

# **Clean Energy from Biomass**

**Progress in coupling biomass gasification and fuel cell**

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[http://ing.univaq.it/~bio\\_en/](http://ing.univaq.it/~bio_en/)



**BIO-ENERGY  
ENLARGED PERSPECTIVES**

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## **Overall objectives**

- **high energy efficiency, even in distributed power generation**
- **ultra-clean environmental performance**
- **near-zero greenhouse gas emissions**

## **Specific project objectives**

- **assembly and operation of an integrated pilot plant**
- **ancillary research activities focused on key areas to the optimization of the plant performance**

## **Challenges**

### **Construction and operation of an integrated pilot plant**

- **500 kWth fast internally circulating fluidized bed (FICFB) gasifier for catalytic biomass steam-gasification**
- **Hot gas clean-up system for acid compounds removal by adsorption on a basic powder, and ceramic candle fine particle filtration**
- **125 kWe Molten Carbonate Fuel Cell (MCFC)**

# Challenges

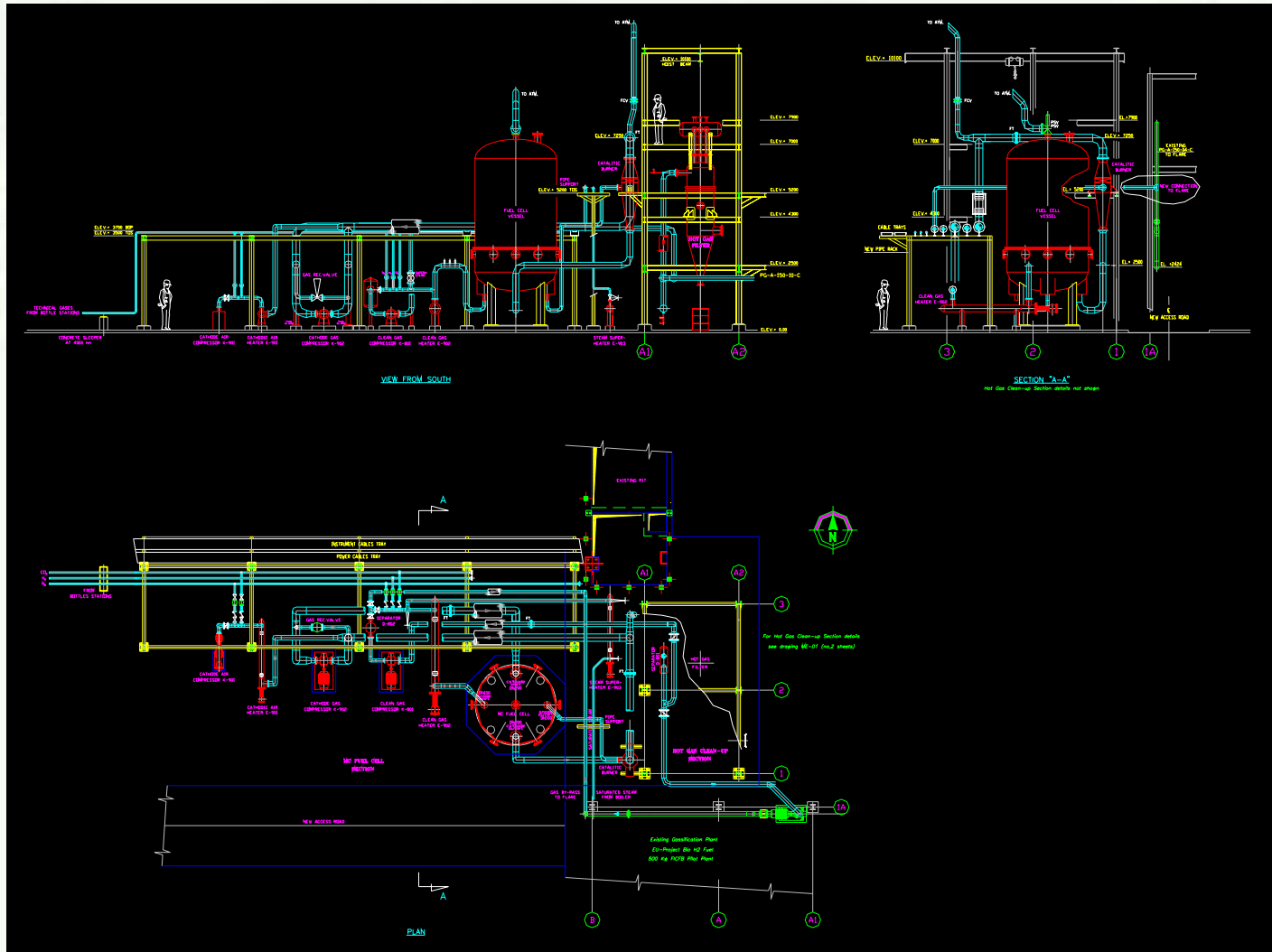
## Accompanying research tasks

- **Development of a low-cost Ni-olivine catalyst to be included in the bed inventory of the gasifier for Hydrogen enhancement and Tar reduction**
- **Operation of a cold model to optimize design and running conditions of the gasification system**
- **CFD model of the gasifier, which combines overall reaction kinetics and heat transfer processes with fluidization dynamics**
- **Simulation tool of the whole system, implemented on commercial software, to develop optimal operation and control strategies**

# Project structure

<b>Participant Name</b>	<b>Main Functions</b>
<b>University of L'Aquila</b> Italy	Coordination, Pilot plant integration and catalytic gasification studies
<b>Technical University of Vienna</b> Austria	System simulation, catalyst performance in 100 kWth gasifier
<b>University College London</b> United Kingdom	Cold modeling and CFD simulation of the gasifier
<b>University of Strasbourg</b> France	Development, characterization and preparation of Ni-olivine catalyst
<b>Ansaldo Ricerche Srl</b> Genova – Italy	Hot gas clean-up system: acid gas removal
<b>Pall Schumacher GmbH</b> Crailsheim – Germany	Hot gas clean-up system: fine particles filtration
<b>ENEA – Research Agency for New Technology, Energy and Environment – Italy</b>	Pilot plant assembly and operation
<b>Ansaldo Fuel Cells SpA</b> Genova – Italy	MCFC stack design and supply

# Detailed engineering of the integrated pilot plant (University of L'Aquila)





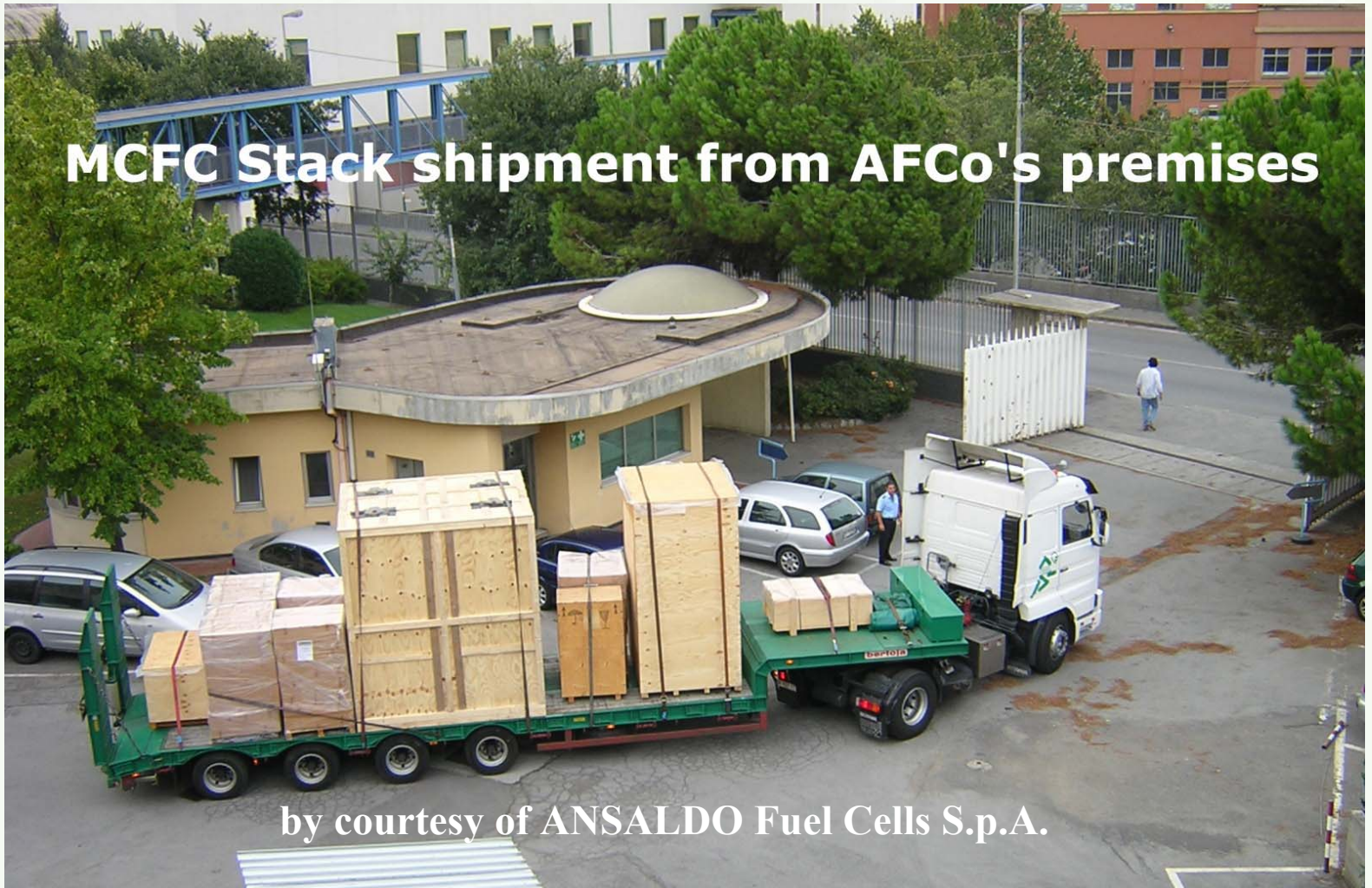
## A view of the the pilot plant at ENEA-Trisaia





# The 125 kW<sub>e</sub> MCFC stack built by Ansaldo Fuel Cells SpA

**MCFC Stack shipment from AFCo's premises**



by courtesy of ANSALDO Fuel Cells S.p.A.



# Fuel gas product quality for the 500 kWth gasifier (Olivine bed inventory)

Full load

Steam/Biomass ratio

0,9

Gas Yield

1,4 Nm<sup>3</sup><sub>dry</sub> / kg<sub>daf</sub>

LHV

~ 13MJ / Nm<sup>3</sup><sub>dry</sub>

N<sub>2</sub>

< 10 % by volume

H<sub>2</sub>

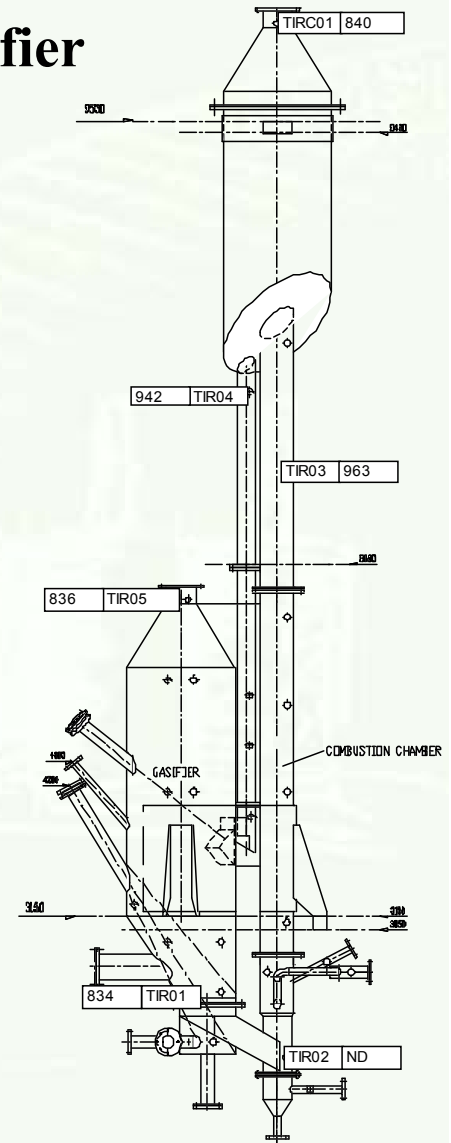
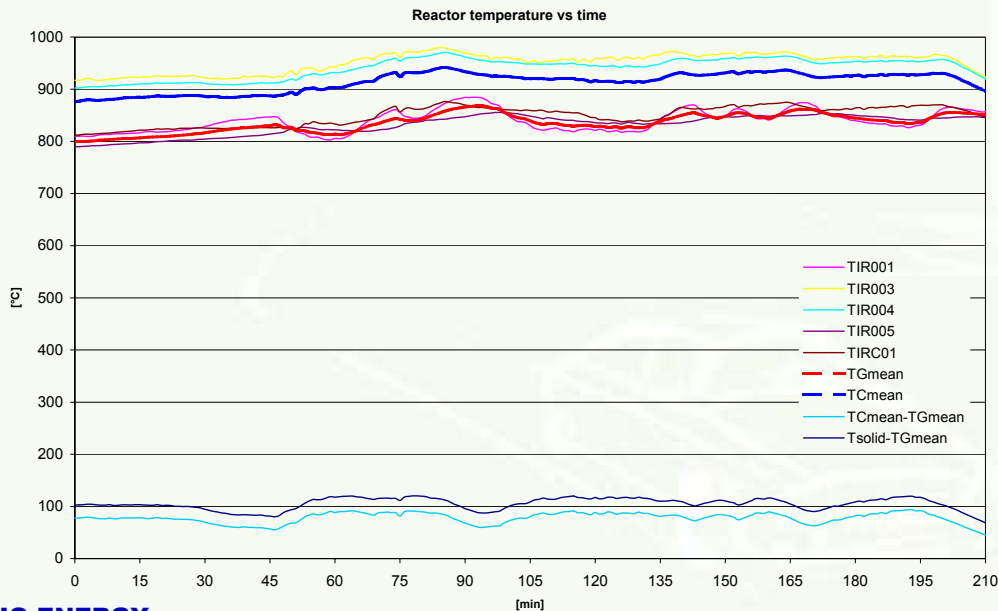
> 33 % “

Light Hydrocarbons

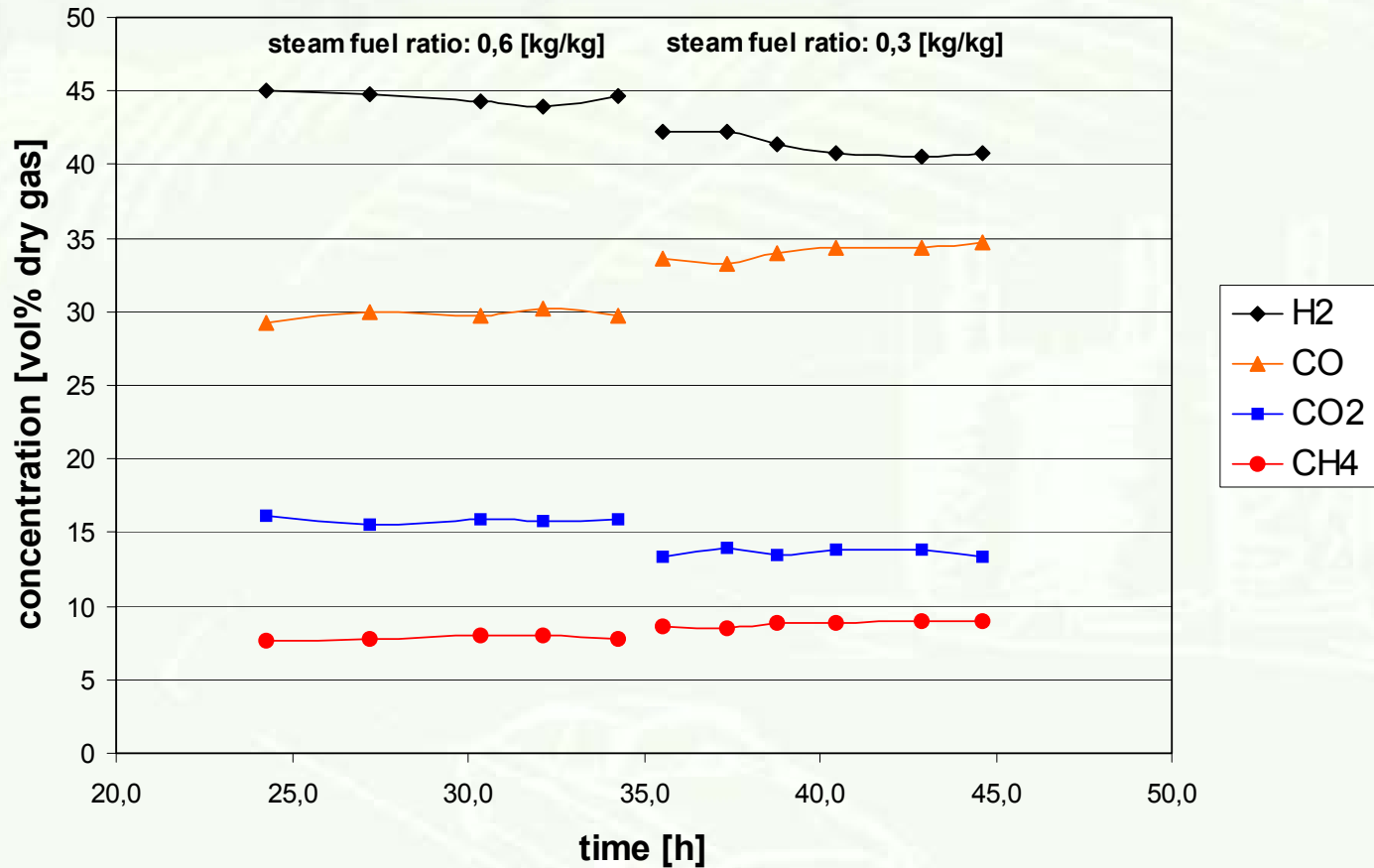
~ 12 % “

Tar (exit of gasifier)

< 6 g / Nm<sup>3</sup><sub>dry</sub>



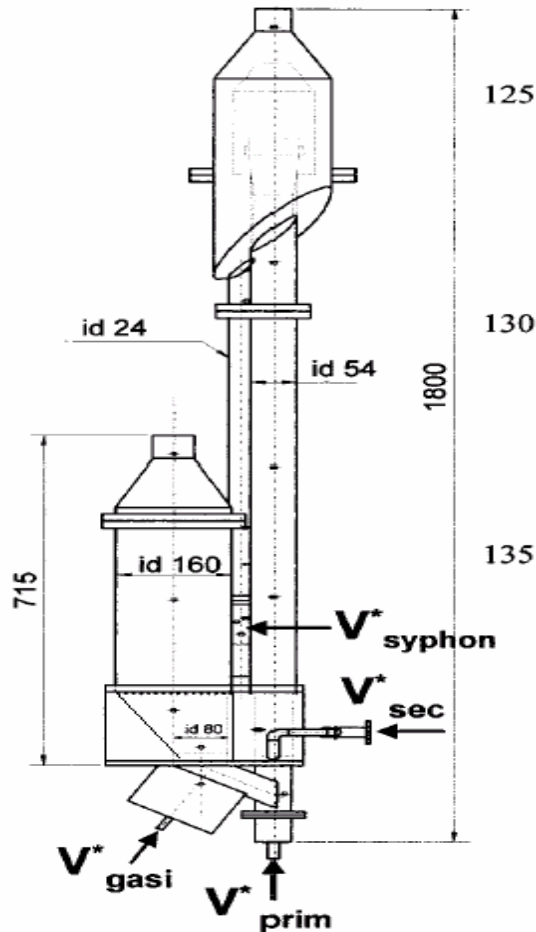
# Fuel gas quality with the Ni-Olivine catalyst (Strasbourg) in the 100 kWth FICFB facility (Vienna)



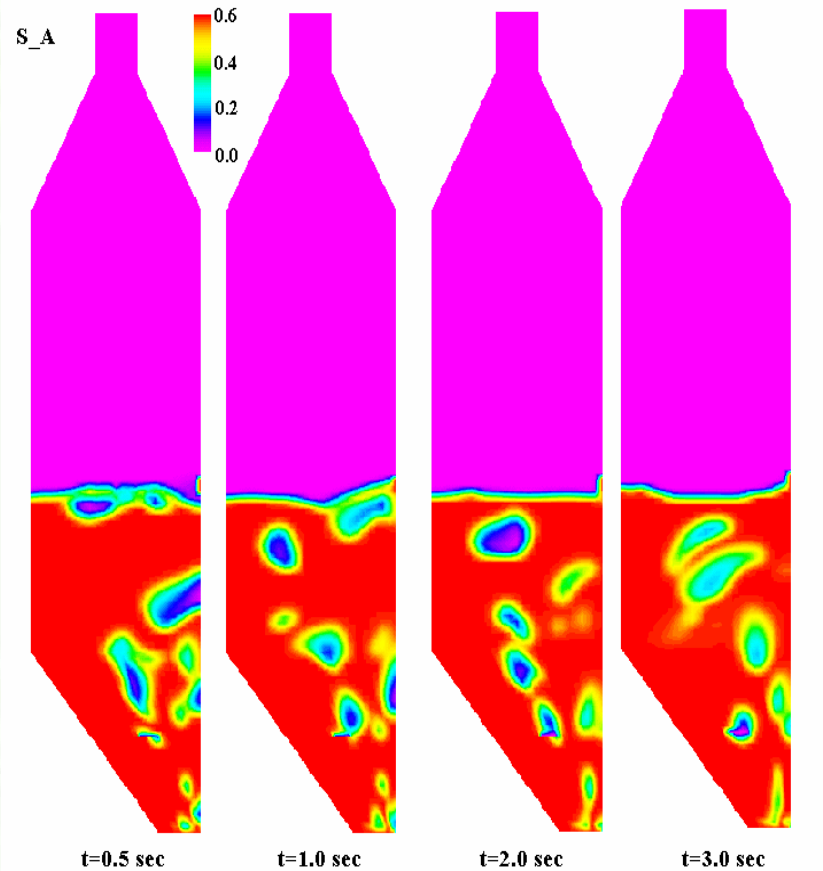
**Tar content = 0.5 g/Nm<sup>3</sup>dry when the bed inventory is 50% Ni-Olivine**

# Simulation of the fluidized bed gasifier (University College London)

## Cold Model



## CFD



Two gas inlets with solid circulation

# Simulation of the integrated plant (Universities of Vienna and L'Aquila)

