ABSTRACTS

SESSION C: HYDROGEN PRODUCTION, DISTRIBUTION AND STORAGE

1.) HYDROSOL-3D: Scale Up of Thermochemical Hydrogen Production in a Solar Monolithic Reactor: a 3rd Generation Design Study

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The principal objective of HYDROSOL-3D is the in-detail preparation of a plant for solar thermo-chemical hydrogen production from water in a 1 MW scale on a solar tower. The main ideas leading to the proposed work stem from the technology developed and the achievements made through the predecessor Projects HYDROSOL and HYDROSOL-II that have introduced the concept of multi-channeled honeycomb monolithic solar reactors for hydrogen generation from water splitting via redox-pair-based thermochemical cycles and demonstrated the feasibility of this process for long-term, cyclic hydrogen production. From the initial idea over the proof of principle and over several steps of improvement, the technology has currently reached the status of a pilot plant demonstration in a 100 kW scale, with a pilot reactor having been installed on the SSPS-CRS solar tower facility of the Plataforma Solar de Almeria, showing that hydrogen production is possible on a solar tower under realistic conditions and demonstrating the high potential of the particular thermochemical cycle technology for further scale-up.

Capitalizing on the above, HYDROSOL-3D focuses on the next steps towards commercialisation carrying out all activities necessary to prepare the erection of a 1 MW solar demonstration plant. HYDROSOL-3D concerns the pre-design and design of the whole plant including the solar hydrogen reactor and all necessary upstream and downstream units needed to feed in the reactants and separate and bottle the products. Two alternative options will be analyzed: adapting the hydrogen production plant to an already available solar facility or developing a new, completely optimised hydrogen production/solar plant. The most promising option will be analysed in detail, establishing the complete plant layout and defining and sizing all necessary components. Validation of pre-design components and process strategies by experiments (in laboratory, solar furnace, solar simulator and solar tower facilities) and a detailed techno-economic analysis covering market introduction will complement the project.

The HYDROSOL-3D consortium has been built accordingly bringing together the experience and knowledge elaborated in all the R&D work carried out up to the current status of HYDROSOL projects, with industrial leaders and innovative SME's capable to bring the technology to maturity and to the market.

2.) HYVOLUTION: A novel bioprocess for hydrogen production from biomass

Dr. Pieternel Claassen

HYVOLUTION is the acronym of the Integrated Project "Non-thermal production of pure hydrogen from biomass" which has been granted in the 6th EU Framework Programme on Research, Technological Development and Demonstration, Priority 6.1 Sustainable Energy Systems. This IP has started on Jan 1, 2006 and will end on Dec 31, 2010. Its aim: "Development of a blue-print for an industrial bioprocess for decentral hydrogen production from locally produced biomass" adds to the number and diversity of hydrogen production routes giving greater security of supply at the local and regional level. Moreover, this IP contributes a complementary strategy to fulfill the increased demand for renewable hydrogen expected in the transition to the Hydrogen Economy. The novel approach adopted in the project is based on a combined bioprocess employing thermophilic and phototrophic bacteria, to provide the highest hydrogen production efficiency in small-scale, cost effective industries. In HYVOLUTION, 10 EU countries, Turkey, Russia and South Africa are represented to assemble the critical mass needed to make a breakthrough in cost-effectiveness.

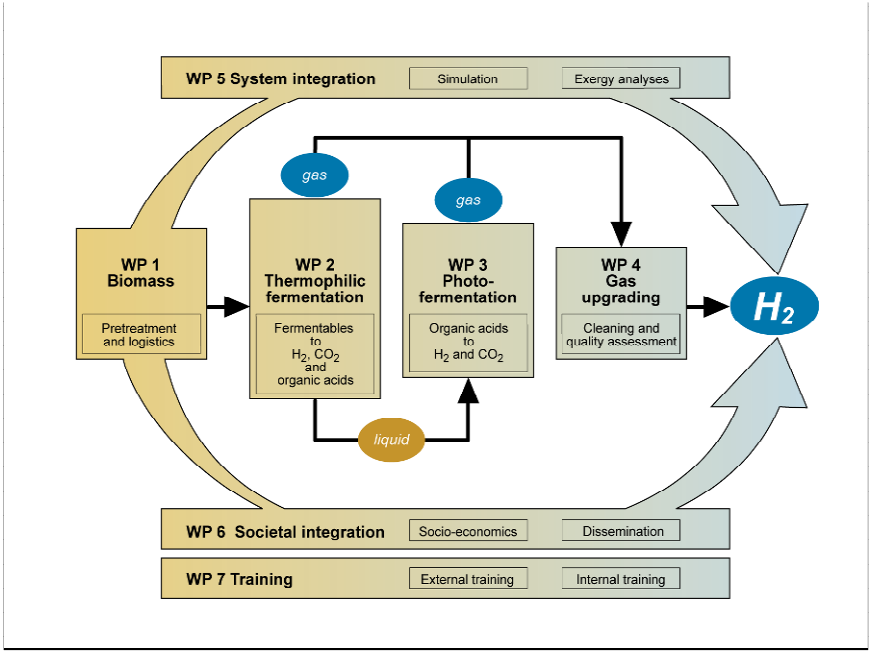

Figure 1: Structure of the HYVOLUTION project.

The process starts with the conversion of biomass to make a suitable feedstock for the bioprocess (WP 1). In WP 2 and 3 the fermentations are optimized in terms of yield and rate of hydrogen production. Dedicated gas upgrading is developed for high efficiency at small-scale production units dealing with fluctuating gas streams (WP 4). Production costs are addressed in WP 5 by combining mass and energy balances. The impact of small-scale hydrogen production plants is addressed in socio-economic analyses performed in WP 6. External as well as internal training issues reside in WP 7 (Fig. 1).

3.) First learnings from the CO2 capture and H2 production Pilot at Puertollano IGCC Plant

Pedro Casero Cabezon, Project Manager, Engineering and R&D Direction, Elcogas S.A.

Puertollano IGCC power plant is the largest coal based IGCC installation in the world since 1998, when its commercial operation started with synthetic gas. This IGCC plant is exploited by ELCOGAS S.A., a Spanish company established in 1992 and shared by European electrical companies and equipment suppliers.

The future of the ELCOGAS IGCC is based on the opportunity that offers to have an operative IGCC plant to R&D activities related with sustainability energy production (reduction of emissions, CO2 capture) and multi-product generation (electricity, hydrogen, synthetic gasoline, biodiesel).

Currently, the ELCOGAS R&D largest investment is focused on carbon capture and H2 production. Within this scope, an industrial scale (14 MW) Pilot using commercial technology has been built integrated in the Puertollano IGCC Plant, aiming to validate at industrial scale the technologies of pre-combustion carbon capture and H2 production associated to an IGCC power plant The first tonne of CO2 was captured last 13th September thus becoming this installation the first of its kind existing in the world.

This Pilot can be fed with both sweet and sour syngas, being able to capture 100 tonnes per day of CO2, while producing 2 tonnes per day of high purity H2 (99.99%) at full load. Due to the R&D nature of the project, all the streams produced are recycled back to the IGCC process.

First lessons learnt from this installation will be introduced, as well as short and medium term plans for its exploitation.

4.) SPHERA Project

Eugenio Guelbenzu, Head of Hydrogen and Electrical Vehicle R+D department, Acciona

The **SPHERA** (**S**oluciones a la **P**roducción del **H**idrogeno **E**nergético y su **R**econversión **A**sociada) project is a Spanish Industry, Trade and Tourism Ministry **CENIT** program project, founded and managed by CDTI, a public institution of the same Ministry and leaded by the Gas Natural.

It is a four year project (2007-2010), with a total budget of 31 million €, and developed by a consortium of 18 industrial and 22 research Spanish organisations.

The Project was structured, in 6 different technology areas and 17 independent work packages. Although the project is focusing on Hydrogen Production basically, it is considering the full chain of Hydrogen, including Storage, Handling, Distribution and Application as well as the analysis of Legal Frames and Incentives for the integration in the Spanish Energy System.

In the presentation, we are showing only the outcomes and result of the activities developed by Acciona Energía, and not the global results which are not public and are regulated by the NDA signed by the consortium members.

The most important results for Acciona Energía are:

- The foundations for the development of Alkaline Electrolysis for RES environment.
- The associated operational, thermal and fluid-dynamic models developed in COMSOL.
- New efficient low temperature catalyzer for glycerin & alcohols reforming.
- Hydrogen Production and Supply Chain model for Spain, either in Green and “Gray” scenarios.
- Hydrogen application in ICE, for electricity and power production. (Microgeneration).
- Pure Hydrogen and H2-CNG mixtures combustion control in any %.
- Hydrogen Diffusion CFD (ANSYS) Model, very useful tool to establish building and infrastructure design, as well as safety and protection measures and actions criteria.

5.) Novel Efficient Solid Storage for Hydrogen: An Overview of the NESSHY Project

Dr. Athanasios Stubos, NCSR Demokritos, Greece

The FP6 Integrated Project NESSHY constitutes a first European attempt to adopt a holistic multidisciplinary approach, addressing key issues related to hydrogen storage in solids such as new materials, novel analytical and characterisation techniques, storage systems and fabrication processes, ab initio and phenomenological modelling using advanced numerical methods for optimal storage design. Special attention is paid to the enhancement of energy efficiency, storage kinetics, operating conditions and safety aspects of produced materials and to the tank design. Quantitative targets for mobile and stationary applications had been set at the beginning of the project and were continuously updated.
The NESSHY consortium consists of a total of 22 contractors from several EU member states including an American partner, while collaboration has been sought with organizations from IPHE countries (Russia, China) through a dedicated Specific Support Action. Industry is represented by three major European companies: French Air Liquide, German Daimler and British Johnson Matthey.
On the material side the project focuses on the following three major classes of materials, where breakthrough solutions could be expected for "reversible storage" systems.

- *Framework Materials / Nanoporous solids* (carbon structures, metal-organic frameworks (MOFs), clathrates)
- *Light Complex Hydrides* (alanates, amides/imides, borohydrides)
- *Magnesium alloys and intermetallics*

Specific routes have been investigated by the NESSHY partners in an integrated effort to move forward and achieve the desired breakthroughs. This effort has been supported by a number of *horizontal activities* including:

- *Numerical methods* (ab initio quantum mechanical modelling, Monte Carlo simulation, density functional theory calculations, molecular dynamics)
- *Novel analytical and characterisation tools* (neutron and X-ray scattering, hydrogenography, high pressure synthesis, TPD)
- *Virtual laboratory* (Round Robin Tests, standardisation and safety issues)
- *Dissemination, Training, International collaboration*

Finally the design, development and evaluation of advanced *storage systems* has been undertaken involving amongst others, tank design and manufacture, heat management, upscaling, cyclability and safety issues.
The overall aim has been to obtain results that may illuminate the future perspectives of hydrogen storage for transport and stationary applications and assist decision makers and stakeholders on the road to hydrogen economy.

The major achievements of NESSHY will be presented in this overview while outreach aspects and recommendations for future activities will also be discussed.