The BIONICO project

PROJECT Info

BIONICO - Biogas membrane reformer for decentralized hydrogen production

Collaborative project: Research and Innovation Action

FCH-02.2-2014 Decentralized hydrogen production from clean CO2-containing biogas

DURATION: 4.3 years

Project Coordinator:
Dr. Marco Binotti
Politecnico di Milano
(Dept. of Energy)

Consortium:
Politecnico di Milano, Johnson Matthey, Tecnalia, Rauschert, Eindhoven University of Technology, ICI caldaie, ENC Energy, Quantis

Where to find us

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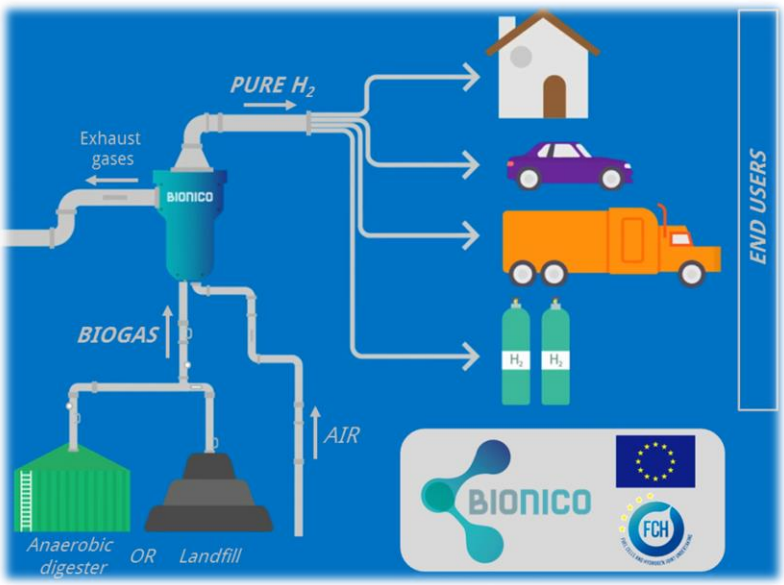
OVERVIEW

The BIONICO project, started in September 2015, has ended in December 2019. BIONICO aimed at developing, building and demonstrating in a real biogas plant a novel reactor concept integrating H_2 production and separation in a single vessel. The hydrogen production capacity was set at 100 kg/day with target purity of 99,99%.



The novel intensified reactor was expected to be more efficient than SoA processes thanks to the direct conversion of biogas to pure hydrogen in a single step, resulting in an increase of the overall efficiency (>70%). The design and optimization of the components of the Balance of Plant were also addressed together with a preliminary economic analysis of the BIONICO plant identifying a proper market for the innovative technology. After more than 4 years of intense collaboration between the partners, BIONICO arrived at the end. Last achievements are showed in the last BIONICO newsletter.

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THE END OF THE BIONICO PROJECT

"After 52 months of hard work the BIONICO project has finally ended. Unfortunately, due to a current dispersion which caused a severe damage to the reactor, we had to close the project without being able to demonstrate the system operation in a real biogas plant.

We missed the final target, but the project allowed us to introduce a significant number of innovations on the components' side and to make a leap forward in the industrialization of Catalytic Membrane Reactor technology. BIONICO consortium built the world largest membrane reactor for biogas-to-hydrogen conversion and tested it for several days at ICI's facilities, verifying the capability of the system to produce nearly pure hydrogen. The experience gained in this years is of inestimable value for further developing the technologies related to membrane reactors. The industrial interest for the project and the technological innovations brought by BIONICO assure us about a promising future for Catalytic Membrane Reactors as key components for green hydrogen production and for process intensification."

Marco Binotti

Coordinator of BIONICO

BIONICO has been a very important project for the development of Membrane Reactors. We have been able to successfully scale-up he building blocks of membrane reactors, such as fluidizable catalysts, supports, dense supported membranes, reactor design and BoP component. At the end we have built one of the largest membrane reactors unit so far and integrated in a stand-aloe working system. And in the meantime have published several interesting scientific papers.

The further experience gained on the topic has also allowed the Membrane group at TECNALIA and the Inorganic Membranes and Membrane Reactors group at TUE to confidently create a company to commercialize these units.

Additionally, the results of BIONICO have been used as bases for the further scale up of the project at higher TRL levels. This year two large projects on membranes and membrane reactors have been granted (INNOMEM and MACBETH) worth together 36 Meuro in development of these systems and BIONICO results are essential for the success of these projects.

Prof. Fausto Gallucci

Technical Manager of BIONICO

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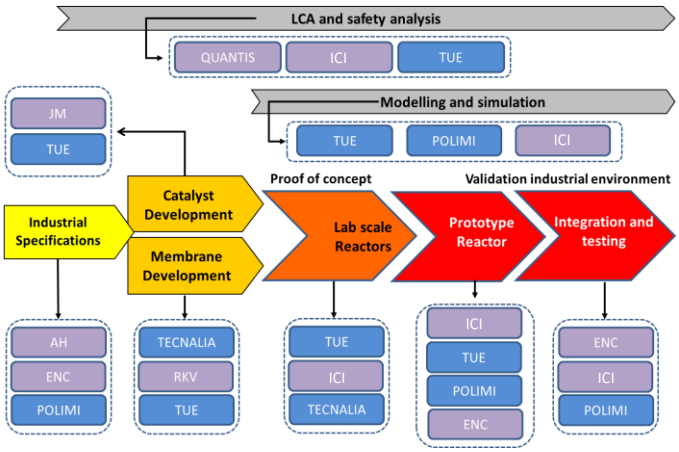
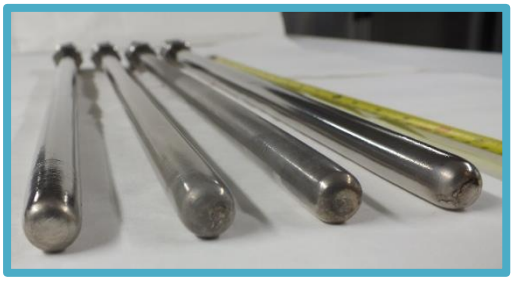
INNOVATION IN KEY-COMPONENTS



Catalyst:

Formulation of a highly active reforming catalyst which can operate under dry, steam or autothermal biogas reforming conditions, and resistant to fluidization conditions. Catalyst interaction with membranes has been tested at lab-scale.



Membranes:

More than 100 Pd-Ag tubular supported membranes have been prepared for the reactor. The Pd-Ag alloy (3-5 μm thickness) is deposited on 50 cm long finger-like ceramic support (14/7 mm outer/inner diameter). Optimization of the manufacturing procedures to get supported membranes of suitable quality for this application. In the new finger-like supports, one of the ends of the tube is a closed porous part, reducing leaks through seals as well as the cost of one Swagelok connection will be saved.

Achieved Target: Perm-selectivity >10000 & N2 leakage level < 10^{-10} mol m^{-2} s^{-1} Pa^{-1}

Reactor:

The largest reactor with tubular membranes for hydrogen production has been designed and manufactured. Moreover a detailed numerical model was developed for its analysis and optimization.

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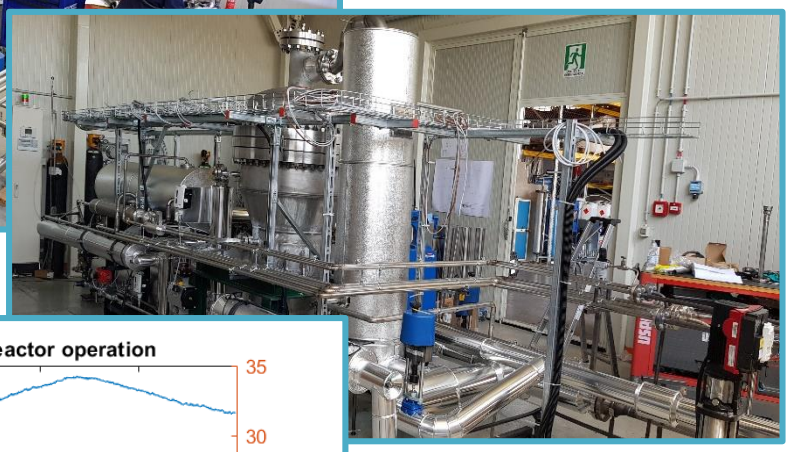
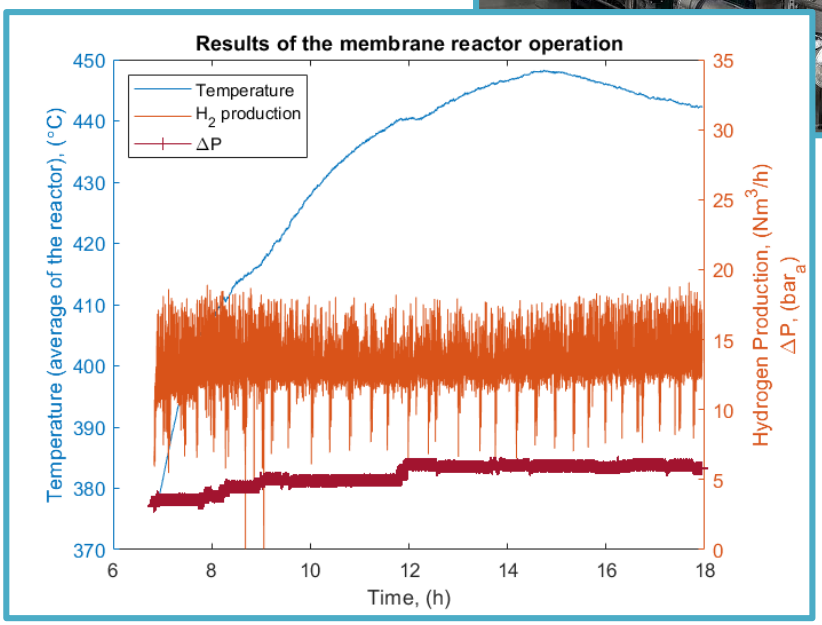
BIONICO PROTOTYPE TEST

BIONICO system was developed and manufactured by ICI Caldaie. Preliminary test with natural gas from the grid were carried out at ICI facilities. The start-up of the system took some hours because the membranes and the catalysts can undergo only slow heating rates (few degrees per minute). After that, a stable and continuous operation was achieved at operating conditions set below the design ones (6 bar and 450 °C). Main operation parameters are depicted in the figure below for a 12 hours long test. Unfortunately, before achieving design conditions (12 bar and 500°C) an unexpected shutdown occurred.





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BIONICO at FCH-JU Review Days 2019

On 19-20th November 2019, BIONICO was presented at the FCH-JU program review days 2019 in Bruxelles.

It was a good opportunity to show and share our achievements with other great projects all around Europe about Hydrogen use and production!

BIONICO Scientific Publications

We published a long series of scientific papers that report our work, from simulations to laboratory tests. Here the links to BIONICO latest results.

TITLE	LINK
Effect of Au addition on hydrogen permeation and the resistance to H2S on Pd-Ag alloy membranes	▶
Achievements of EU projects on membrane reactor for hydrogen production	▶
Palladium based membranes and membrane reactors for hydrogen production and purification: An overview of research activities at Tecnalia and TU/e	▶
On concentration polarisation in a fluidized bed membrane reactor for biogas steam reforming: Modelling and experimental validation	▶
Potentiality of a biogas membrane reformer for decentralized hydrogen production	▶
Life Cycle Assessment and Economic Analysis of an Innovative Biogas Membrane Reformer for Hydrogen Production	▶
Long-term stability of thin-film Pd-based supported membranes	▶
Techno-economic assessment in a fluidized bed membrane reactor for small-scale H2 production: effect of membrane support thickness	▶
Influence of H2S on the hydrogen flux of PdAgAu thin membranes	▶

More information on BIONICO (including public reports, dissemination activities and presentations) are available at the project website: http://www.bionicoproject.eu

Acknowledgement

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