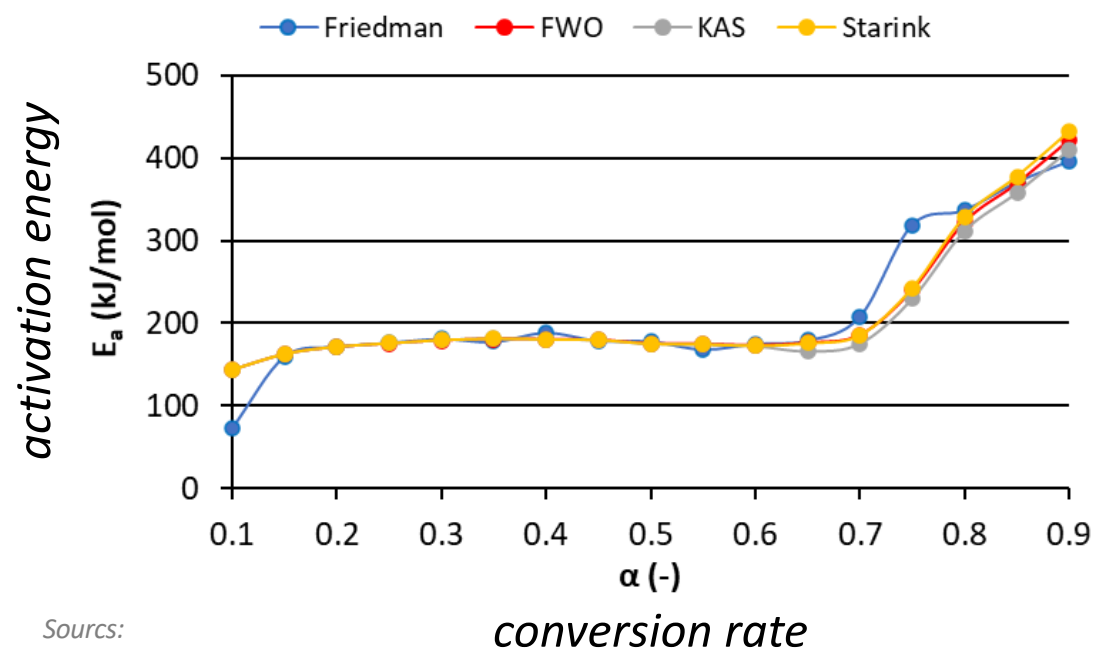
## *different application fields*

- different fuels
  - waste biomass
  - plastic materials
- different products
  - electricity
  - hydrogen
- different technologies
  - moving-bed updraft
  - moving-bed downdraft
  - bubbling fluidized-bed

## *approach*

- experimental development from lab to demonstration
- support from/to CFD modeling

thermogravimetric analyser:  
**Mettler Toledo TG/DSC3+**  
integrated with a **GC-MS** for gas analysis



Sources:

Dessi et al. *Energy* 2021;217:119394

Porcu et al. *Appl Energy* 2021;293:116933

Fermoso et al. *Energy Conv Manage* 2018;164:399-409

Mureddu et al. *Fuel* 2018;212:626-637

kinetic performance determined  
by different isoconversional  
methods

kinetic triplet:  $\frac{d\alpha}{dt} = A \exp\left(\frac{-E}{RT}\right) f(\alpha)$

- activation energy ( $E$ )
- pre-exponential factor ( $A$ )
- reaction model ( $f(\alpha)$ )

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# *moving-bed updraft*



Sources:

Pettinau et al. *Int J Hydrogen Energy* 2010;35:9836-9844

Ward et al. *Fuel* 2020;267:117303



“Performance testing of a moving-bed gasifier using **coal, biomass, and waste plastic** blends to generate **white hydrogen**”

Funded by:



**U.S. Department of Energy**  
*Cooperative Agreement DE-FE0032044*



Hamilton Maurer International, Inc.

Cost share from:

**EPRI**

**HMI**

**Sotacarbo**



- 200 kW<sub>th</sub>
- air-blown gasification
- atmospheric pressure
- process widely characterized at pilot and demo scale (in Italy and US)

new experimental campaign

- plant optimization towards H<sub>2</sub>
- different fuel blends

Source: Pettinau et al. *Int J Hydrogen Energy* 2010;35:9836-9844



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# *moving-bed downdraft*

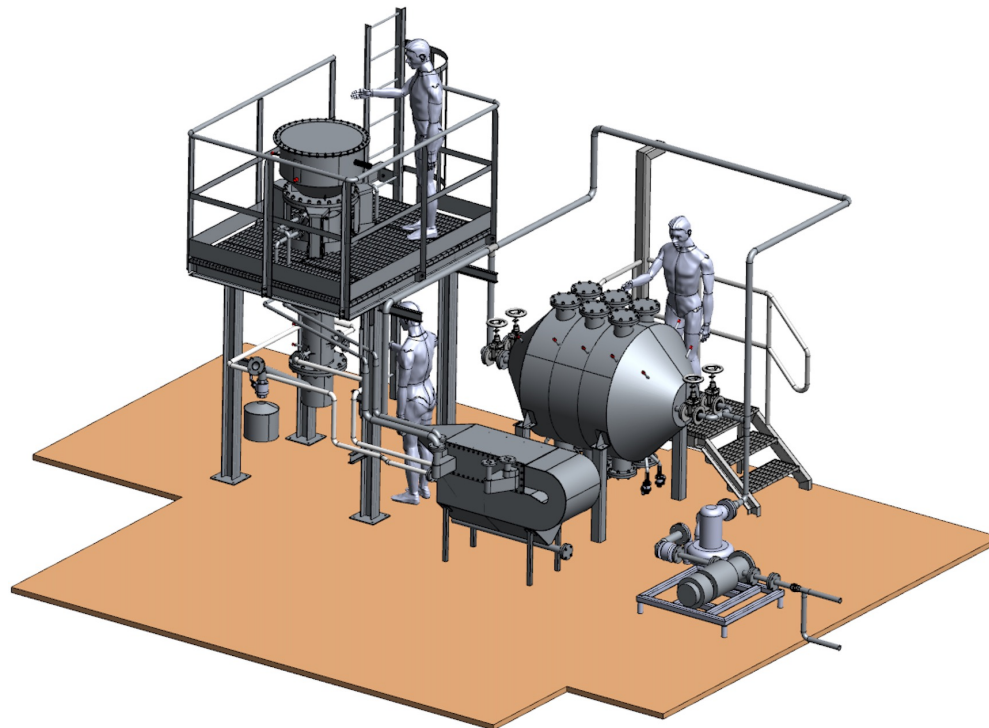
Energy recovery from **brewer's spent grain** as a support to craft beer production

Funded by:



**Sardegna Ricerche**

*CUP: D84E19000120005*



- 40 kW<sub>th</sub>
- 10 kg/h of primary fuel
- air-blown gasification
- atmospheric pressure

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- **bubbling fluidised-bed**
- conclusions

# *bubbling fluidized-bed*



bench-scale

**MFiX**  
Multiphase Flow with  
Interphase eXchanges

lab analysis (TGA)



pilot-scale

## bench-scale BFB unit

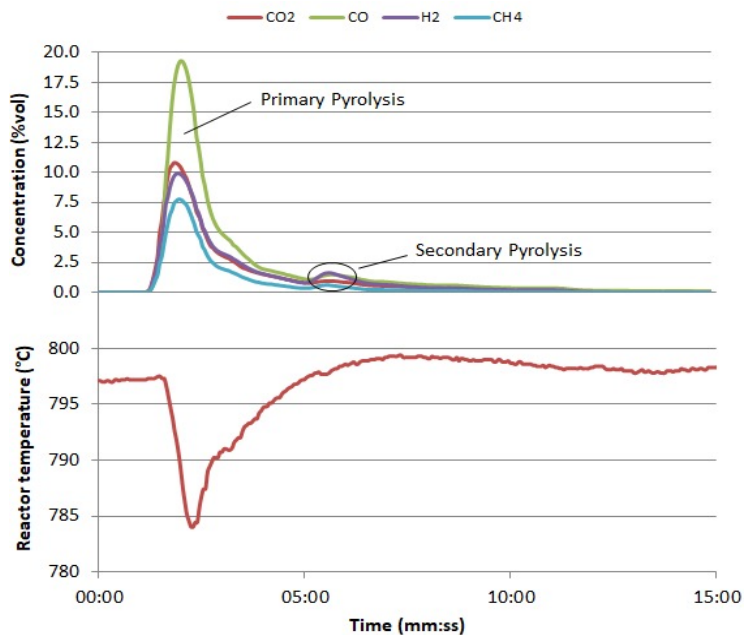


- feedstock capacity: **100 g/h**
- reactor height: **800 mm**
- inner diameter: **26 mm** (reactor)
- inner diameter: **54 mm** (freeboard)
- olivine size: **125-212  $\mu\text{m}$**

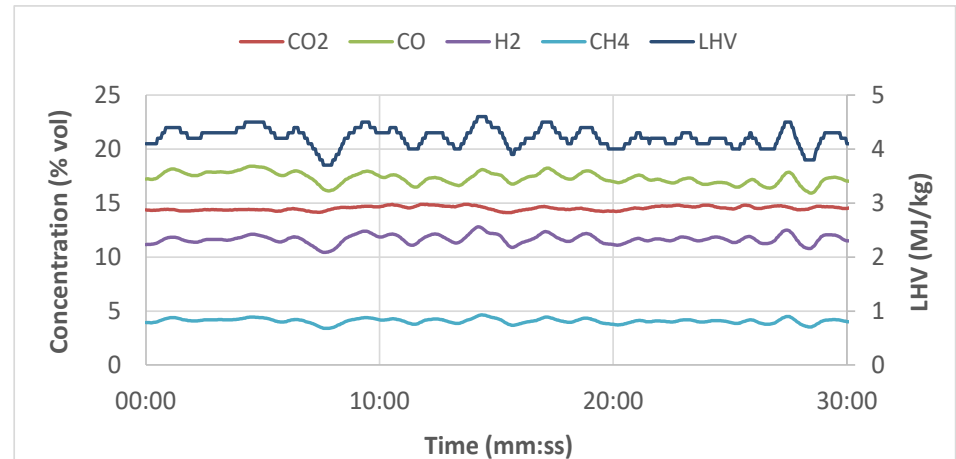
available since **January 2017**

# biomass pyrolysis and gasification

pyrolysis (batch mode)



gasification (continuous mode)

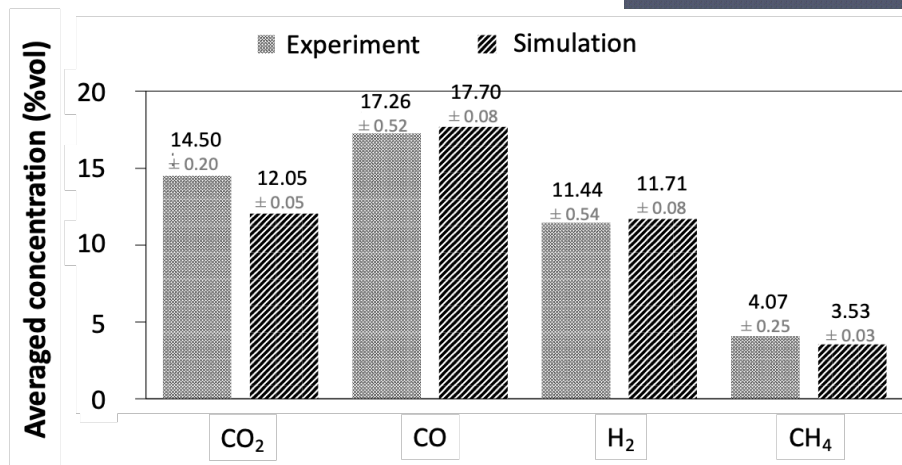
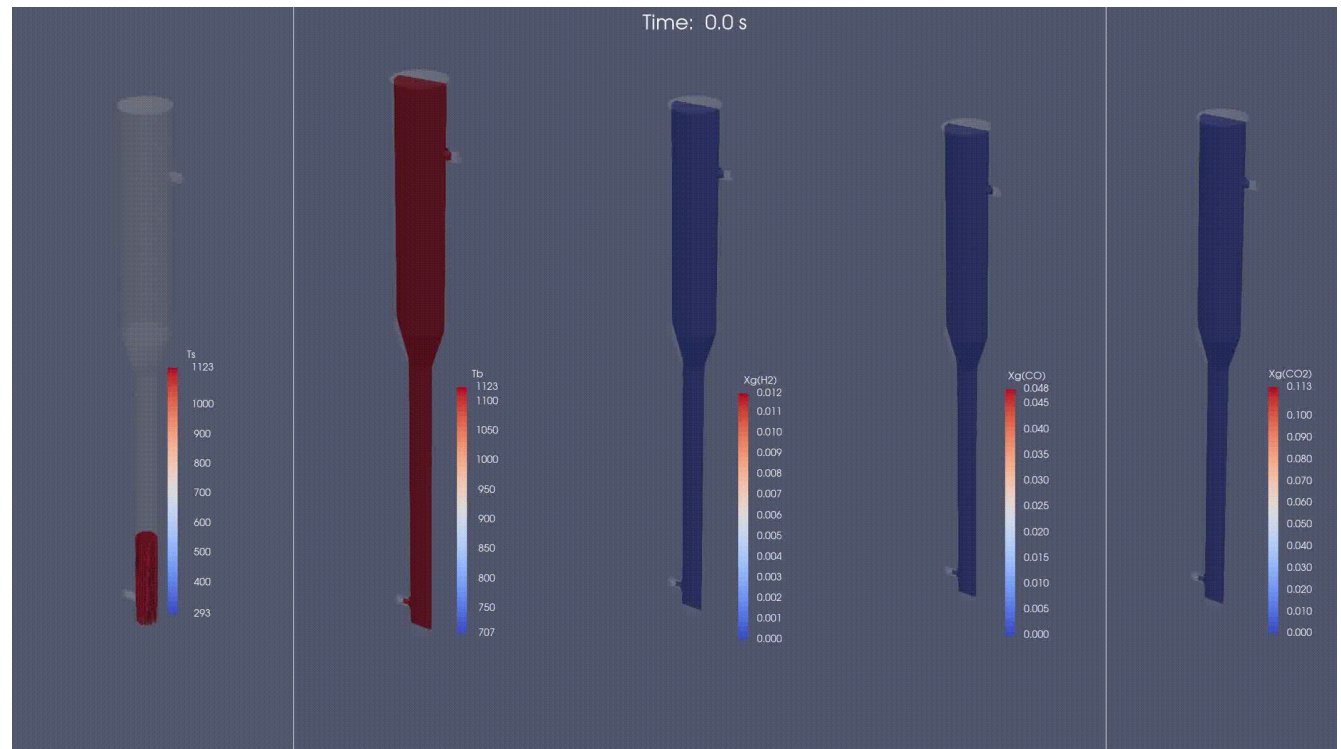


steady state temp.: **850 °C**

equivalence ratio: **0.26**

Source: Porcu et al. Appl Energy 2021;293:116933

Equivalence ratio	0.24		0.26	
	Concentration (% by volume)	Standard deviation (%)	Concentration (% by volume)	Standard deviation (%)
N <sub>2</sub> (by difference)	48.56	-	52.73	-
CO <sub>2</sub>	14.85	0.28	14.50	0.20
CO	18.24	1.30	17.26	0.52
H <sub>2</sub>	14.31	1.58	11.44	0.54
CH <sub>4</sub>	4.04	0.74	4.07	0.25
O <sub>2</sub>	0.00	-	0.00	-



**MFiX** Multiphase Flow with Interphase eXchanges

**NEL** NATIONAL ENERGY TECHNOLOGY LABORATORY

Source: Porcu et al. Appl Energy 2021;293:116933

## *the FABER unit*

### *FABER – Fluidized Air Blow Experimental gasifier Reactor*



- feedstock capacity: **40-100 kg/h**
- thermal input: up to **400 kW**
- electric output: up to **120 kW**
- reactor height: **4,700 mm**
- inner diameter: **489 mm**
- gasification agents: **air, O<sub>2</sub>, H<sub>2</sub>O**
- bed temperature: **700-950 °C**

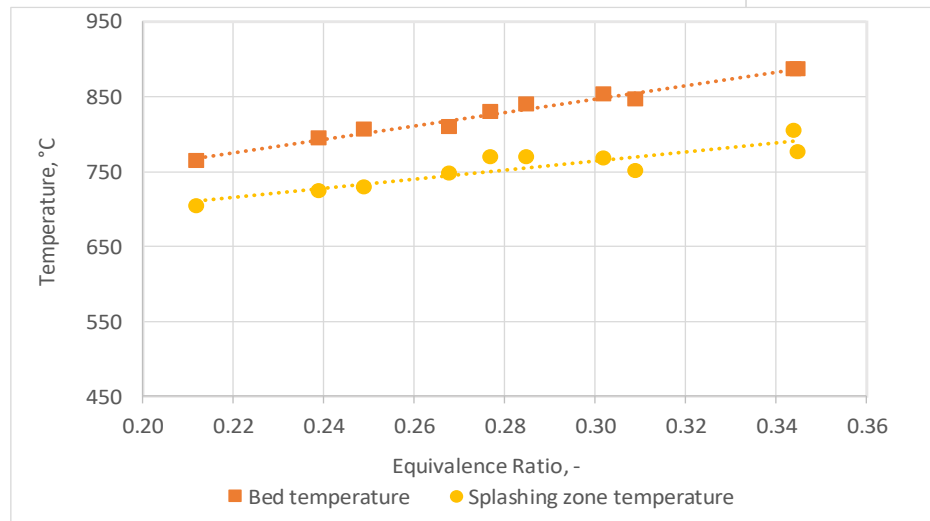
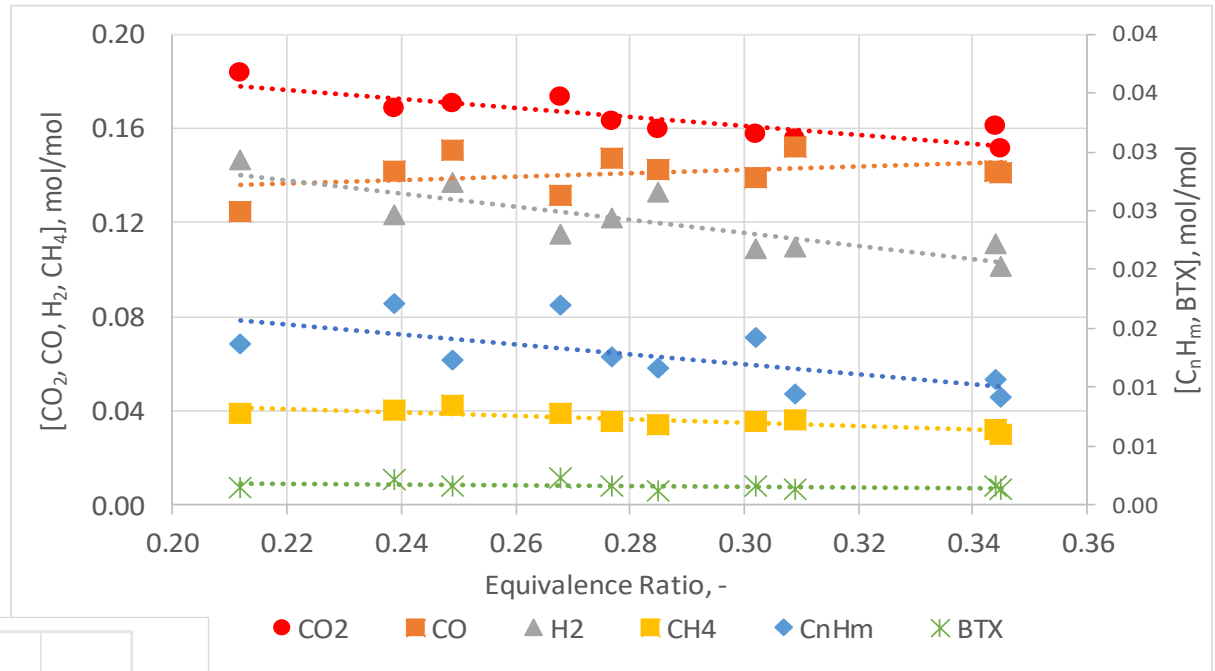
available since **January 2018**



# pilot-scale gasification tests

wide characterisation with  
**eucalyptus chips**  
air-blown gasification

Università  
degli Studi  
della Campania  
*Luigi Vanvitelli*



preliminary tests with  
**Blupolymer Granulo**  
(UNI 10667-1 and UNI 10667-16)  
air-blown gasification

Source: Parrillo et al. Energy 2021;219:119604

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## *simulation*

- tuned with experimental data from:
  - kinetic analysis (TGA)
  - bench-scale runs
- good agreement between predicted and measured values

## *experimental*

- different processes characterized in different conditions
- experimental optimization of the units

## *simulation*

- model scale-up to pilot scale (FABER unit)

## *experimental*

- other waste fuels
  - non-recyclable plastics
  - shifting to O<sub>2</sub>-blown to maximise H<sub>2</sub> production
  - blends (plastic-biomass-other)
- development of hot gas cleanup
- scale-up to demonstration (1 MW<sub>e</sub>)

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*thank you*

*for your attention*