

UNIfHy- UNIQUE gasifier for Hydrogen production (Grant Agreement 299732)

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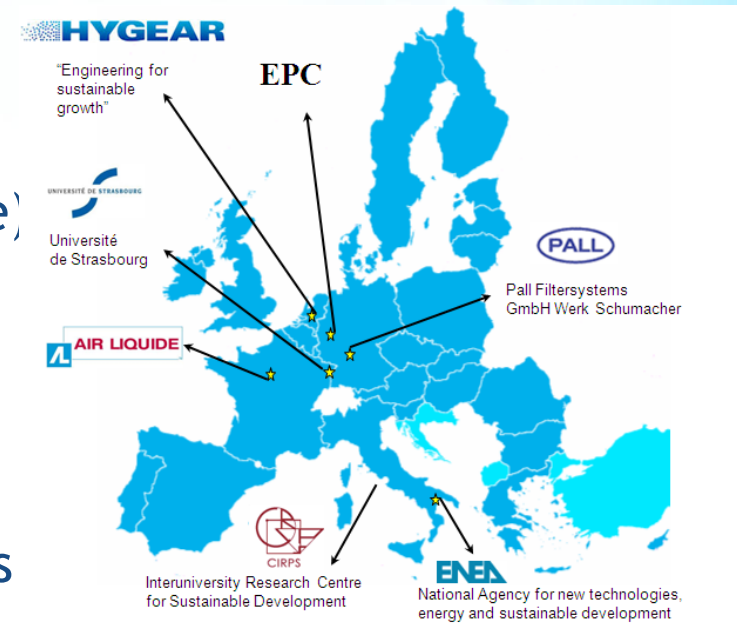
CIRPS-Interuniversity Centre for Sustainable
Development

www.unifhy.eu



PROJECT OVERVIEW

- UNIfHY: UNIQUE gasifier for hydrogen production
- Call topic: SP1-JTI-FCH.2011.2.3 BTH - Biomass-to-hydrogen (Thermochemical route)
- Duration: 09-01-2012 / 08-31-2015
- Budget: Total budget= 3,555,652.00 € , FCH contribution= 2,203,599.00 €
- Overall purpose of project: The project aims to develop a biomass steam gasification process coupled to syngas purification to produce pure hydrogen from biomass, increase well-to-tank efficiency and contribute to a sustainable energy portfolio, exploiting results obtained in past R&D EU projects on hot gas catalytic conditioning.
- Stage of implementation: Mid Term review passed satisfactorily, 05-14-2014



PROJECT TARGETS

Develop a cost competitive, energy efficient, sustainable, thermo-chemical hydrogen production process based on:

State of art

- Hot gas cleaning is a focal point in the gasification by the European projects funded in FP6 (CHRISGAS, BIGPOWER, AER-GAS II, GREEN FUEL CELLS, BIOCELLUS)
- The development of a suitable tar reforming catalyst for integration in a ceramic hot gas filter element has been pursued.
- The most effective way to produce pure hydrogen for PEM application is the steam reforming of methane with successive purification by means of HT/LT WGS and PSA.

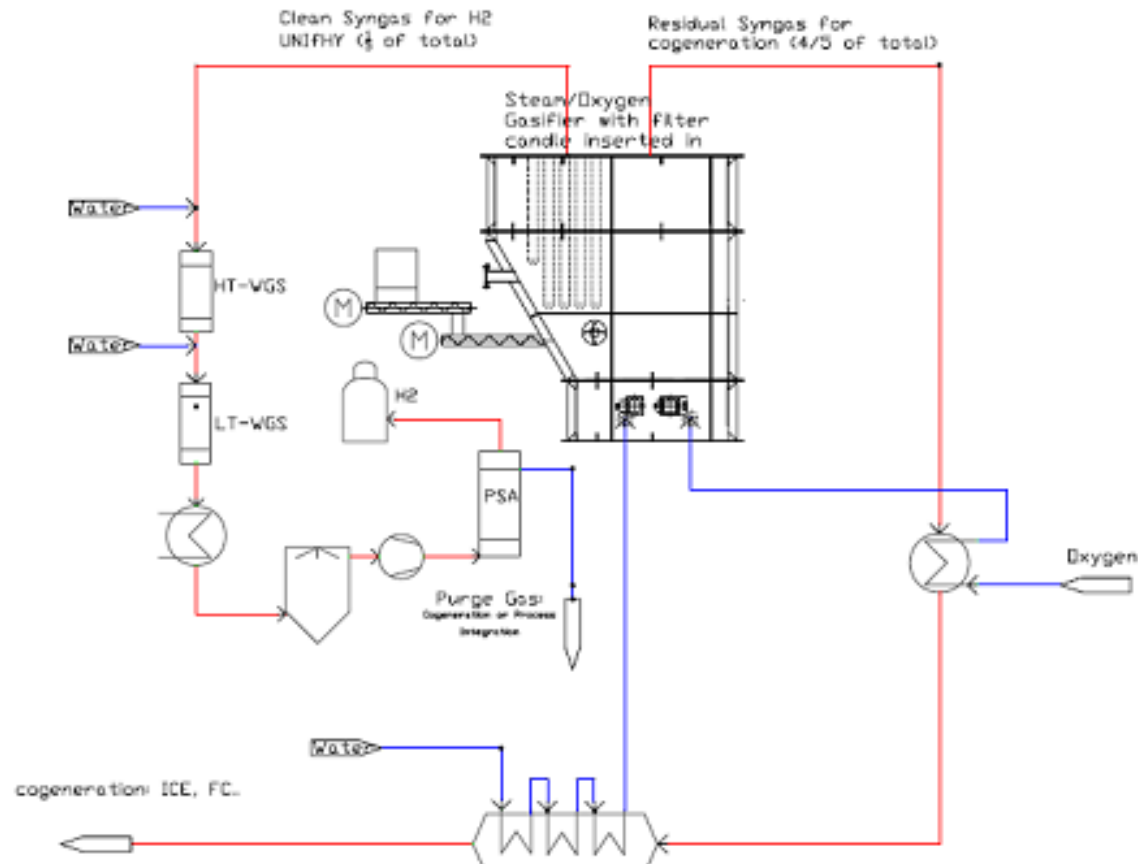
Project targets

- Biomass gasification with catalytic hot syngas cleaning and conditioning integrated in the gasifier vessel (UNIQUE gasification concept).
- Water-Gas Shift-WGS performed with catalysts impregnated on ceramic foams for low pressure drops
- Pressure Swing Adsorption - PSA for hydrogen separation from syngas
- High thermal integration and efficiency, by means of utilization of the H₂-depleted syngas within the conversion process
- Utilization of plant components of proven performance and reliability.

The overall scope of UNIfHY is the integration of these components to obtain a continuous process for pure hydrogen production from biomass for fuelling stations in a low-cost, effective way.



PROJECT TARGETS

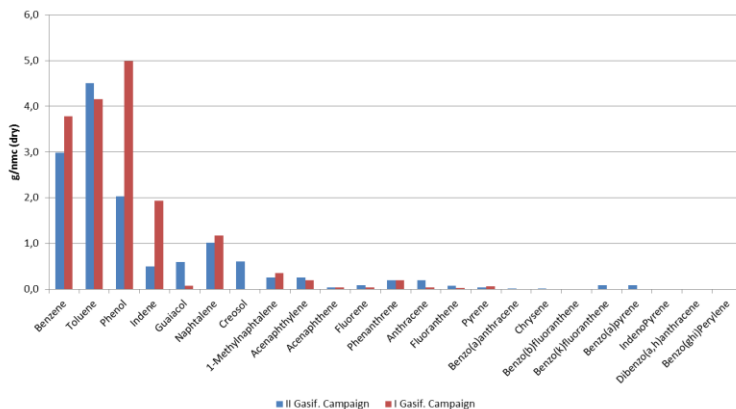


UNiFHY 1000 flowsheet

Test Campaign - Operating Conditions and Results 1000 kWth (ENEA)

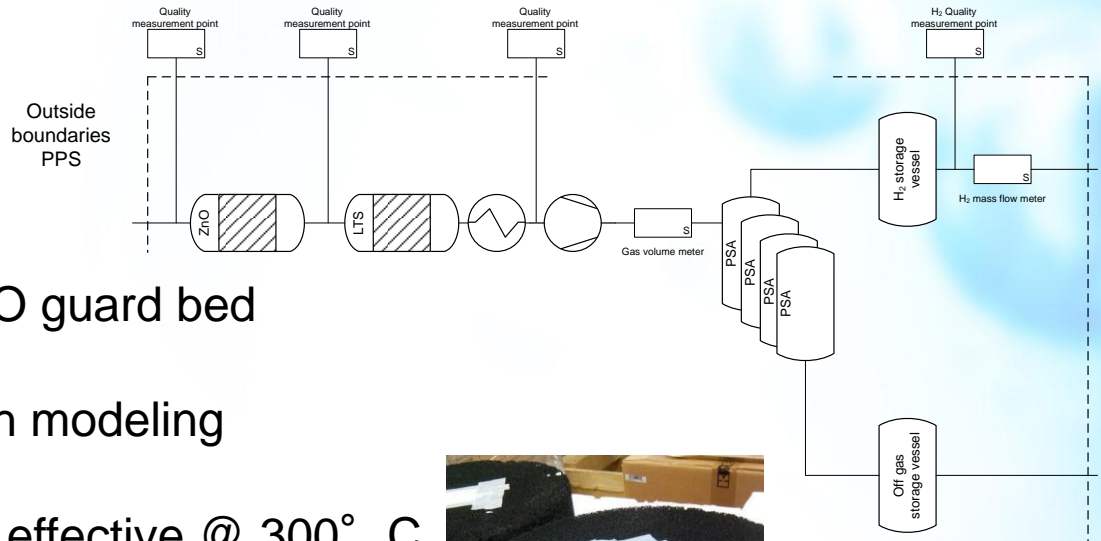
Test	Steam/O ₂
Biomass Feeding Rate (kg _{dry} /h)	160
Steam Feeding Rate (kg/h)	68-73
O ₂ Feeding rate (kg/h)	50-52
O ₂ Enrichment (%-wt)	100
Steam/Biomass (kg/kg _{wet})	0,4
ER	0,22
Gasification T (°C)	880 - 900
Pressure (bar _a)	1,0-1,1

Steam/O ₂ Gasification Tests	2 nd campaign
Gas yield (Nm ³ /kg _{Biomass, dry})	1.0
Gas components	(%v, Dry)
CO	31-33
H ₂	25-26
CH ₄	13-14
CO ₂	24-27
Light hydrocarbons	2,4-2,6
N ₂	<3
H ₂ O (% v, wet gas)	~ 40
HHV (kcal/m ³ ; MJ/m ³)	3130-3230 13.1-13.5



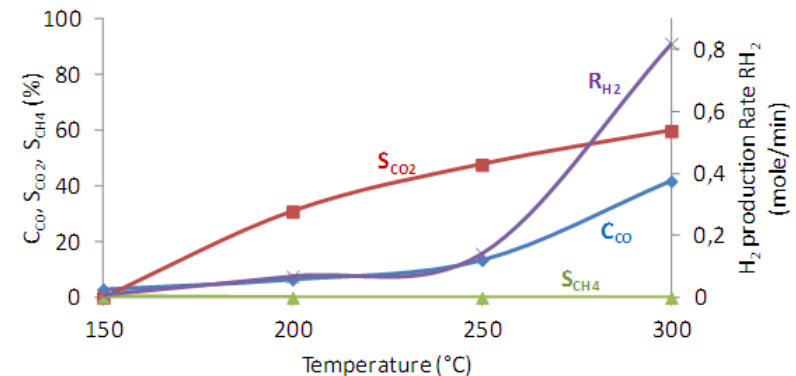
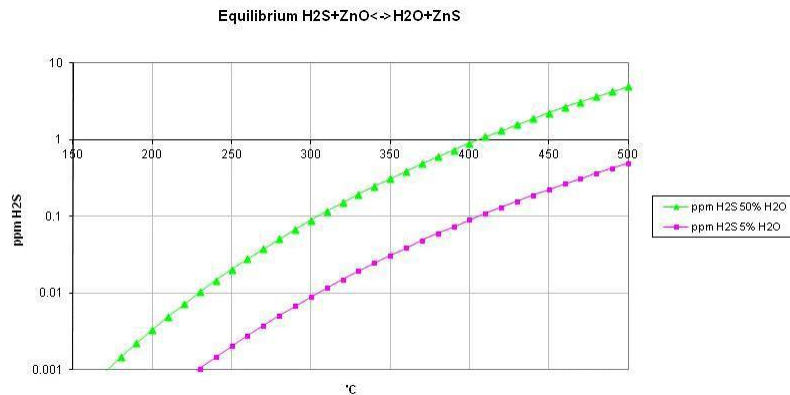
Contaminats	Steam/O ₂
Particles (g/Nm ³)	12-16
Gravimetric Tar (g/Nm ³ _{dry})	3-5
Tot Chromatographic tar (g/Nm ³ _{dry}) (Excluding Benzene)	8-11

Design Portable Purification System (PPS) and assembly (HYGEAR, UNISTRA)



Effectiveness desulfurization ZnO guard bed

- Low pressure drop
- Water effect equilibrium through modeling
- Requirement H_2S : 0.1 ppm
- Desulfurization ZnO guard bed effective @ 300°C
- Procurement finished**



PROJECT TARGETS AND ACHIEVEMENTS

MAIP, AIP target	Project Target	Current status/achievement	Expected final achievement	State of art
Cost of H ₂ < €5/kg at exit of the purification unit	Cost of H ₂ < €5/kg at exit of the purification unit	H ₂ cost <€16/kg with UNIFHY 1000 <€8/kg with UNIFHY 5000 Plant Utilization index ≥ 7000 h/year	H ₂ cost <€5/kg is obtainable with a plant utilization index ≥ 6000 h/year	H ₂ from SMR costs 8 €/kg From electrolysis 10 €/kg
Chemical efficiency >66 %	Chemical efficiency >66 %	Chemical efficiency >43 %	Chemical efficiency =70 %	Chemical efficiency from methane >75%
Development and scale-up on materials and reactor design for continuous hydrogen production from biomass.	<ul style="list-style-type: none"> Catalytic candle for syngas free of tar and particulates New Cu/Foam catalyst for WGS at atm. pressure Greater flexibility in PSA feed stream composition. 	<ul style="list-style-type: none"> Catalytic candles were tested showing tar <0.3 g/Nm³ WGS tests with Cu foam showed CO conversion of 40 % PSA can produce 5.0 H₂ with 70% recovery 	<ul style="list-style-type: none"> Catalytic candles were tested showing tar <0.3 g/Nm³ Equilibrium conversion with Cu foam > 90 % PSA can produce 5.0 H₂ with 70% recovery 	<ul style="list-style-type: none"> Cold gas cleaning with low efficiency and wastes disposal High pressure /Δp for WGS reactor PSA with standard syngas composition (from methane)

RISKS AND MITIGATION

Risk Identified	Severity	Contingency Plan (comments)
Catalytic filtration candles: risk of low activity or deactivation	Very low	Similar catalyst already realized and tested during the UNIQUE project
WGS catalysts/foam: risk of low efficiency or unstable operation	High (from laboratory tests)	Characterization after tests at industrial plant will permit to identify the real loss of activity.
Gas composition and contamination level: Risk of non compatibility with the purification system	Low	ZnO guard bed was introduced in the project to remove H ₂ S.

Mitigation: The risks are mitigated in the UNIFHY project mainly by adopting already proven technologies in the field of gasification, HT-gas cleaning, WGS and PSA for hydrogen separation.

SYNERGIES WITH OTHER PROJECTS AND INITIATIVES

Grant Agreement number: 211517 - FP7

Project acronym: UNIQUE

Project duration: 01/01/2008 - 31/12/2010

Project title: Integration of particulate abatement, removal of trace elements and tar reforming in one biomass steam gasification reactor yielding high purity syngas for efficient CHP and power plants

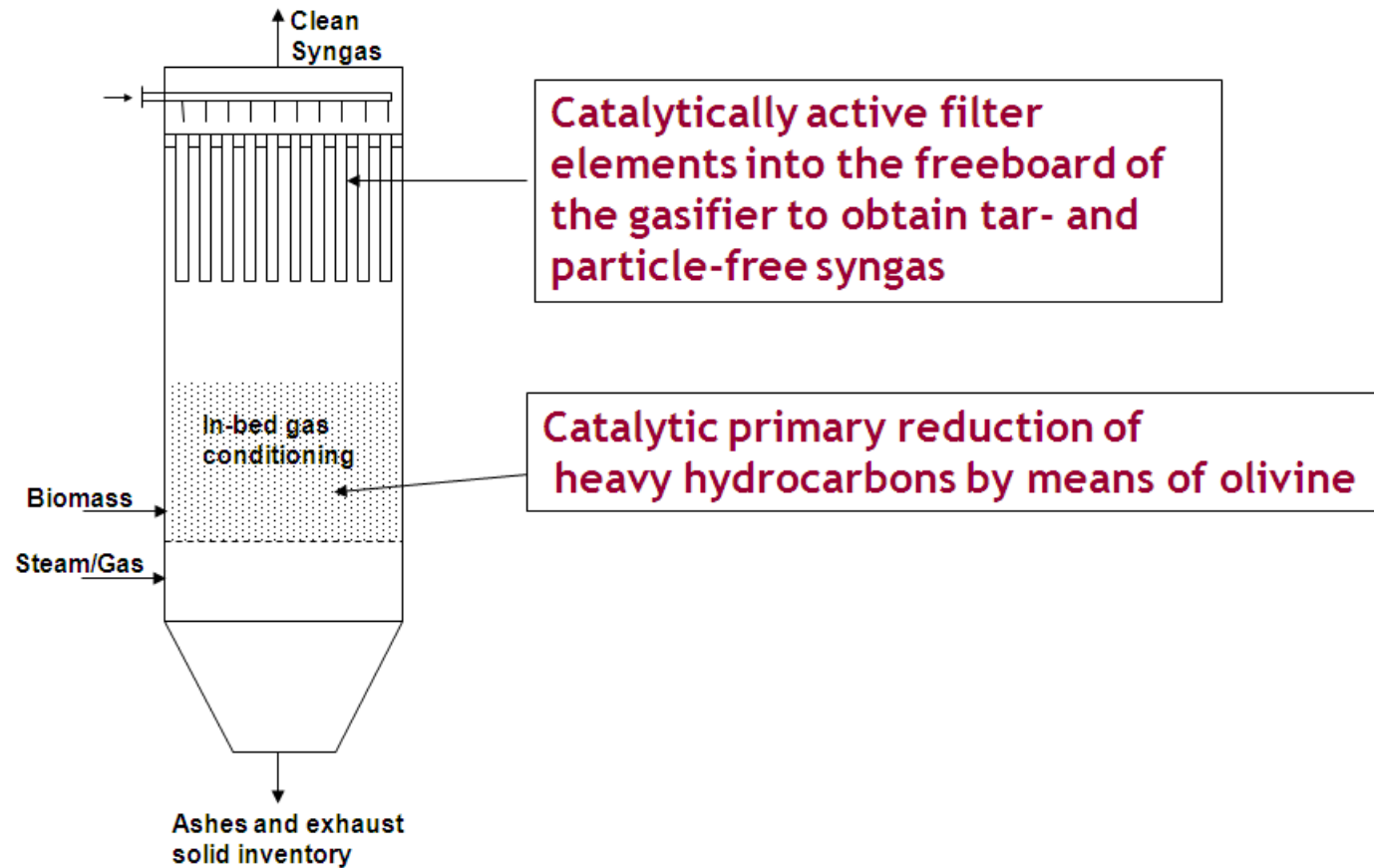
The UNIQUE integrated system was tested at laboratory scale and at industrial scale

SOFCOM

“Coupling of SOFC with biogas and bio-syngas”

WP2 (Lab tests), WP5 (system analysis) and WP7 (syngas and SOFC demonstration at Helsinki) regarding syngas contaminants.

HORIZONTAL ACTIVITIES



CIRPS was able to test new catalytic filter candles for Hot syngas Cleaning & Condition

PALL was able to produce more efficient and reliable catalytic filter candles

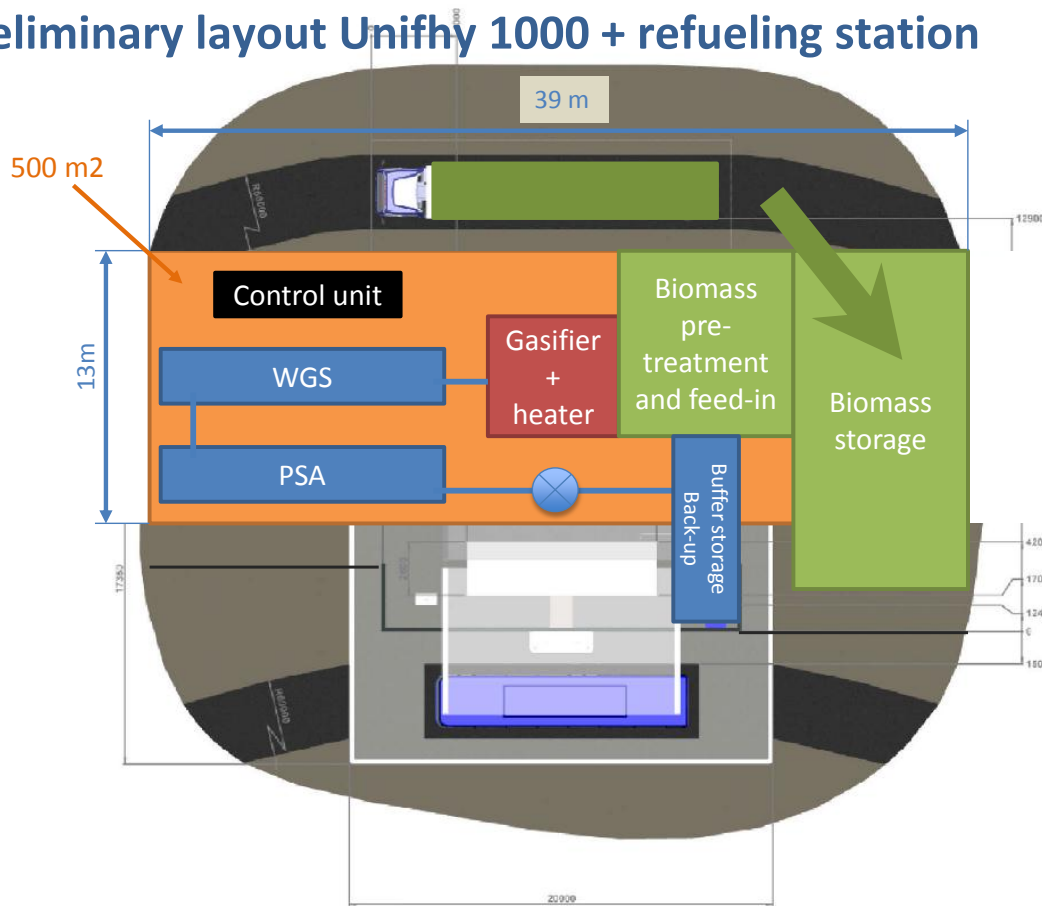
ENEA was able to complete 1 MWth biomass gasification platform

DISSEMINATION ACTIVITIES

- 6 Scientific papers in the peer-reviewed international Journal:
 - International Journal of Hydrogen Energy
 - Energy Procedia
 - Chemical Engineering Transaction, etc.
- 18 communications at International conferences(17 in Europe and 1 in ASIA)
- 3 events for public awareness:
 - SEP - International Exhibition of Environmental Technologies; 19-22 March 2013, Padova, Italy - www.seponline.it
 - Hannover Messe - Engineering and energy, renewables, engineering, decentralized energy, hydrogen/fuel cells, 8-12 April 2013 Hannover (Germany), www.hannovermesse.com
 - Envex- International low carbon environmental technology & green energy, 1-14 June 2013-Seoul (Korea), www.envex.com
- Project website: www.unifhy.eu

EXPLOITATION PLAN/EXPECTED IMPACT (AIRLIQUIDE, EPC)

Preliminary layout Unifhy 1000 + refueling station



7000 h/y operation

	UNIFHY 1000	UNIFHY 5000
H2 costs	€/kg	€/kg
CAPEX	8,8	3,9
M&Op	4,7	2,0
Feedstock	1,5	1
Energy costs	1	0,8
TOTAL cost	16	7,7