The BIONICO project

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 H₂ 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.
"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 the 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-alone 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
The BIONICO project

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.
**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.
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.

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<td>Achievements of EU projects on membrane reactor for hydrogen production</td>
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More information on BIONICO (including public reports, dissemination activities and presentations) are available at the project website: [http://www.bionicoproject.eu](http://www.bionicoproject.eu)

Acknowledgement

The BIONICO project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking under grant agreement No 671459. This Joint Undertaking receives support from the European Union’s Horizon 2020 research and innovation programme, Hydrogen Europe and Hydrogen Europe Research

Disclosure: The present document reflects only the author’s views, and neither the FCH-JU nor the European Union is liable for any use that may be made of the information contained therein.