BIOROBUR
Biogas robust processing with combined catalytic reformer and trap

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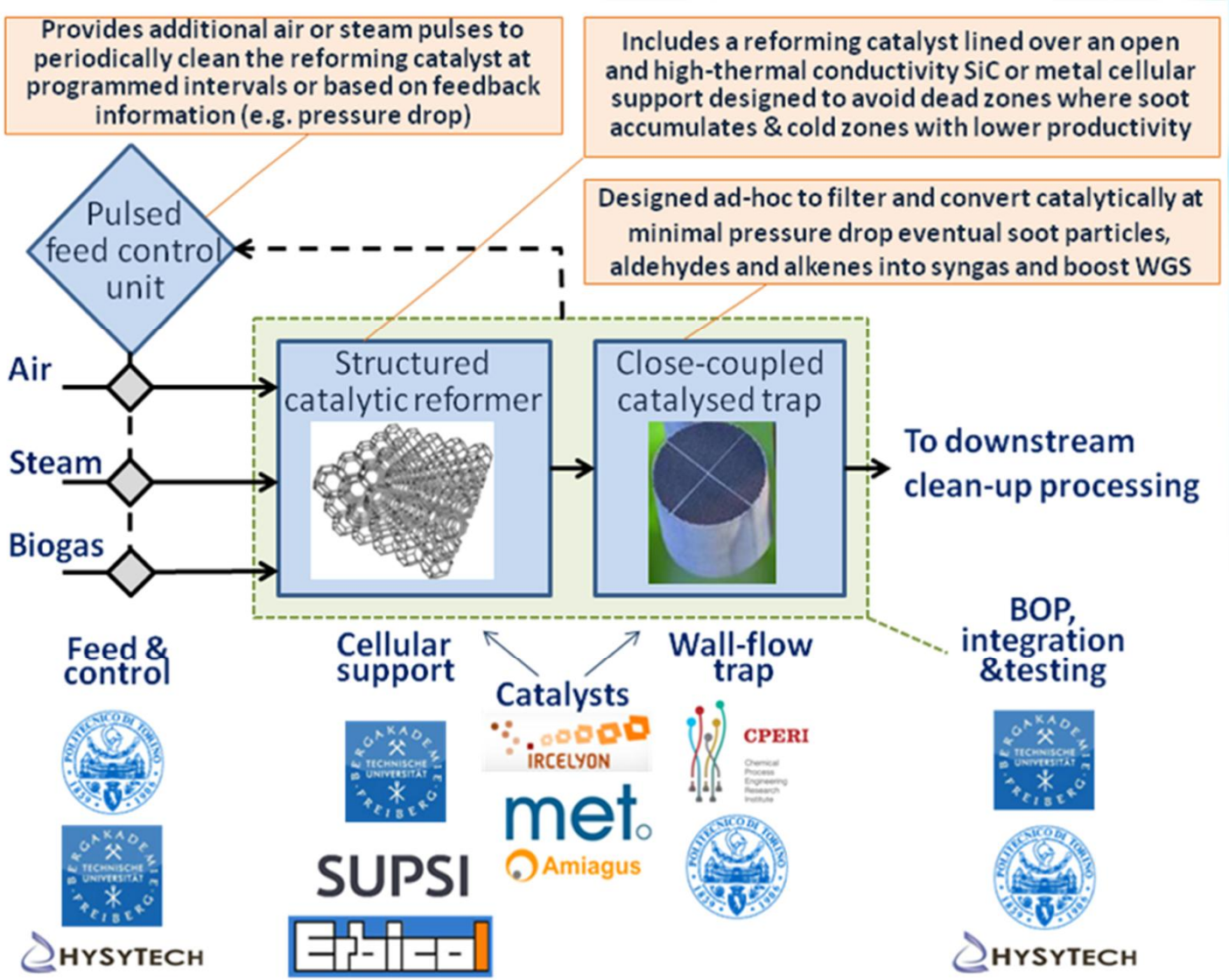
Programme Review Days 2016
Brussels, 21-22 November

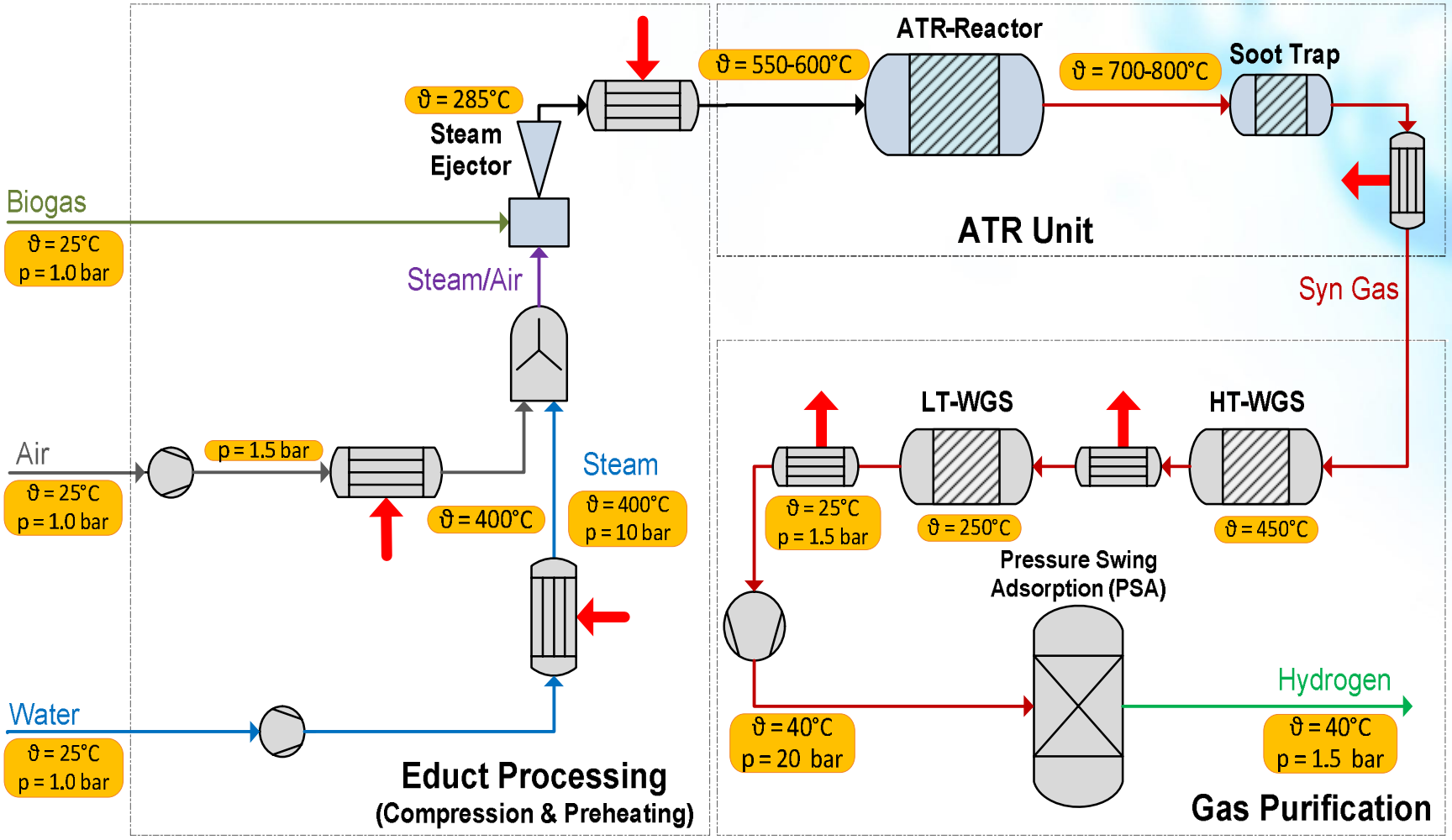
Project Overview

Project Information	
Call topic	Biogas Reforming
Grant agreement number	325383
Application area (FP7) or Pillar (Horizon 2020)	Hydrogen production and distribution
Start date	01/05/2013
End date	30/08/2016
Total budget (€)	3.909.726
FCH JU contribution (€)	2.486.180
Other contribution (€, source)	-----
Stage of implementation	100%
Partners	POLITO; TUBAF; SUPSI; IRCE; CPERI; ERBICOL; HST; MET.

Project overview and the main roles of the partners



Project overview & Simplified Block flow diagram of BioRobur



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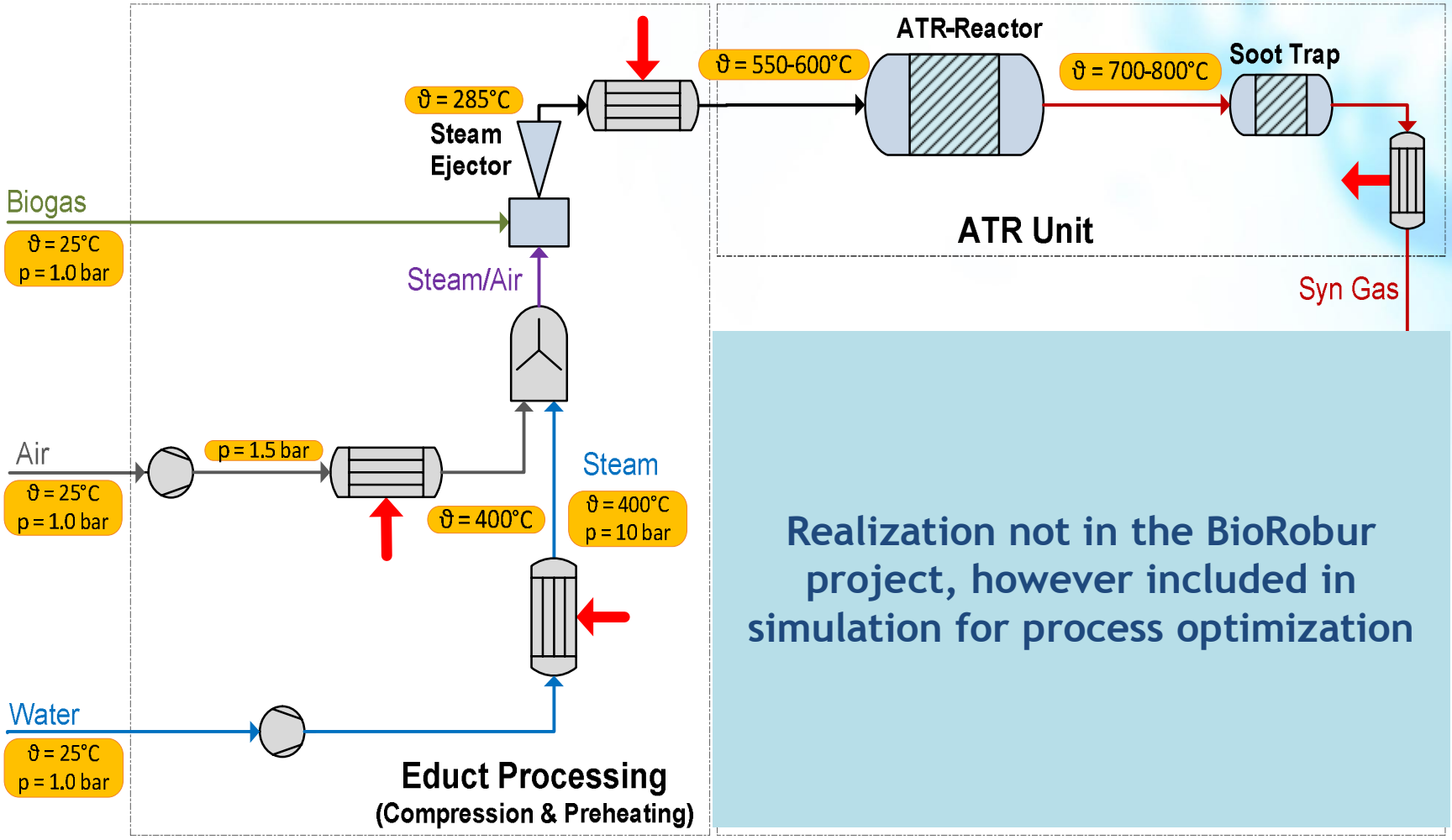
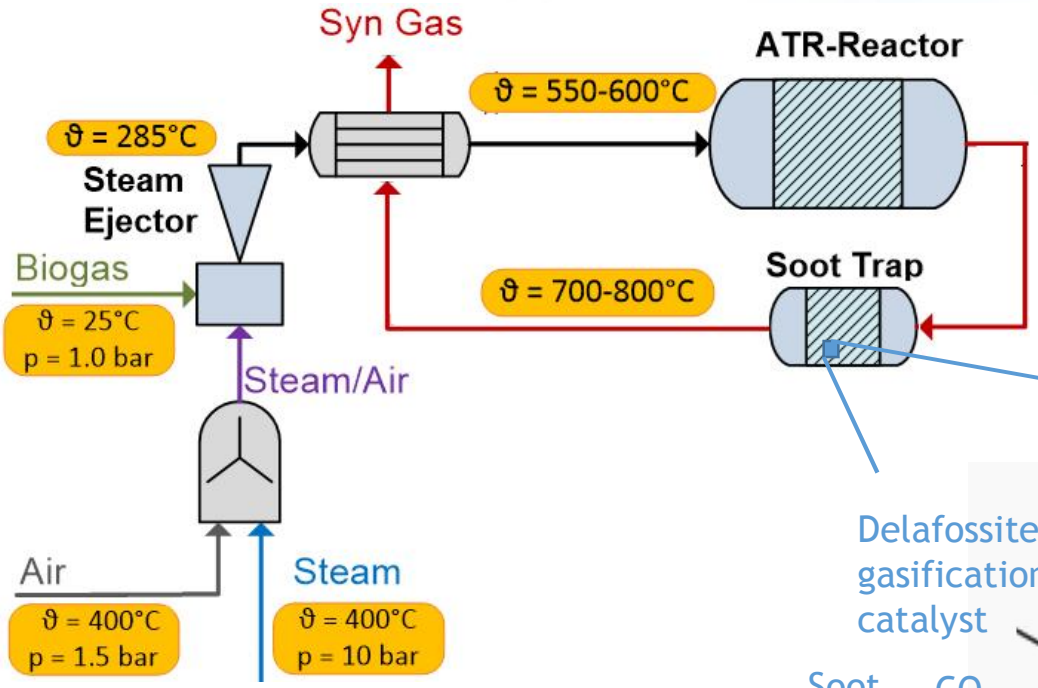


Realization not in the BioRobur project, however included in simulation for process optimization

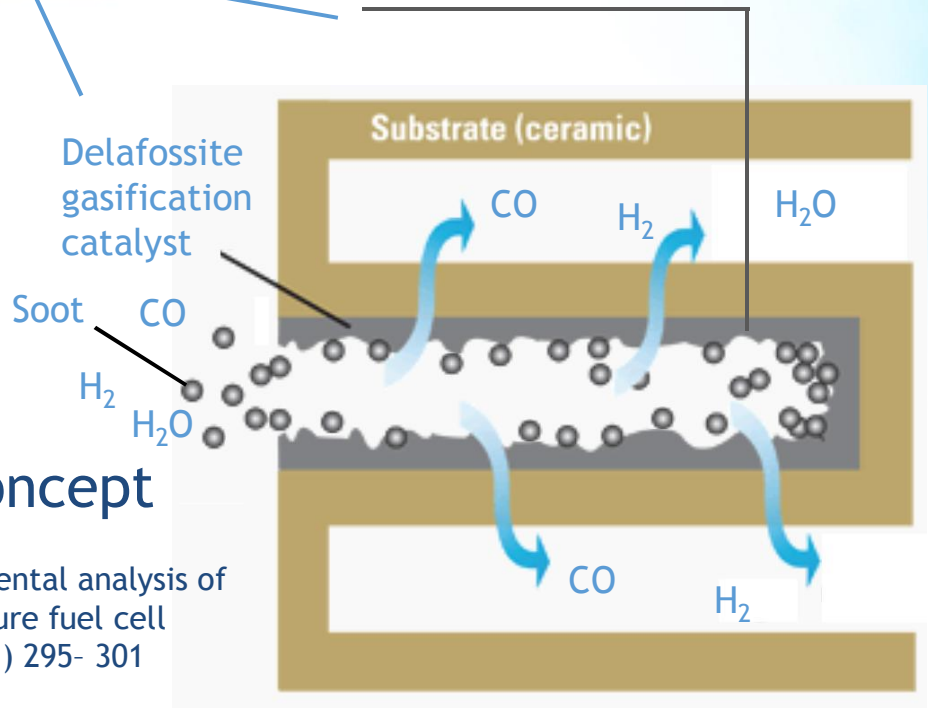
PROJECT ACTIONS The innovative concept

The biogas fuel processor



The trap decouples the residence time of soot at high temperatures from that of the produced syngas.

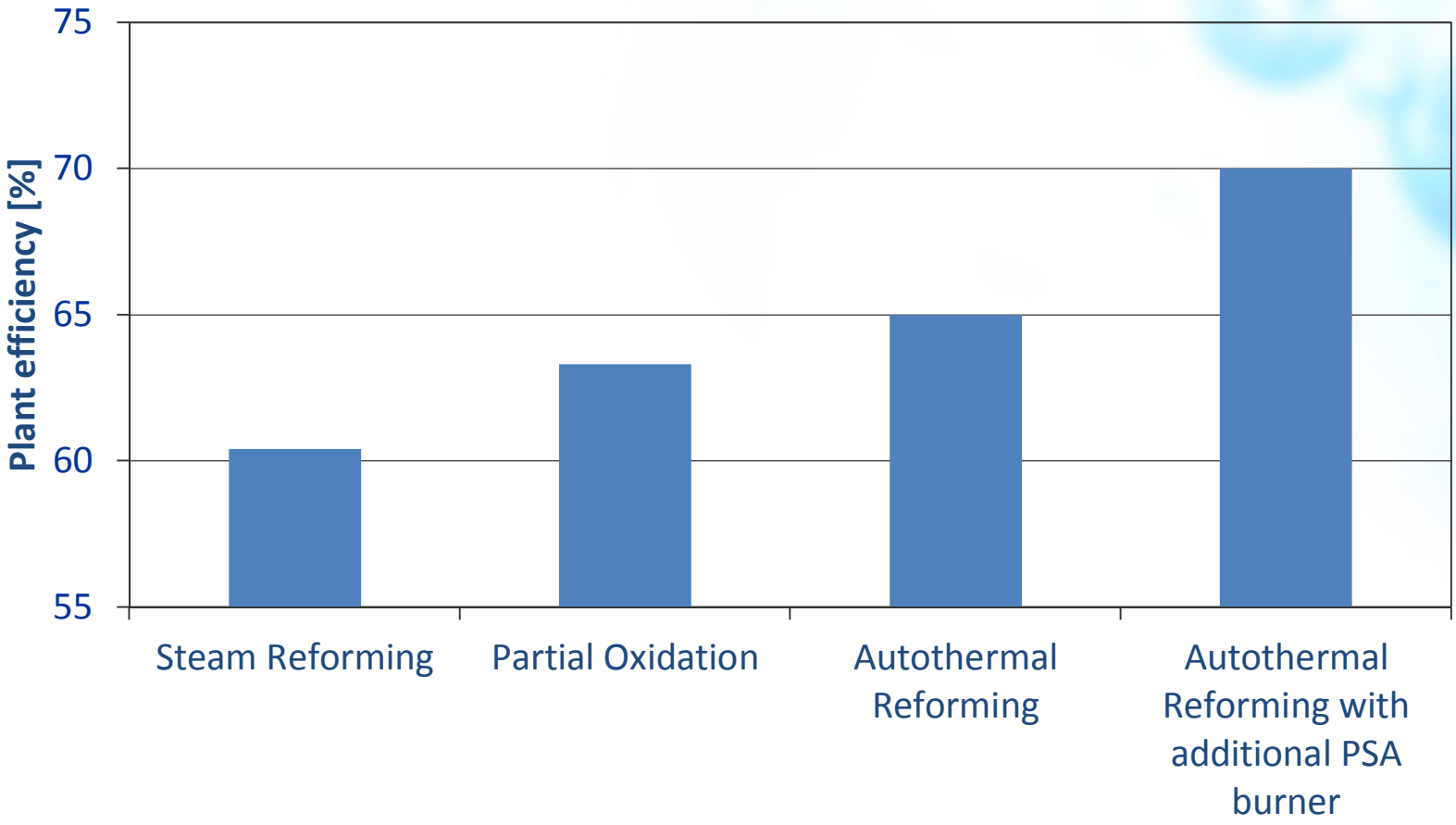
A nanostructured delafossite catalyst further boosts the gasification kinetics so that the soot-free thermodynamic conditions can be attained.



The self-regenerating trap concept

A. Raimondi, A. Loukou, D. Fino *, D. Trimis, Experimental analysis of soot abatement in reducing syngas for high temperature fuel cell feeding, Chemical Engineering Journal 176– 177 (2011) 295– 301

PROJECT ACTIONS
Modelling with ASPEN Plus

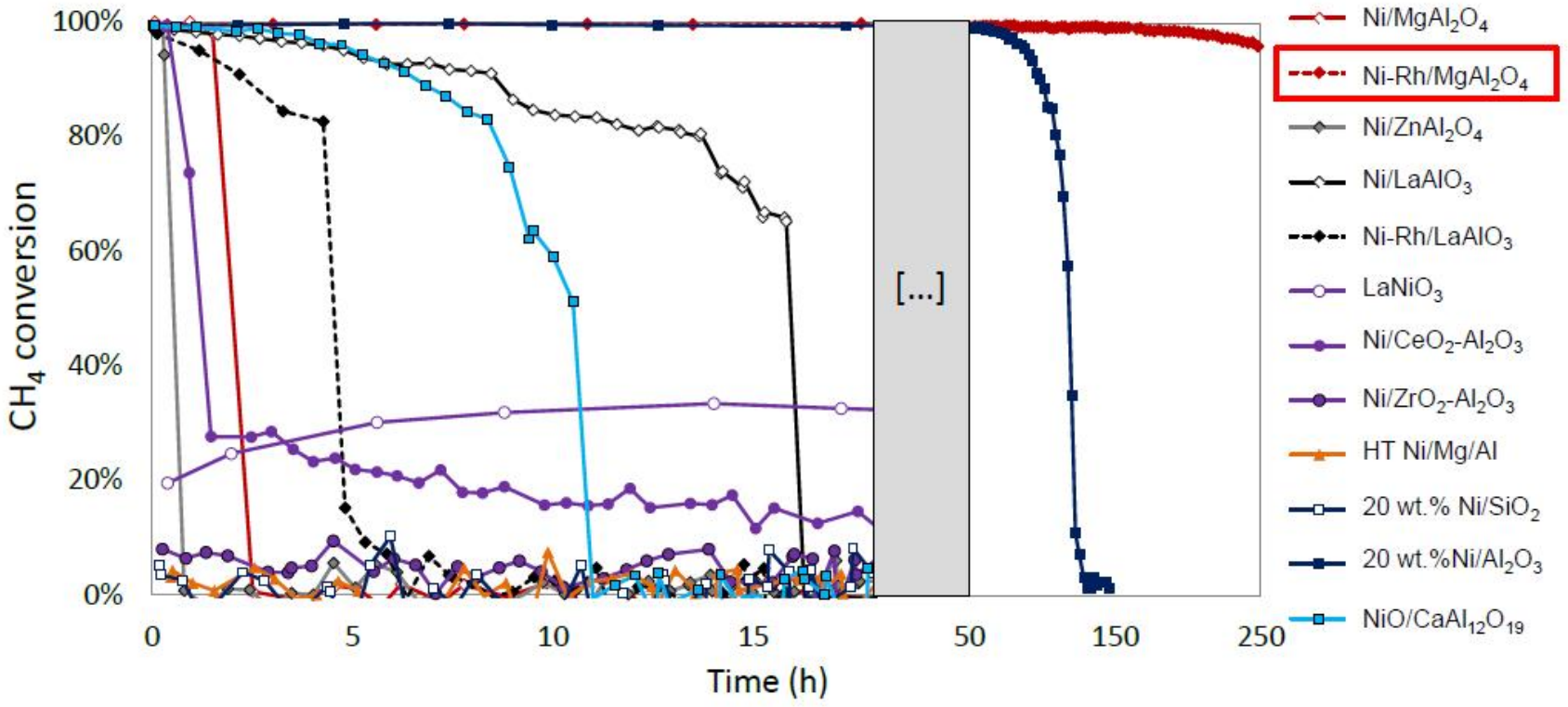


Plant efficiency at a maximum of heat integration

PROJECT ACHIEVEMENTS

Catalysts screening @ powder scale: CH4 conversion @ 700° C

H_2O : 42% ; Ar : 28% ; CH_4 : 14 % ; CO_2 : 9 % ; O_2 : 7 %



5-0.05 wt.% Ni-Rh/$MgAl_2O_4$ is most resistant to deactivation

PROJECT PROJECT ACHIEVEMENTS

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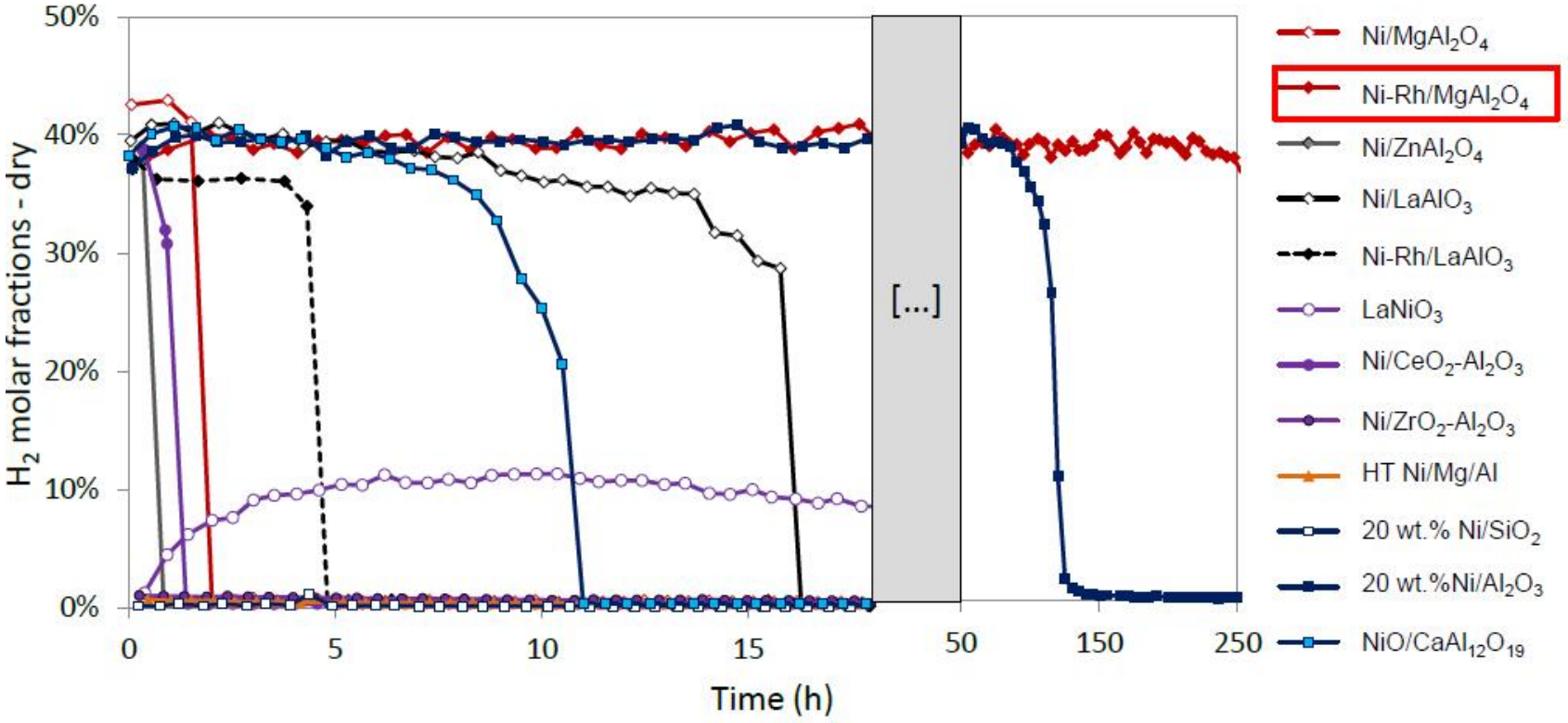

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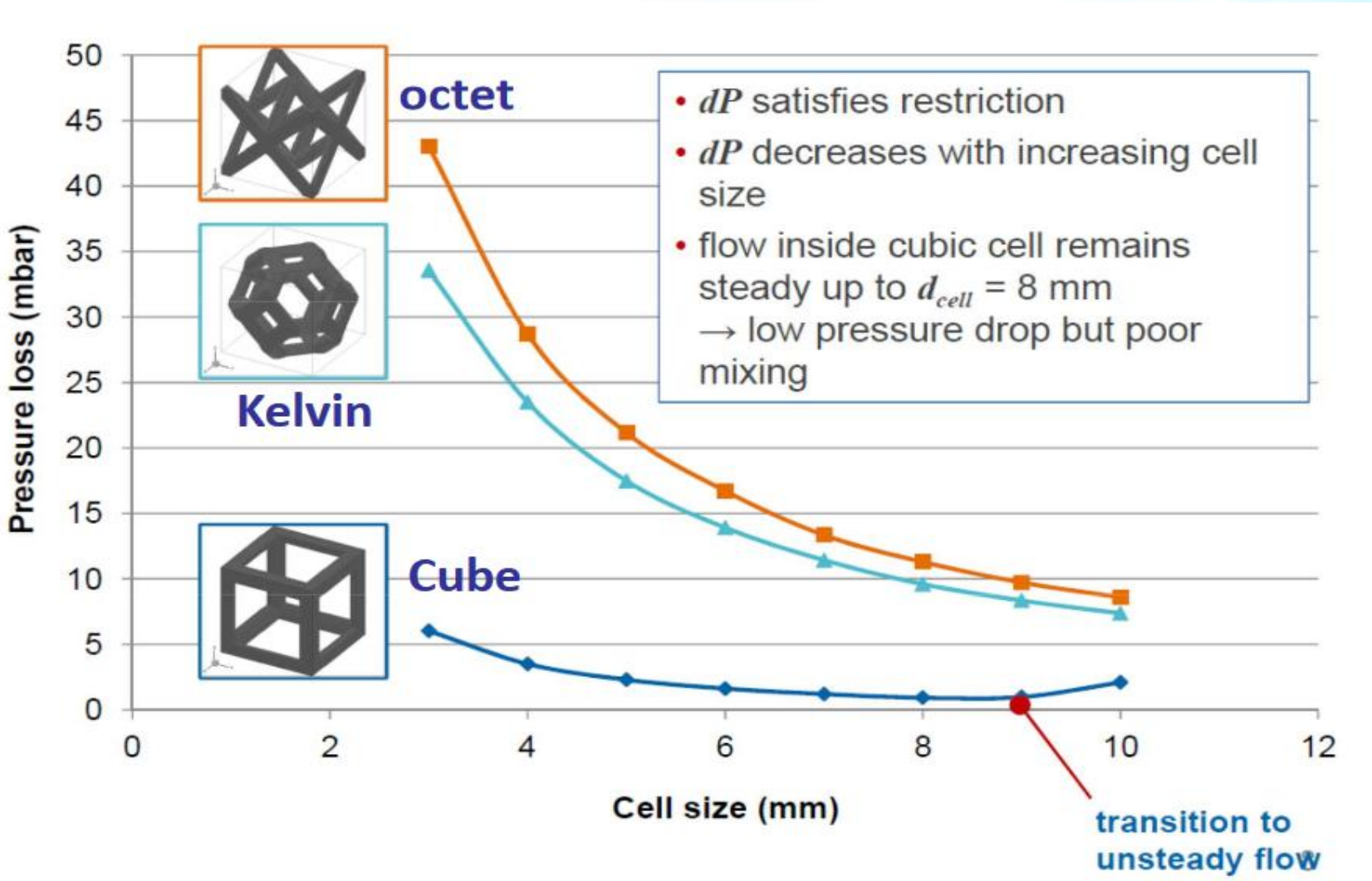
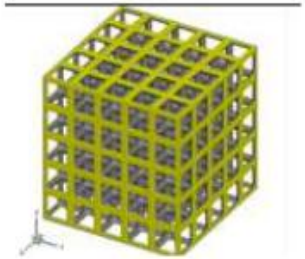
PROJECT ACHIEVEMENTS

Supports: pressure drop modelling evaluation

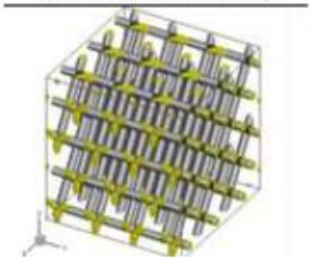


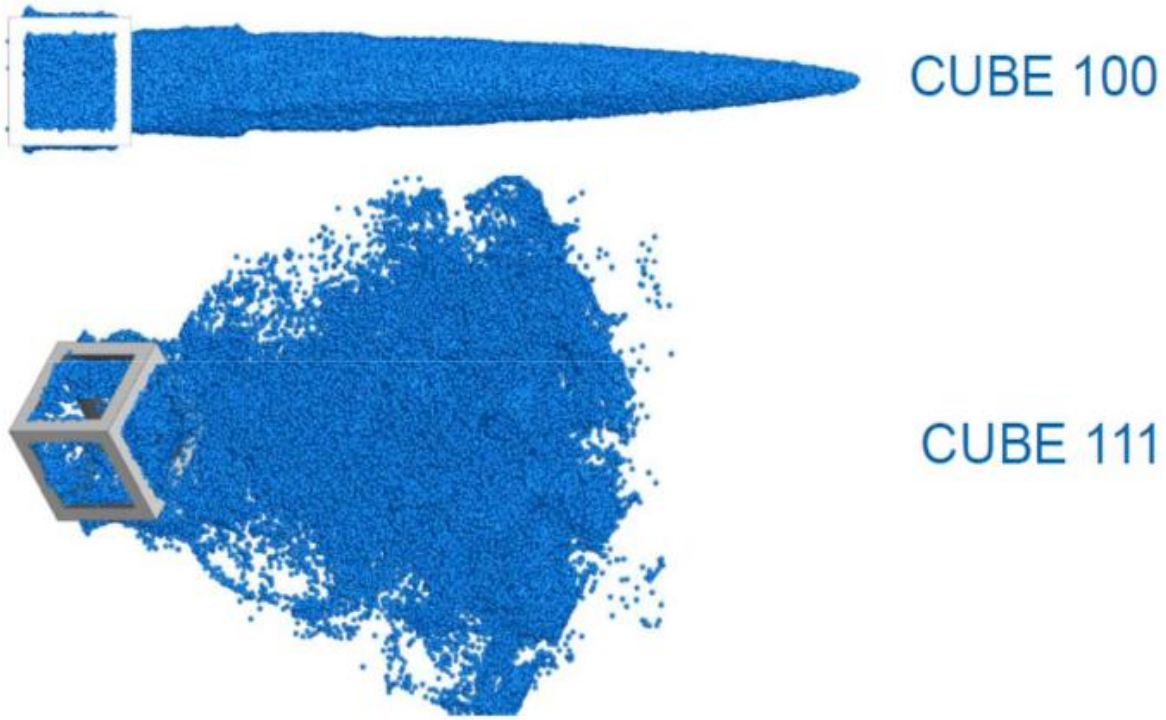
…from cube to rotated cube

Cubic lattice (100)



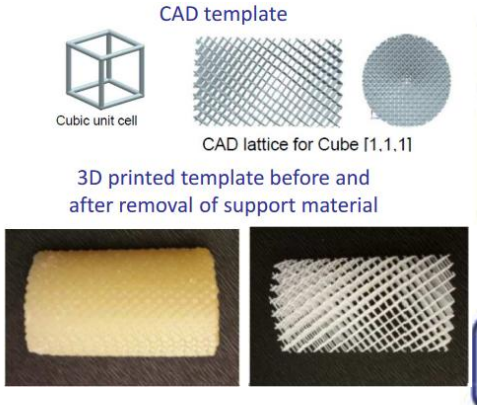
Cubic lattice (111)
(Rotated Cube)





Spreading of massless tracer particles in an infinite lattice of cubic cells (only one cell is drawn for visibility)

PROJECT ACTIONS
From design to manufactoring



Slurry preparation
- Bimodal distribution of powders
- 2 phases/3 days

Ball mixing
- Standard ball mixer
- Alumina balls

Template impregnation
- Homogeneous coating on template
- Multiple deposition

- Air blower
- Centrifuge

Removal of excess slurry

Drying
- 40/60°C

Pyrolysis
- 850°C
- Nitrogen flow

LSI/reaction bonding
- 1500°C/vacuum
- Si + C → SiC

Surface nitridation/ oxidation
- N2 @ 1300°C
- 1600°C in Air

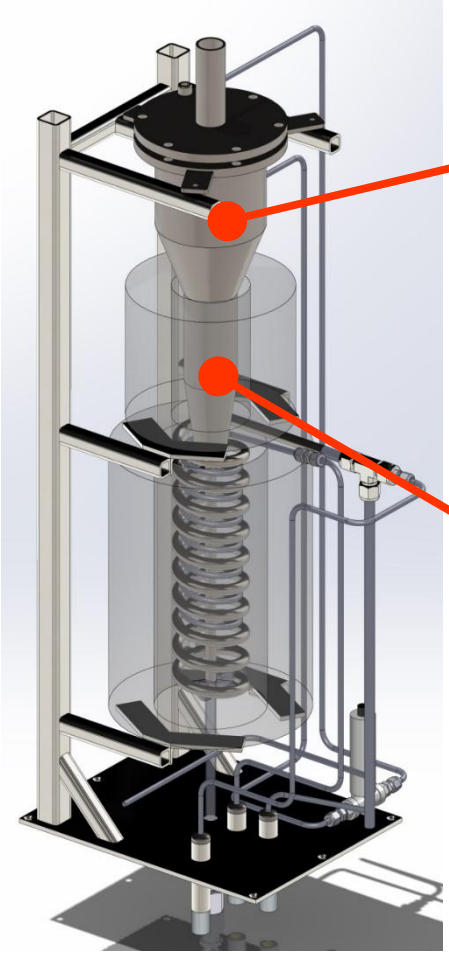
Machining
- Diamond tools
- Glue inglobation

Foam
- From market (polyurethane)

Lattice
- Produced by 3D-printing

End product

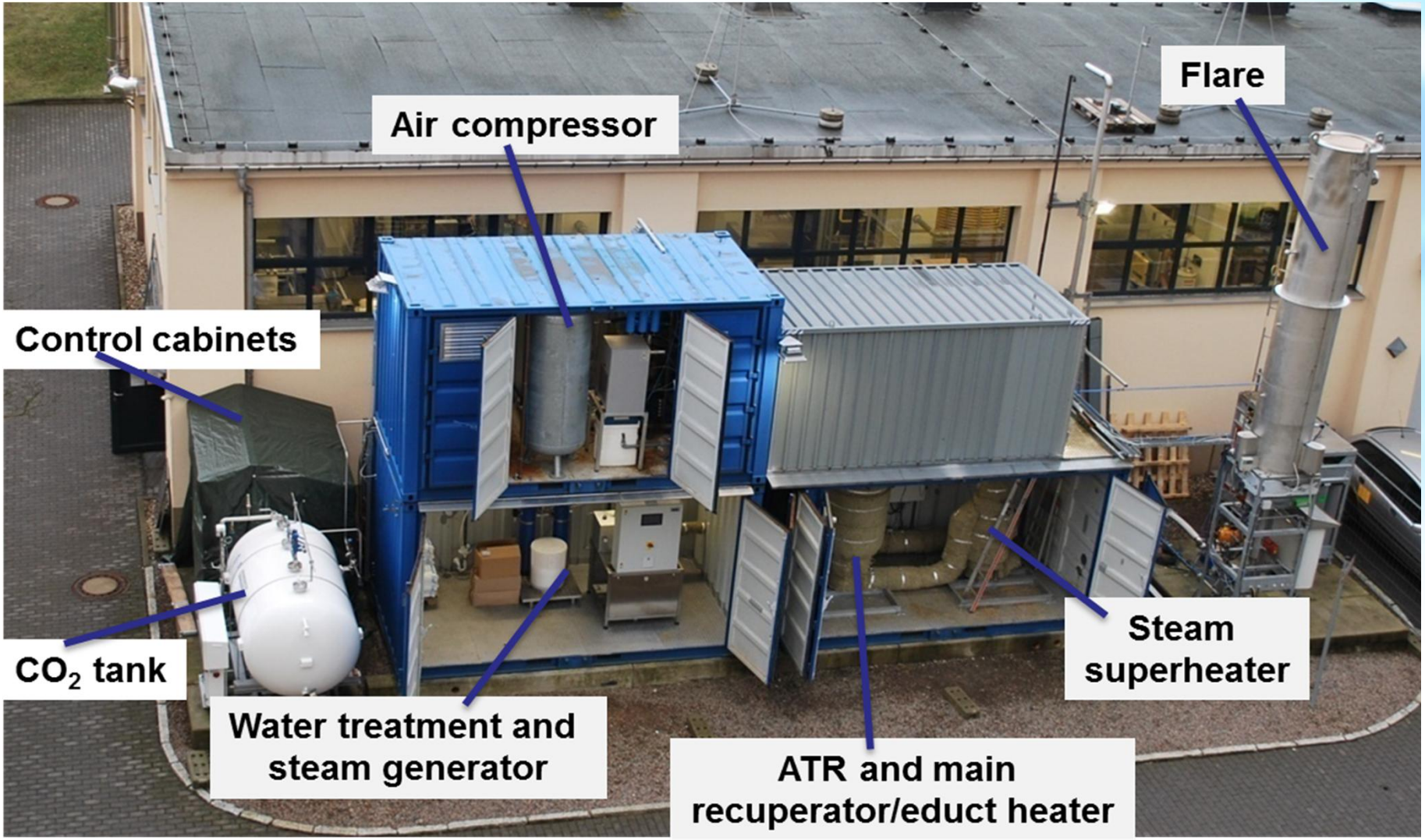
PROJECT ACTIONS Pilot scale test rig



Uncoated and coated SiC composite monoliths

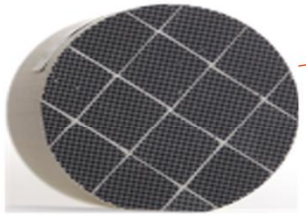
ATR supports

PROJECT ACTIONS Demonstration Plant



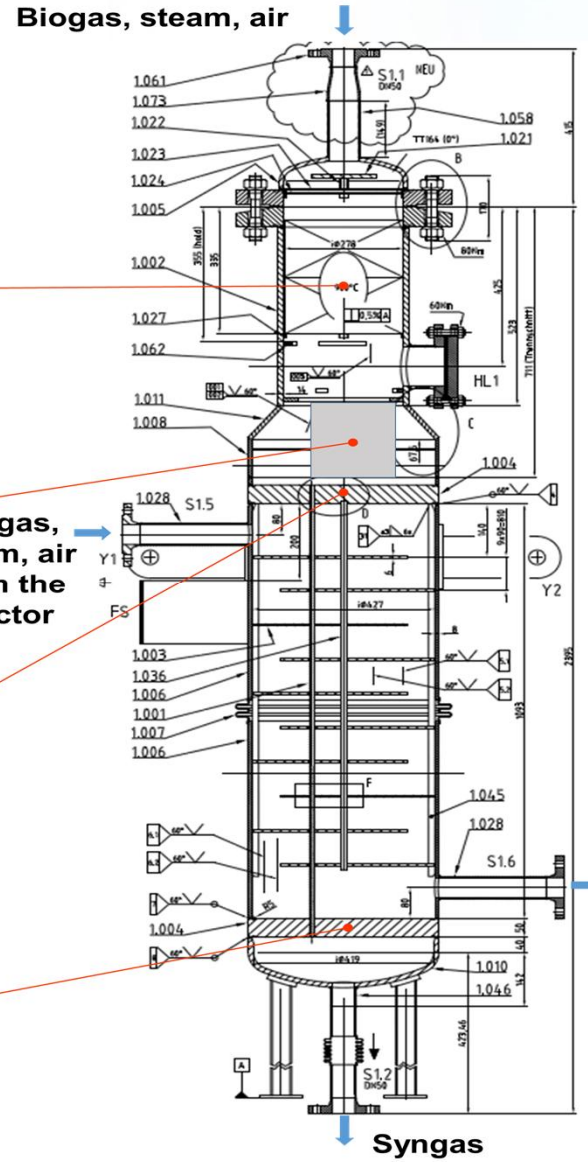
PROJECT ACTIONS Demo plant (core section)

ATR catalyst



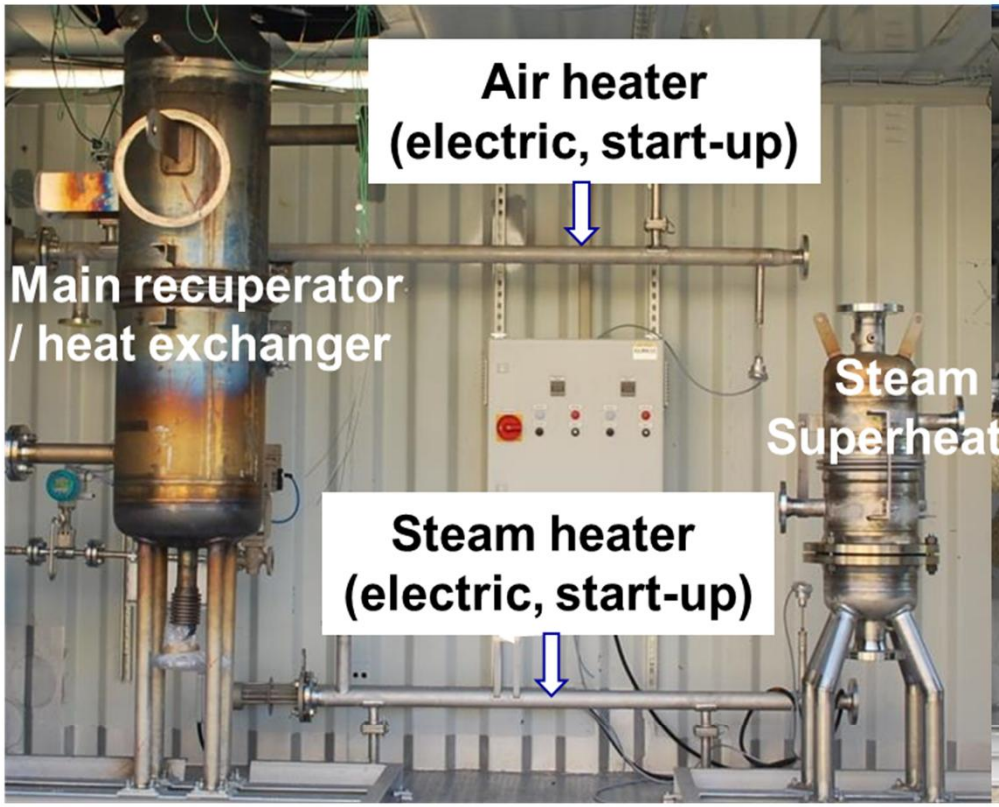
Catalysed trap

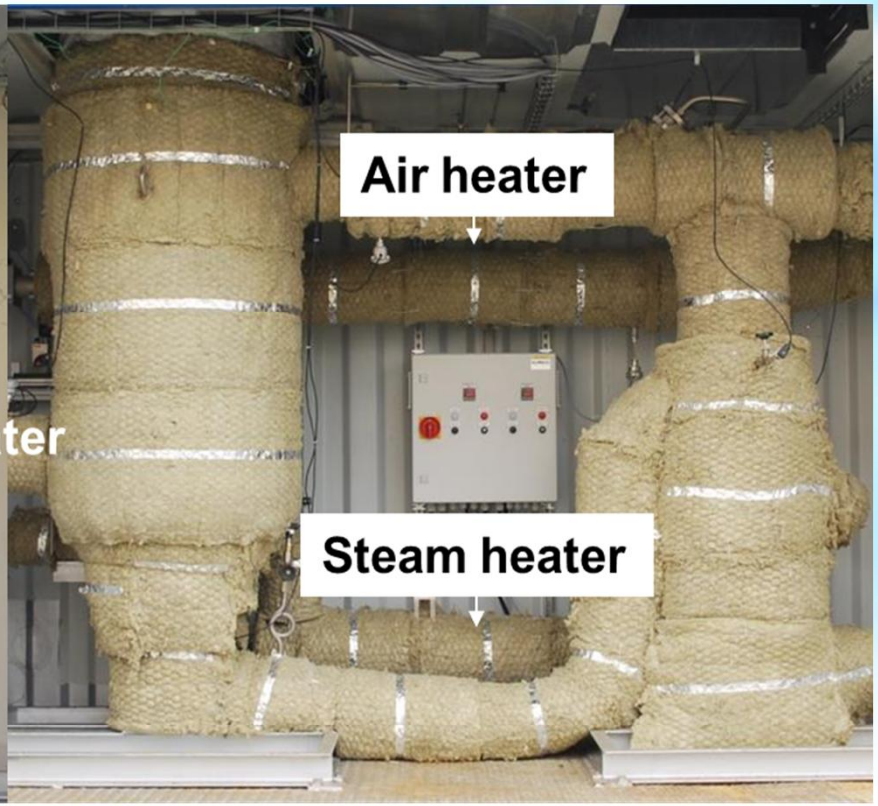
Heat exchanger



PROJECT ACTIONS Main components

Supporting heating systems





Technical data:

Installed power air heater:	8.5 kW
Installed power steam heater:	10 kW
Maximum operating temperature:	500°C

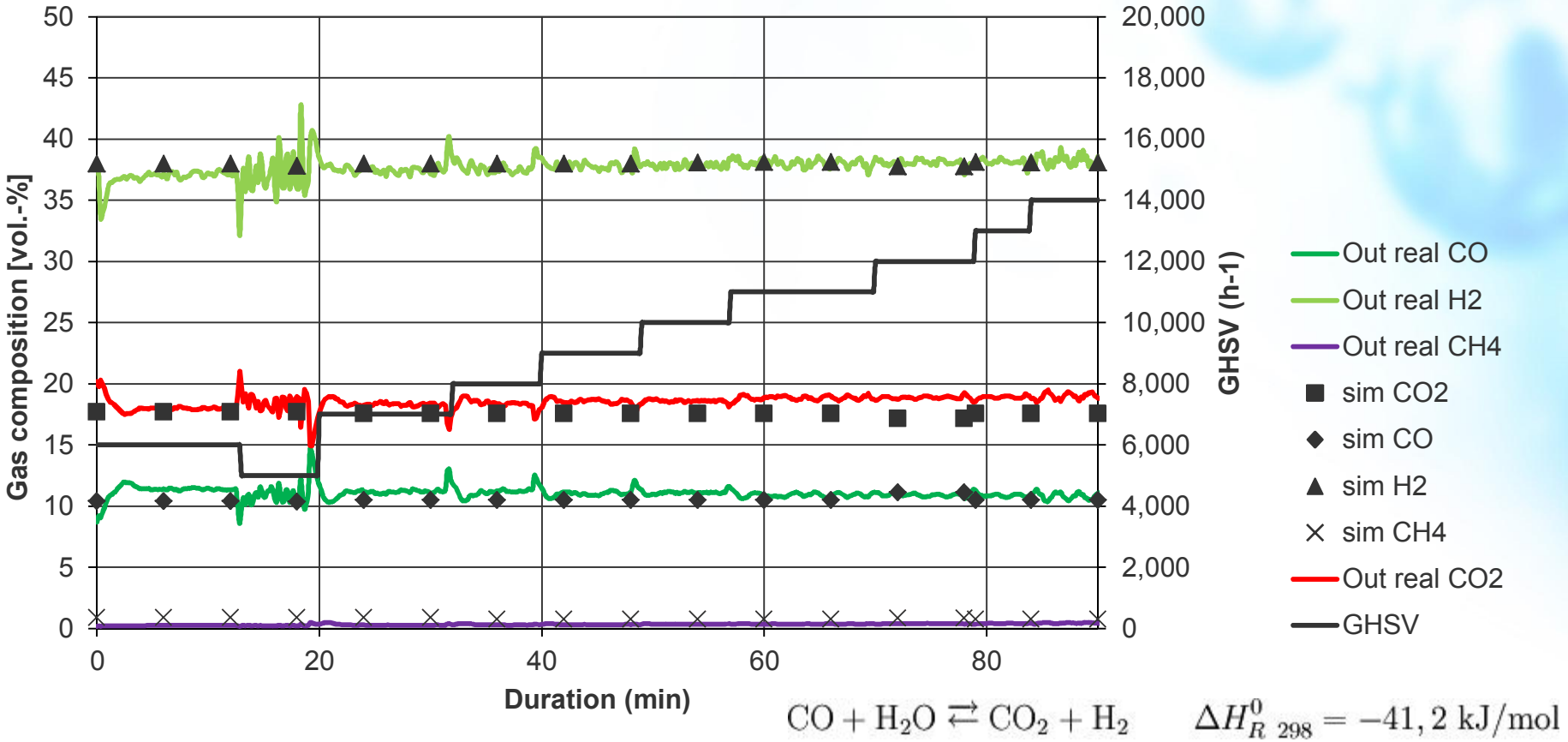
PROJECT ACTIONS Plant Operation Test

Analysed Structures

	Foam	Monolith
	H: 250 mm D: 260 mm 	H: 150 mm D: 270 mm 
Material	15/0.05 wt.-% Ni/Rh	Pt/Rh
O/C	1.1	1.0 – 1.3
S/C	2.0	2.0 – 15
GHSV [h^{-1}]	4 000	6 000 – 16 000
T_{in} [°C]	500	430
CH_4/CO_2	60/40	
Activation	25/75 H_2/N_2 at 600°C for 3 h	–

PROJECT ACHIEVEMENTS
Plant Operation Test

Monolith: Gas Composition (dry) for GHSV from 5 000 to 14 000 h^{-1}

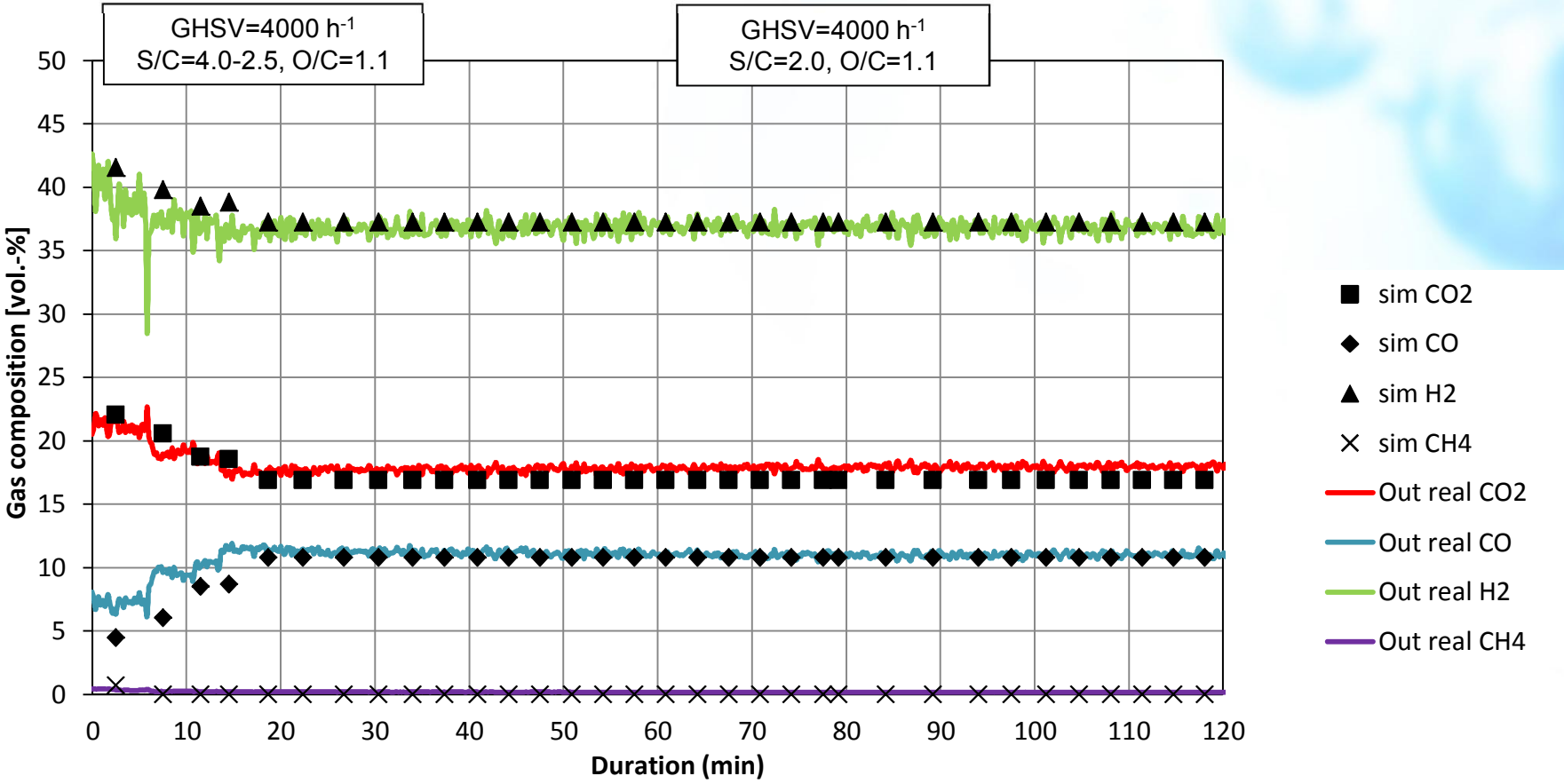


$$CO + H_2O \rightleftarrows CO_2 + H_2 \qquad \Delta H^0_{R\ 298} = -41,2\ \mathrm{kJ/mol}$$

- O/C = 1.1, S/C = 2.0, T = 450°C
- Small changes of composition by changing of GHSV

PROJECT ACHIEVEMENTS
Plant Operation Test

Foam: Gas Composition (dry) for GHSV of 4 000 h^{-1}



- O/C = 1.1, S/C = 2.0, T = 500°C
- Thermodynamical equilibrium reached

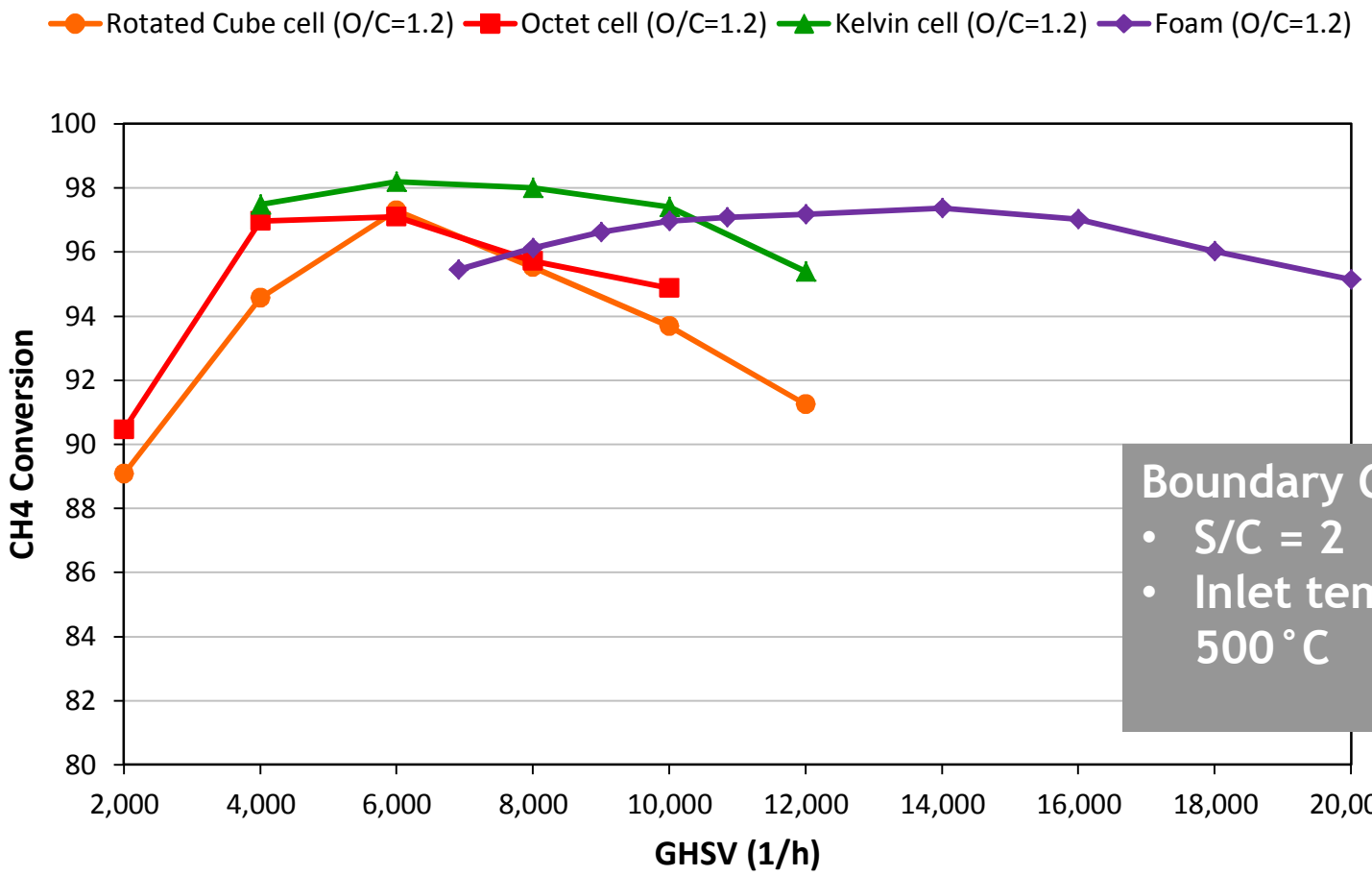
PROJECT ACTIONS
Comparison with small-scale tests

Analysed Structures at small scale

	Foam	Kelvin Cell	Octet Grid	Rotated Cube
O/C	1.0 – 1.3			
S/C	2.0			
GHSV [h^{-1}]	4 000 – 20 000	2 000 – 12 000		
T_{in}	500°C; 600°C; 700°C			
CH_4/CO_2	60/40			
Activation	20/80 H_2/N_2 at 700°C for 2 h			
H: 100 mm D: 48 mm				

PROJECT ACHIEVEMENTS
Comparison with small-scale tests

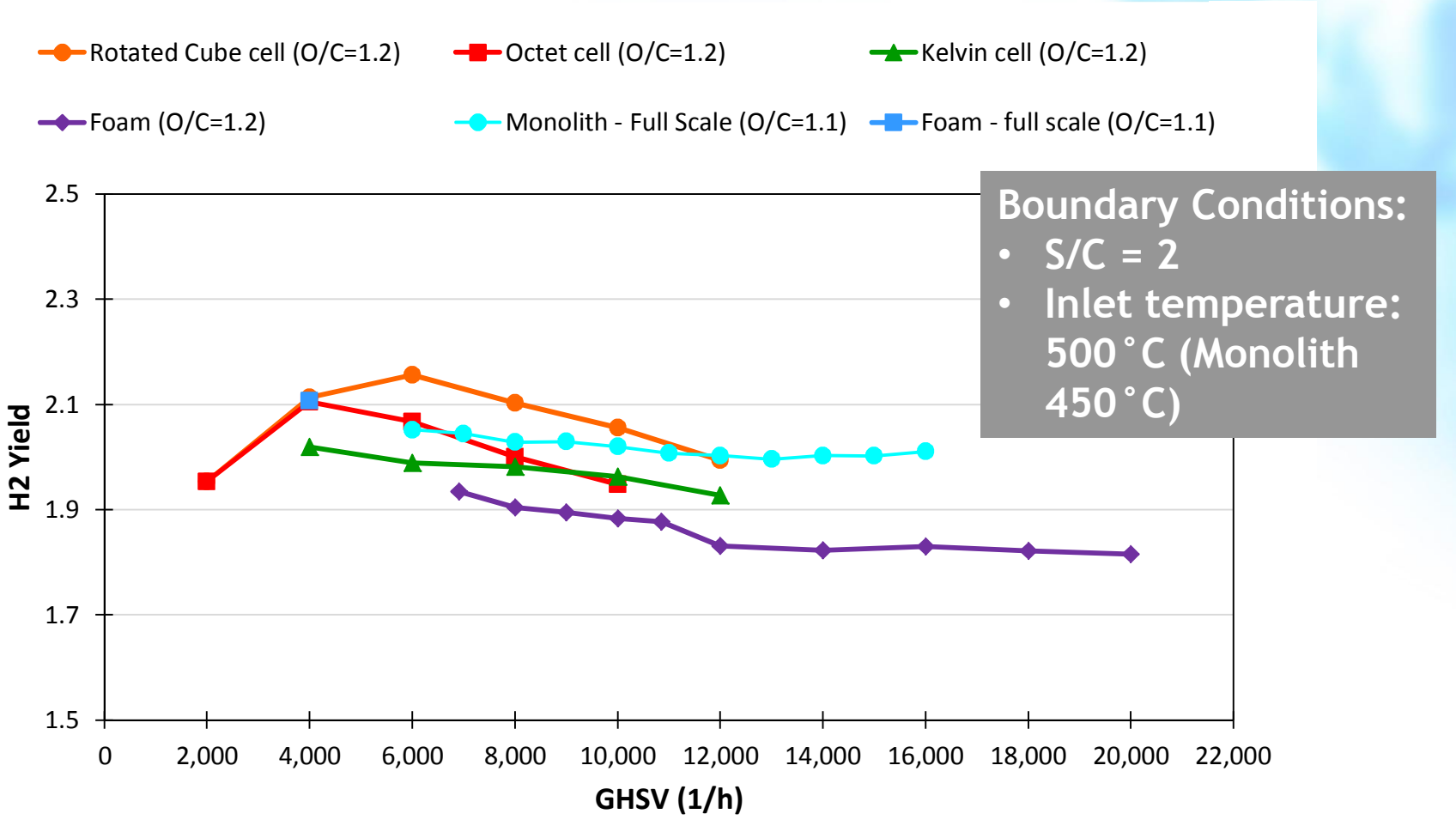
Comparison of Small-Scale and Plant Test Results



Boundary Conditions:
- S/C = 2
- Inlet temperature: 500 °C

PROJECT ACHIEVEMENTS
Comparison with small-scale tests

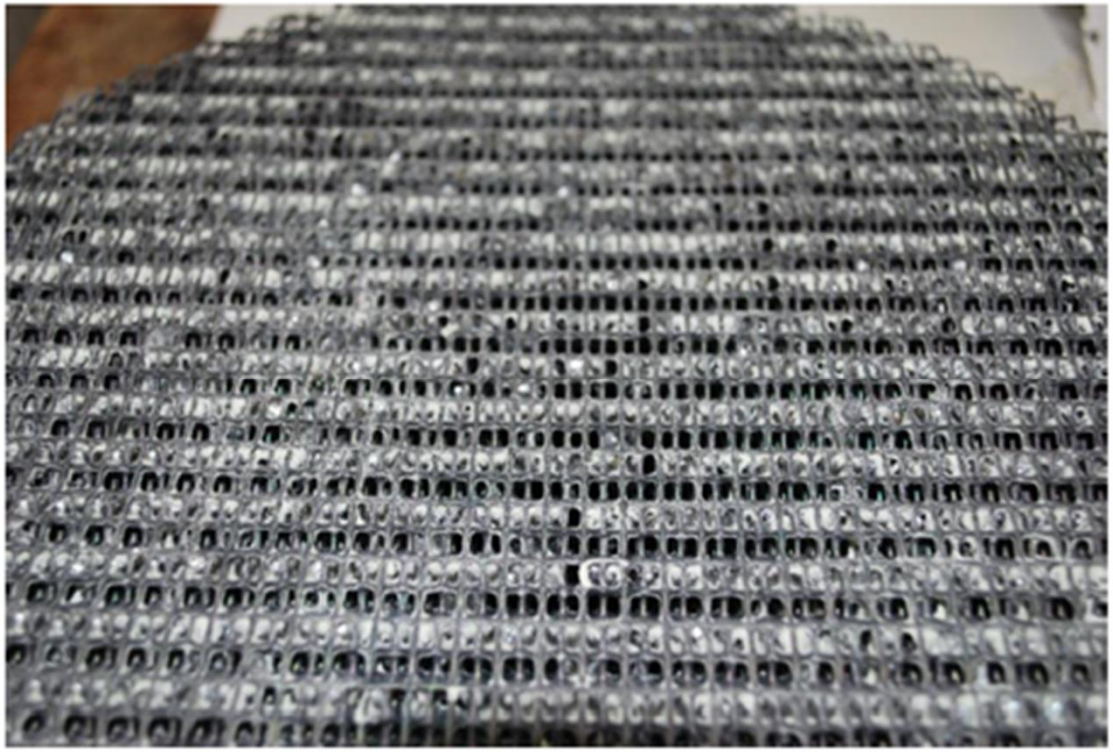
Comparison of Small-Scale and Plant Test Results



Boundary Conditions:
- S/C = 2
- Inlet temperature: 500 °C (Monolith 450 °C)

PROJECT ACHIEVEMENTS
Full scale Coated rotated cube cell

It was not possible to tests it in the demonstration plant.



A problem with the coating was found, which did not allow the activation of the catalyst and so the biogas reforming

Dissemination activities

- 7 papers on International Journals
- Several Conference presentations
- 1 Chapter Book
- Final dissemination event @ WHEC
- Media production

Project acronym: BioRobur
Project full title: Biogas robust reforming with combined catalytic ATR and trap units
Contract no.: 325383

BioRobur whec 21st 2016 Zaragoza Spain

Zaragoza, June 13th – 16th June 2016

"Palacio de Congresos"

(Plaza Lucas Miret Rodriguez, 1, 50018 Zaragoza)

WHEC2016 - BIOROBUR WORKSHOP			
COMPANY	**PARTICIPANT**	**WHEC2016 CONGRESS ABSTRACT/POSTER PRESENTERS INSERT ID NUMBER OF THE WORK (if you submitted any abstract)**	**ONLY ON 14th JUNE WORKSHOP BIOROBUR**
POLITO	DEBORA FINO	USER CODE: 601 ABSTRACT ID NUMBER : 864	
	SAMIR BENSAID	USER CODE: 601 ABSTRACT ID NUMBER : 863	
	SORANI MONTENEGRO	USER CODE: 601 ABSTRACT ID NUMBER : 862	
IRCE CNRS	MATHILDE LUNEAU	USER CODE: 561 ABSTRACT ID NUMBER : 745	
	YVES SCHUURMAN		ONLY ON JUNE, 14th
HST	MASSIMILIANO ANTONINI		ONLY ON JUNE, 14th
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	FLORIAN RAU		ONLY ON JUNE, 14th
CPERI	SOUZANA LORENTZOU	USER CODE: 621 ABSTRACT/POSTER ID NUMBER : 699	
	DIMITRIOS ZARVALIS	USER CODE: 621 ABSTRACT/POSTER ID NUMBER : 854	
	GEORGE KARAGIANNAKIS	USER CODE: 621 ABSTRACT/POSTER ID NUMBER : 808	

Exploitation

We are going to add new “sap” by enlarging the consortium

ACEA (IT)

ENVIRONMENTAL PARK (IT)

KIT (DE)

DBI (DE)

JM (UK)

to try to ameliorate and thanks to another FCH-JU fund:

Thank you for your attention!

BioRobur

Reformer

Trap

BERGAKADEMIE FREIBERG TECHNISCHE UNIVERSITÄT

Scuola universitaria professionale della Svizzera italiana

SUPSI

Erbicol

IRCELYON

met.

aptL AEROSOL & PARTICLE TECHNOLOGY LABORATORY

POLITECNICO DI TORINO