“Improvements to Integrate High Pressure Alkaline Electrolysers for Electricity/H2 production from Renewable Energies to Balance the Grid”

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0 Executive Summary

This report tries to summarize briefly the main goals, tasks and expected results in the Elygrid project.

The index and scope of the document has been defined in accordance with the requirements exposed in the justification procedure in the point “Publishable summary”.

All the partners involved in the project have contributed for the preparation of this document.

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1 Summary description of the project

This section will be edited by the Commission as such. This summary report has to be updated at the end of each reporting period.
Please provide a summary description of the project context and the main objectives. The length of this part cannot exceed 4000 characters.

Global demand for the production of H_2 is set to grow exponentially. A further challenge will be a change from the hydrogen production processes based on fossil fuels which generate CO2 as an unwanted by product towards the use of H_2 mass production electrolysers. This key market is considered strategic for the industrial partners looking towards H_2 as the environmentally acceptable solution to their growing energy needs.

The ELYGRID project, "Improvements to Integrate High Pressure Alkaline Electrolysers for Electricity/H2 production from Renewable Energies to Balance the Grid", aims at contributing to the reduction of the Total Cost of hydrogen produced via electrolysis coupled to Renewable Energy Sources, mainly wind turbines, and focusing on mega watt size electrolyzes (from 0.5 MW and up). The objectives are to improve the efficiency related to complete system by 20 % (10 % related to the stack and 10 % electrical conversion) and to reduce costs by 25%. The work will be structured in 3 different parts, namely: cells improvement, power electronics, and balance of plant (BOP). Two scalable prototype electrolyzers will be tested in facilities which allow feeding with renewable energies (photovoltaic and wind).

The consortium is integrated by a mix of academic, research and industrial partners. Industrie Haute Technologie (IHT) is the industrial partner inside the Consortium which is able to produce high pressure alkaline electrolysers in big size per unit (3.5 MW / 760 Nm^3/h). A new membrane is being developed by the Consortium with the possibility of improving the performance and characteristics of the electrolyser. The current density used nowadays is 0.2 A/cm^2 and it is expected that the current can be increased at least by the double up to 0.5 A/cm^2. Therefore the hydrogen capacity production per unit can be raised to more than 3 Ton/day achieving one of the goals described in MAIP 2008-2013 where the target in 2020 for the unit capacity is 3 Ton/day.

The main project objectives can be summarized below:

- Define new operation conditions for improvements in performance and efficiency
- Development (synthesis) of advanced materials for electrolysis cell diaphragms/membranes to be used for field testing.
- Increase the efficiency of the stack by increasing operation temperature and electrolyte concentration
- Identify technical improvements related to the Balance of Plant (BOP) which represents approximately 15% of the CAPEX.
- Redesign power electronics, based on transistor instead of thyristor, less sensible to the electrical grid parameters. Power electronics optimization considering factors like efficiency, harmonics and reliability
- Design, develop and test the concept of converters for 3300 A DC and 800 V
- Field test of new stack with a 1,6 m diameter membrane

- Identification of technological market and local value-chain suppliers
- Outreach, social awareness and promotion of alkaline electrolysis coupled with renewable energy sources through demostration projects, field testing and integration
- Assessment on RCS aspects for electrolyzer technology to facilitate commercialization worldwide
- Comparative Life Cycle Assessment (LCA) studies carried out according to the practice guidance developed by the FCH JTI

2 Description of the work performed and main results

Please provide a description of the work performed since the beginning of the project and the main results achieved so far. The length of this part cannot exceed 4000 characters.

The main results will be listed by work package in the following points.

WP2

Stable and durable membranes of the new composition have been manufactured by tape-casting at EMPA and by vertical coating at VITO. The materials investigated for using as composite membranes are synthetic or natural silicate based fillers supported in PPS. On the other hand, different concepts of membranes based on Zirfon have been developed.

The membranes are showing similar results concerning cell voltage, membrane conductivity and gas purity than asbestos and Zirfon® based membranes. The different membranes are being assessed in base on the new operation conditions (120ºC and 30% KOH) in order to know its chemical stability.

From the perspective of physicochemical properties of the separator (ionic resistance, pore size and bubble point), the separators show quite promising behavior since they combine low ionic resistance with convenient permeability and bubble point.

These tests are being developed at lab scale (30 -130 mm) and the partners involved in membrane development are looking for companies interested in the production of promising membranes at 1.600 mm diameter.

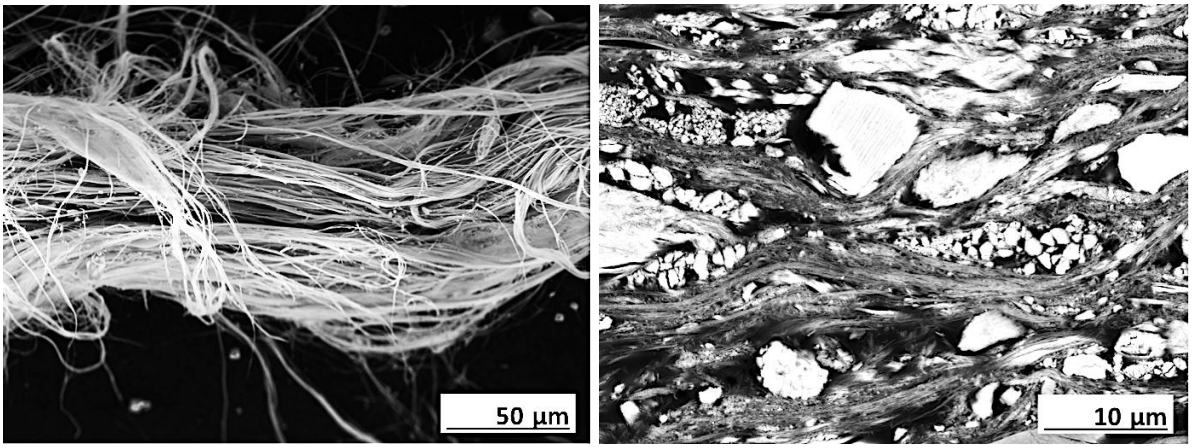

Figure: Scanning electron microscopy images of free bunch of fibrous asbestos deposited on conductive carbon tape (left). The asbestos tissue embedded in organic resin (right).

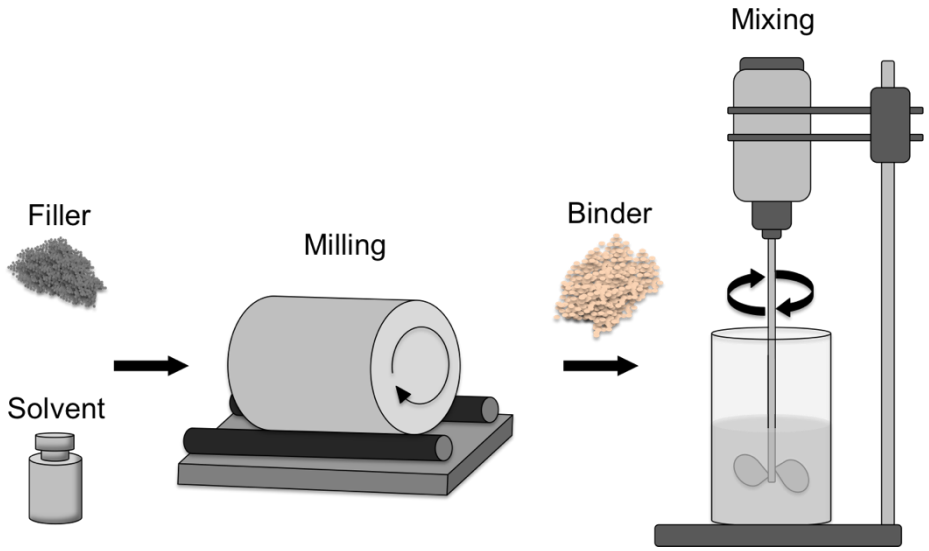

Figure: Illustration of the slurry production process for the tape-casting on the PPS felts.

Figure: Lab installation for vertical casting at VITO

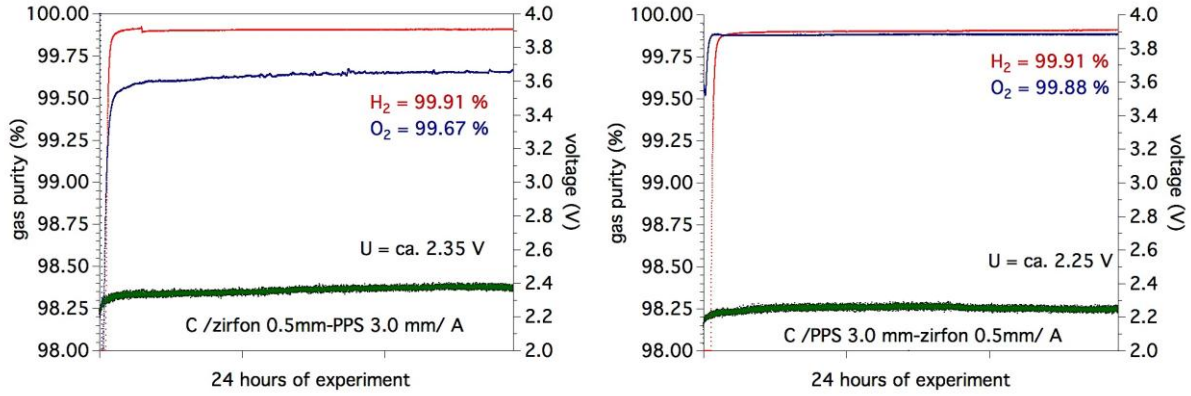

Figure: Electrolysis results with 2 different Zirfon® based membranes (VITO) on PPS support.(0.5 mm layer, 3.0 mm total thickness).

WP3

The main progresses in this WP have been:

- Definition of the Scenario: LV Grid connection, power quality limits, restrictions and general specifications.
- Analysis of an Alkaline Electrolyser in order to clarify its electrical behaviour. Extrapolation of results to a 2.6MW Electrolyser to be used as the load for the power stage. Other important requirements for the load, such as isolation, harmonic content and other control features have been established as restrictive requirements.
- Definition, analysis and comparison of three different topologies. The first focused on an industrial scenario application and the two other ones based on the idea of renewable energies integration and grid regulation.
- Comparison of the simulation results, conclusions and selection of the start-up topology for prototyping.

WP4

The scope of the WP4 includes tasks more focused on the model development and validation but other important tasks like mechanical redesign of head plates or tie rods and an update control system which involves a significant improvement of the global BOP and TCO. The main progresses have been:

- Control configuration tool of the BOP. It will be useful to assess changes in the BOP and total cost of each system
- Safety analysis methodology developed in order to assess future changes in the BOP
- Set of models developed and data available for model validation (partial loads, thermal validation, V/cell, etc) obtained from the electrolyser
- Mechanical redesign of head plates, tie roads and gas separators which involves a cost reduction
- Improvements in the control system focused on the operation coupled to RES

Figure: Picture of the electrolyser of IHT at FHA facilities

WP5

Tests of potential membranes proposed by Vito and Empa in 130mm have been done by IHT in the test electrolyser located in Monthey, Switzerland. The test bench has been running and works have been done on it during several periods. The results seem promising but more tests must be done during the second period in order to confirm the first result.

In parallel, during the second period more tests will be carried out with membranes in the installation located at Walqa with a diameter size of 1.600 mm.

Figure: Picture of the Type S-556 electrolyser of IHT

WP6

This WP is focused in different activities like business cases, LCA, identification of potential users, standardization, cost models, RCS and dissemination. The main progresses have been:

- The main RCS applied to an electrolyser have been identified and assessed during the second period of the project.

- The cost model for the reference unit has been defined in order to assess the cost reduction of future changes.
- A Live Cycle Assessment is being developed in order to compare the reference unit and the new one with the changes obtained in the project
- The market studies have been focused on energy storage market. This market has been segmented in 4 segments and 9 applications.
- The communication plan has been developed during the first period.

3 Expected final results and potential impact

Please provide a description of the expected final results and their potential impacts and use (includind socio-economic impact and the wider societal implications of the project so far). The length of this part cannot exceed 4000 characters

The project has a well oriented market approach and the expected results are therefore mainly focused on satisfying the needs of the growing hydrogen technologies market. The industrial partner (IHT) has the capability of manufacturing high pressure alkaline electrolysers in the range of MW. Nowadays, one big unit of this technology (3,5 MW) can produce up to 760 Nm^3/h of hydrogen at 32 bar. Therefore, taking these features as base line for the project, all the improvements that can be developed during the project will increase the competitiveness of this kind of electrolysers by redesign, modeling, new materials or an update control system in order to operate properly with RES. If the project reaches the goals proposed, the new production unit could match the goals described in the MAIP 2008-2013.

AA2 - Production: Distributed production of hydrogen by water electrolysis	2010 baseline	2015 mid-term	2020 long-term	ELYGRID goals 1st 2015
Unit capacity (Ton/d)	1,5	1,5	3	3,5 - 4
Efficiency (%)	65	68	70	>70% stack efficiency
Cost (M€/(t/d))	3,1	2,8	1,9	In progress

These big units producing hydrogen at pressure (32 bar) could be used to produce huge amounts of hydrogen for power-to-gas applications, helping the hydrogen fuel cell vehicles deployment or industrial applications. Therefore, they can have a direct application and market once the project has finished.

The works done in cell improvement will contribute to increase the knowledge about membrane development. Besides, the small possibilities of membranes available on the market for these applications could be raised with the membranes developed during the project.

The power electronics design is one of the key issue related to electrolysers coupled to renewable energies. A new prototype is being designed in order to match properly the electrolyser operation together with RES and therefore a new equipment developed by Ingeteam will be available in the market for these applications by the end of the project.

The project is also working deeply in the RCS analysis and LCA in order to try to consolidate and make easier the deployment of this technology during the next years. Besides, during the second period of the project more dissemination activities will be done so that stakeholders, potential users or general public can know in more detail about this technology.

The project is focused on the production of hydrogen coupled to RES and therefore the results obtained could be very useful for the development of the EU due to the dependence of imported fossil fuels for electric power generation, contamination produced by this kind of generation and because EU countries have a great potential of RES which can be optimized with this new application.