# Advanced Multi-Fuel **Re**former **for** Fuel **CELL** CHP Systems

# ReforCELL

**Newsletter – Issue 1 – July 2012**

## Editorial

1st of February officially marked the start of the ReforCELL Project: Advanced Multi-Fuel **Re**former **for** Fuel **CELL** CHP Systems A three year project for the development of a high efficiency fuel cell based heat and power generation system through innovative design of membrane reactor technology for pure hydrogen production, and optimization of the integrated system. ReforCELL is a joint effort of a multidisciplinary and complementary team of 11 European partners. The project is partly funded by the European Community's 7th Framework Programme for the Fuel Cells and Hydrogen Joint Technology Initiative.

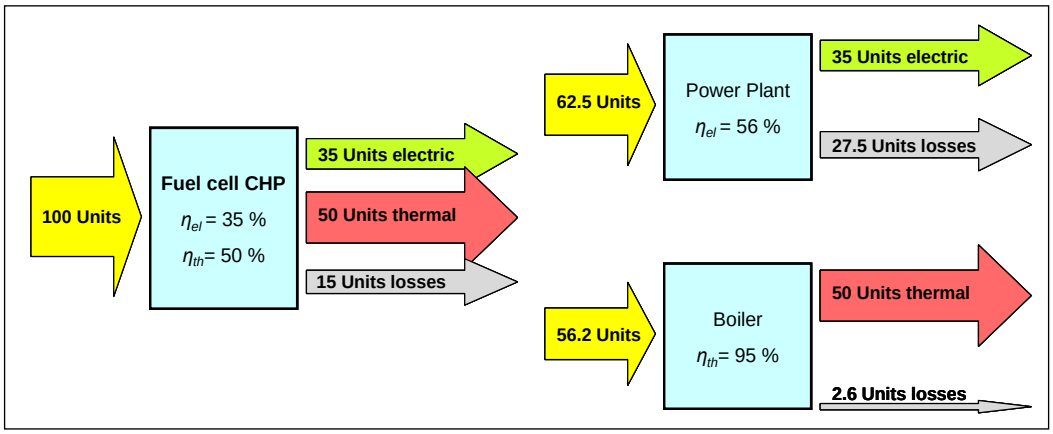
The present newsletter is the first release of the biannual letter that will be published by ReforCELL presenting the progress on the project and highlighting information related to the R&D fields addressed.

## In this Issue:

# What is ReforCELL?

## Concept

Stationary fuel cells offer a clean and efficient source of electricity in systems ranging from 1 kW up to 1 MW or more. With appropriate fuel processing technology, fuel cells are able to tap into established or accessible sources of fuels such as natural gas but also various other fuels including biofuels and bio-gases. With cogeneration or combined heat and power (CHP), efficiencies improve dramatically from 30–50 % up to as high as 80-90 % with significant primary energy savings. In spite of these demonstrated benefits, cost and reliability issues make the technologies' long-term potential difficult to predict. In order to reduce costs and increase the reliability of the technology, work must be done on fuel processing design and system optimization.




*Fuel cell based Combined Heat and Power*

ReforCELL aims at developing a high efficiency CHP system based on:

i) Design, construction and testing of an advanced catalytic membrane reactor for pure hydrogen production from reforming and optimization of the reactor components (catalyst, membranes, heat management etc.)

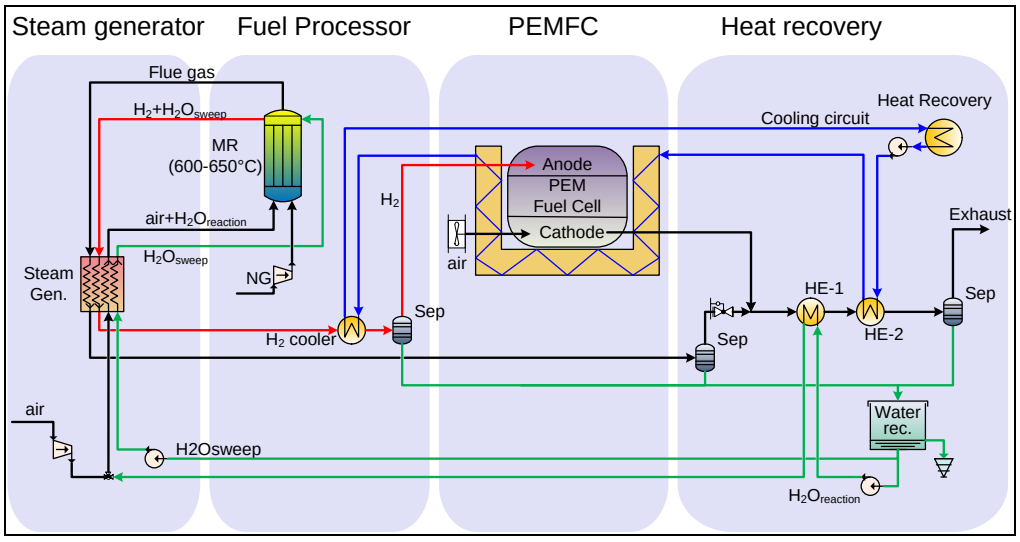
ii) Design and optimization of all the components of CHP system for the integration of the membrane reformer to the fuel cell stack.

The main idea of ReforCELL is to develop a novel more efficient and cheaper membrane reactor in order to intensify the process of hydrogen production through the integration of reforming and purification in one single unit.

## Project objectives

ReforCELL aims at developing a high efficiency (above 42 % electric and 90 % total) PEM fuel cell micro Combined Heat and Power system based on a novel, more efficient and cheaper pure hydrogen production unit, together with optimized design of the subcomponent for the BoP.

The main objective of ReforCELL is to develop a new catalytic membrane reactor for pure hydrogen production (5 $Nm^3/h$) from hydrocarbon reforming in order to intensify the process of hydrogen production. The target will be pursued with the integration of the reforming and purification in one single unit. The novel reactor will be more efficient than the state-of-the-art technology due to an optimal design aimed at circumventing mass and heat transfer resistances. Moreover, the design and optimization of the subcomponents for the BoP will be also addressed.




*System schematic layout*

This objective is directly related to the development of a novel catalytic membrane reactor (CMR) for hydrogen production with:

- Improved performance (high conversion at low temperature for the autothermal reforming reaction);
- Enhanced efficiency (reduction of the energy consumption);
- Long durability under CHP system working conditions.

## Scientific and Technical challenges

The technical objectives needed to achieve these goals with the novel catalytic membrane reactor are:

- Develop an advanced catalyst suitable for different reforming reactions under moderate (<700°C) conditions and resistant to sulphur compounds and coke formation and at reduced cost;
- Develop new hydrogen permeable membrane materials with improved separation properties, long durability, and with reduced cost, to be used under reactive conditions;
- Assess the large scale production of the membrane developed;
- Understand the fundamental physico-chemical mechanisms and the relationship between structure/property/performance and manufacturing process in membranes and catalysts;
- Design, model and build a novel more efficient (e.g. reducing the number of steps) multi-fuel catalytic membrane reactor configurations for small-scale pure hydrogen production;
- Validate the new membrane reactor configurations, and design a semi-industrial Autothermal Reforming (ATR) prototype for pure hydrogen production;
- Improve the cost efficiency of membrane reactors by increasing their performance, decreasing the raw materials consumption and the associated energy losses.

Other technical objectives are related to the integration and validation of the multi-fuel reformer into the PEM fuel cell CHP system:

- Design the optimum CHP system (aided by simulation tools);
- Test the reliability of the novel reactor with a Fuel Cell CHP system;
- Assess the health, safety and environmental impact of the system developed, including a complete Life Cycle Analysis (LCA), of the developed system.

## Partnership

For a maximum impact on the European industry, ReforCELL is carried out by a multidisciplinary and complementary team consisting of 11 top level European organisations from 6 countries: 6 Research Institutes and Universities and 5 industrial partners from different sectors (from hydrogen producer and catalyst developer to boilers and systems integrators). In this way, the ReforCELL brings together solid experience in conception and erection of hydrogen production systems, catalyst and membrane

development, system integration, plant optimization, LCA and industrial risk analyses.

## Project structure

The project is structured and divided into nine well-defined objective-oriented work packages following the focus on efficiency improvement of the overall m-CHP system based on PEM fuel cell and innovative multi-fuel processor. Therefore, the work structure is based on the following sub activities:

WP1: Project management

WP2: Definition of industrial specifications required for CHP performance

WP3: Development of novel catalyst materials for ATR reactions for $H_2$ production.

WP4: Development of novel membranes for $H_2$ separation to be used in CMR operating for ATR.

WP5: Integration of the catalysts and membranes in lab-scale CMRs for the ATR process.

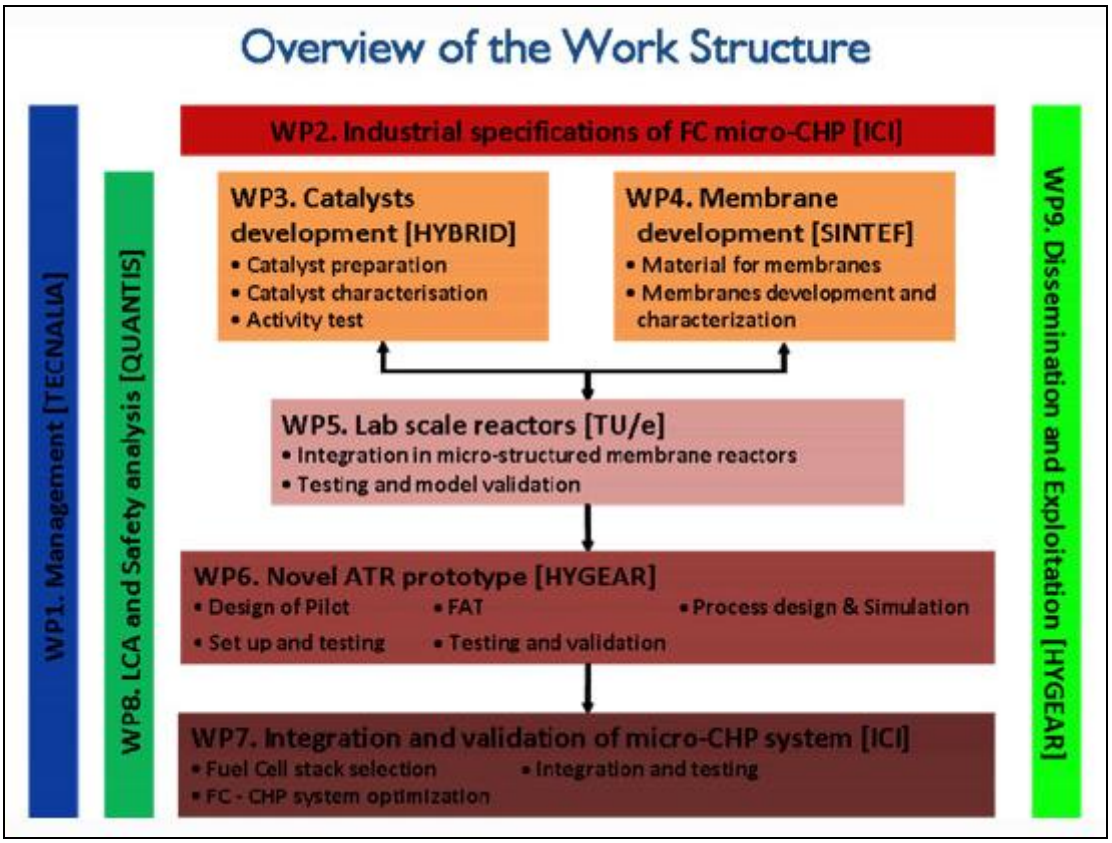
WP6: Design and set-up of a single pilot prototype

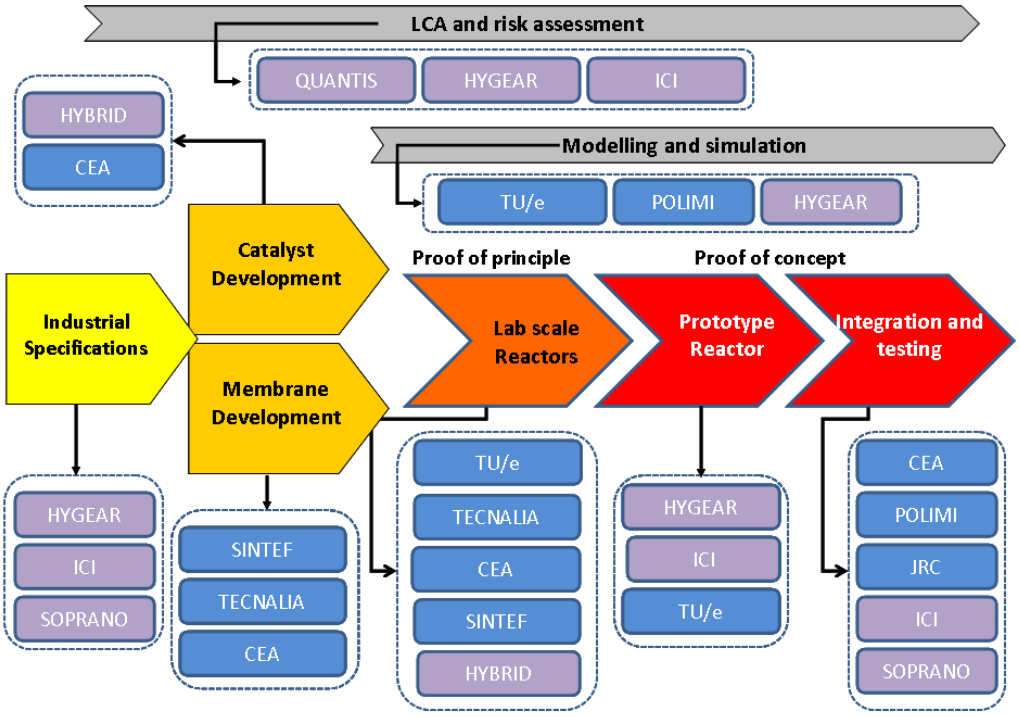
WP7: Design, build and test the innovative m-CHP system based on PEM technology and novel BoP

WP8: Life Cycle Assessment for the complete m-CHP system. In addition, GHG and $CO_2$ impacts will be analysed along with an industrial risk assessment study.

WP9: Dissemination of results to be carried out with the support of organizations and platforms.

The figures below show an overview of the integration between the work packages and the synergies between the partners for the accomplishment of the objectives.



# ReforCELL in progress

## Kick-off meeting February 2012, San Sebastian, Spain

On February the 15th, the project coordinator Tecnalia hosted the kick-off meeting at their premises in San Sebastian, Spain. In the meeting, the partners discussed the main goals and S&T objectives of the project. In the meeting the partners aligned the methodology and associated work plan for effectively achieving the defined tasks. Besides, relevant managerial aspects concerning coordination, communication and planning were addressed and agreed between the participants.

## Advancement status

The on-going activities are evolving on schedule, where the starting activities involve mainly the work packages 2, 3 and 4. As first deliverable of WP2, a definition of industrial requirements identified the characteristics of state-of-the-art technology regarding reactor, PEM, BoP, raw materials specifications and integrated CHP systems.

Activities in WP3 started dealing with the selection of the most appropriate commercially available catalysts and development of novel catalysts. The selection of commercial catalysts is mainly made upon criteria of selectivity, resistance to carbon formation, operating temperature range and the feedstock. The activities of preparation of novel catalysts for ATR are performed by Hybrid Catalysis (using POSS® technology) and target the objectives of improved performance and stability.

Activities in WP4 carried out by Sintef and Tecnalia started with the development of membrane supports, advanced Pd-based membranes and non-Pd-based membranes. Porous ceramic and metallic supports are being selected and surface modified to achieve the surface quality requirements for depositing hydrogen selective layers. Moreover, the use of a ceramic interdiffusion barrier to be deposited onto metallic porous supports is being studied. The developments on Pd and non-Pd-based membranes are targeting stable high permeability layers.

# Highlights

Dr. Rune Bredesen from Sintef has been invited to give a plenary talk at ICIM12 entitled 'Pd-based membranes and their applications':

12th International Conference on Inorganic Membranes
9-13 July; Enschede, The Netherlands,
Plenary One – Metal Membranes, July 10th.

## Upcoming events:

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| ***5 - 10 August 2012*** | Gordon Research Conference: Fuel Cells |
| ***25 - 29 August 2012*** | 20th International Congress of Chemical and Process Engineering (CHISA 2012) and the 15th Conference on Process Integration, Modelling and Optimisation for Energy Saving and Pollution Reduction (PRES 2012)<br>Prague, Czech Republic<br>http://www.chisa.cz/2012/ |
| ***26 - 29 August 2012*** | Electromembrane processes and materials - 2012<br>Český Krumlov, Czech Republic<br>http://www.elmempro.com/En/ |
| ***2 - 5 September 2012*** | 22nd International Symposium on Chemical Reaction Engineering (ISCRE 22)<br>Maastricht , the Netherlands<br>http://conf.ti.kviv.be/iscre22/index.asp |
| ***23 - 27 September 2012*** | Euromembrane 2012<br>London, UK<br>http://www.euromembrane2012.com |
| ***8 - 10 October 2012*** | The fuel cell 12th Forum for Producers and Users & International Forum for Battery and Energy Storage Technologies (f-cell and Battery+Storage 2012)<br>Stuttgart, Germany<br>http://www.f-cell.de/englisch/home/ |
| ***28 October - 2 November 2012*** | 2012 AIChE Annual Meeting<br>Pittsburgh (PA), USA<br>http://www.aiche.org/Conferences/AnnualMeeting/index.aspx |
| ***7 - 8 November 2012*** | 14th Aachener Membran Kolloquium<br>Aachen, Germany |

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| | http://www.amk.rwth-aachen.de |
| ***3 - 7 December 2012*** | 20th International Conference on Chemical Reactors (CHEMREACTOR-20)<br>Mondorf-les Bains, Luxembourg<br>http://conf.nsc.ru/CR-20-2012/en |
| ***27 February - 1 March 2013*** | 9th International Hydrogen & Fuel Cell Expo (FC EXPO 2013=<br>Tokyo, Japan<br>http://www.fcexpo.jp/en/ |
| ***21 - 24 April 2013*** | 9th European Congress of Chemical Engineering (ECCE-9)<br>The Hague, Netherlands<br>http://www.ecce2013.eu/ |
| ***2 - 5 July 2013*** | 11th European Fuel Cell Forum<br>Lucerne, Switzerland<br>http://www.efcf.com/events/ |

**ReforCELL in figures:**

- *11 partners (4 SME; 1 IND; 6 RES)*
- *6 countries*
- *5.6 M€ project (2.9 M€ EU funded)*
- *Start February 2012*
- *Duration: 36 months*
- *Key milestones:*
  - *September 2013- Validation of lab-scale reactor*
  - *July 2014- Validation of the pilot scale prototype*
  - *January 2015- Validation of the m-CHP system*


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More information on ReforCELL (including a non-confidential presentation of the project) is available at the project website and FCH-JU website:

**http://www.reforcell.eu**

**http://www.fch-ju.eu/project/advanced-multi-fuel-reformer-chp-fuel-cell-systems**

## Acknowledgement:


ReforCELL research project is partly funded by the European Community's 7th Framework Programme for the Fuel Cells and Hydrogen Joint Technology Initiative under the project grant agreement n° 978997.


## 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.

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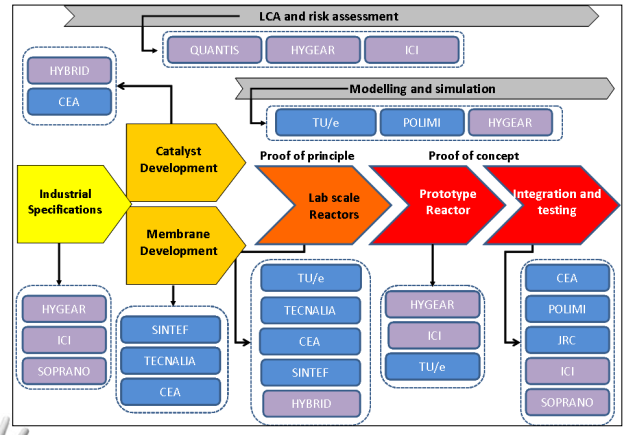
## Summary:

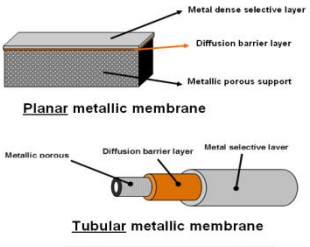
ReforCELL aims at developing a high efficiency (above 42 % electric and 90 % total) PEM based micro-CHP system through: i) design, construction and testing of an advanced catalytic membrane reactor for pure hydrogen production from hydrocarbon reforming, and ii) design and optimization of all the components for the integration of the membrane reformer to the fuel cell stack.

The main idea of ReforCELL is to develop a novel more efficient and cheaper membrane reactor in order to intensify the process of hydrogen production through the integration of reforming and purification in one single unit. In order to achieve this objective, novel stable catalysts and high permeable and more stable membranes need to be developed. Afterwards, suitable reactor design will be realized and tested at laboratory scale for later scaling up to prototype scale (5 $Nm^3/h$ of pure hydrogen) and tested in a CHP system.

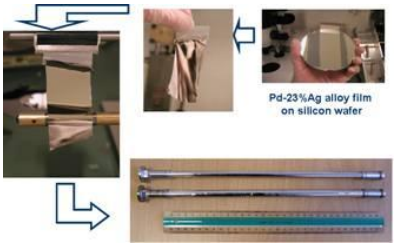
The connection of the novel fuel processor within the CHP will be optimized by designing heat exchangers and auxiliaries required in order to decrease the energy losses.

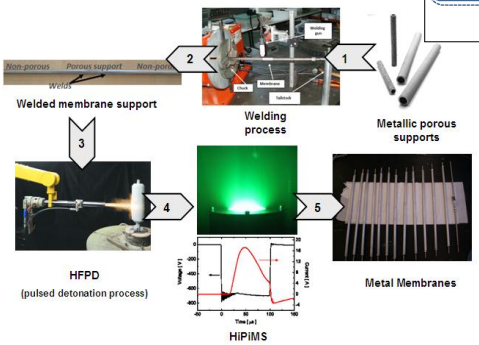


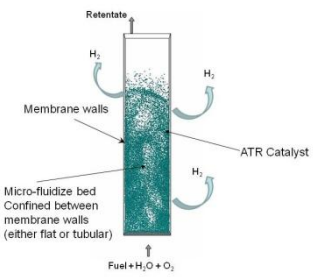



Cross section SEM micrograph of Pd-based membrane





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