elyntegration

Grid Integrated Multi Megawatt High Pressure Alkaline Electrolysers for Energy Applications

MIDTERM PROJECT REPORT

DELIVERABLE 1.2

GRANT AGREEMENT 671458

PUBLIC

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking under grant agreement No 671458. This Joint Undertaking receives support from the European Union's Horizon 2020 research and innovation programme and Spain, Belgium, Germany, Switzerland.

This work is supported by the Swiss State Secretariat for Education, Research and Innovation (SERI) under contract number 15.0252.

Esther Albertín [1], Fernando Palacín [1], Pablo Marcuello[2], Yolanda Alvarez-Gallego[3], Christian Immanuel Müller[4], Guillermo Matute[5], Patrick Larscheid[6]

[1] Fundación para el desarrollo de las nuevas tecnologías del hidrógeno en Aragón (FHA)

[2]Industrie Haute Technologie (IHT)

[3]Vlaamse Instelling voor Technologisch Onderzoek (VITO)

[4] Fraunhofer Institute for Manufacturing Technology and Advanced Materials (IFAM)

[5] Instrumentación y Componentes (INYCOM)

[6] RWTH Aachen University, Institute of Power Systems and Power Economics (IAEW)

Author printed in bold is the contact person/corresponding author

Content

Figures

1 EXECUTIVE SUMMARY

This report includes the information regarding the first period of ELYNTEGRATION, from 1st September 2015 to 28th February 2017.

The index and scope of the document has been defined in accordance with the requirements exposed in the justification procedure in the point Part A- Publishable summary

All the partners have contributed to elaborate the summary of the project's progress.

2 SUMMARY OF THE CONTEXT AND OVERALL OBJECTIVES OF THE ACTION

In addition to the role of Water electrolysis in the chemical industry, AWE has the potential to become a key enabling technology in the deployment of hydrogen in the energy markets, through the provision of energy storage services, grid and balancing services. Furthermore, hydrogen could allow the integration or connection between electricity grids and other grids and markets, like gas grid.

The strategic goal of the ELYNTEGRATION Project (Grid Integrated Multi Megawatt High Pressure Alkaline Electrolysers for Energy Applications) is the design and engineering of a robust, flexible, efficient and cost-competitive single stack Multi Megawatt High Pressure Alkaline Water Electrolysis (AWE) of 4,5 T H2/day capable to provide cutting-edge operational capabilities under highly dynamic power supplies expected in the frame of generation/ transmission/ distribution scenarios integrating high renewable energies (RE) shares.

The final design of the MW HP AWE will be achieved on the basis of the development, validation and demonstration of a HP AWE industrial prototype comprising:

- cylindrical stack consisting of industrial size elementary cells
- balance of plant (BOP)
- power electronics
- advanced communication & control system

In the early phase of the development process, great attention is brought to the identification of end-user's needs and relevant/critical operational requirements.

A set of specific objectives has been defined for the project, both at functional capabilities level and value proposition for AWE, and include

- High system efficiency and high current density
- Flexibility
- Durability in steady state and dynamic conditions
- Enhanced communication and control capabilities
- Regulatory frameworks, standards, tariffs, scenarios and end-users
- Business scenarios and business models

ELYNTEGRATION project is carried out by a multi-disciplinary consortium, coordinated by FHA, well-balanced and with complementary expertise, which will aim at achieving the project objectives. The consortium includes an alkaline electrolyser manufacturer, research organizations to develop the new designs and components (FHA, VITO, IFAM, IAEW) and an engineering and technology provider (INYCOM)

3 WORK PERFORMED FROM THE BEGINNING OF THE ACTION TO THE END OF THE PERIOD COVERED BY THE REPORT AND MAIN RESULTS ACHIEVED SO FAR

During the first half of the project (from September-15 to February-17) several advances have been made towards achieving the objectives of ELYNTEGRATION. The main progress and results are listed by work package in the following:

3.1 WP2

In Task 2.1 a review of the regulatory framework for the integration of electrolysers into electric power grids was conducted. It was identified, that prescribed technical requirements for grid connection are not expected to be critical. It could be shown, that end-user prices for electricity are highly dependent on regulatory frameworks thus impacting the economic efficiency of electrolysers. This task was mainly conducted by IAEW.

The second task of WP2 focused on re-evaluating the technical targets for the final design of the electrolyser. Emphasis was given to parameters that have direct impact on the acceptance of the system in potential future markets for electrolyser. The main parameters identified of significant importance are related to response time and maximum and minimum capacitiy. This task was mainly conducted by FHA.

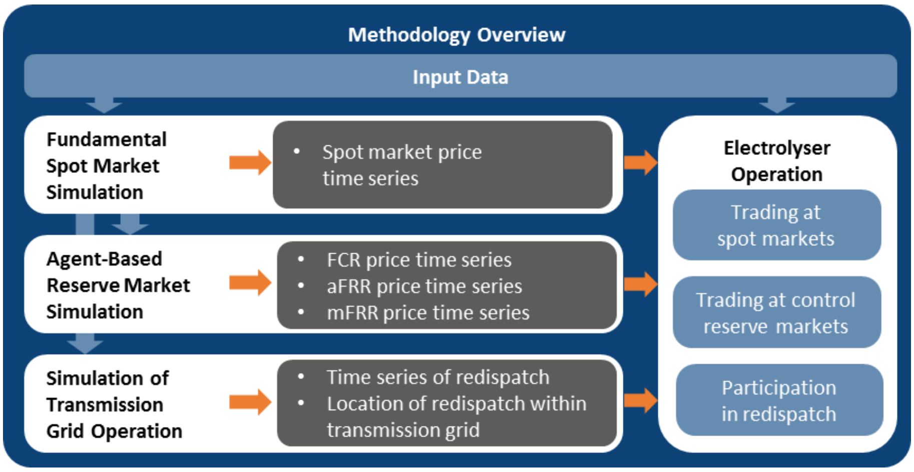

Figure 1. Methodology overview, evaluation of business models

Extensive work has been carried out by IAEW in Task 2.3 towards development and evaluation of potential new business models (BM) for electrolysers within the context of power systems with high shares of renewable energies. These BM include cross-commodity arbitrage trading between spot markets for electricity and hydrogen markets, provision of control reserve products and of grid services. Different simulation approaches were used in order to determine future contribution margins for all BM. The results show, that promising electricity markets are especially those with future high shares of renewable energies. Results of this task are presented in deliverable 2.3 (available at Elyntegration.eu).

3.2 WP3

Relating to the electrolysis stack development and design, ELYNTEGRATION partners are dedicated in Task 3.1 to the development of new membranes and electrodes developed by VITO and IFAM respectively. In both cases, different characterization routes have been carried out in order to select the best candidates to be tested during the project.

During Task 3.2, all the materials developed have been tested in-situ at a small scale test bench at IHT facilities in order to gather data for the first selection of the materials to be tested further. A total of 9 membrane candidates and 3 batches of electrodes have been tested providing promising results in terms of performance and stability. From the tests carried out, it is foreseen to select between 2 or 3 candidate membranes and 1 type of electrode to be further tested in the next phase of the project.

Task 3.3 is the development and use of an intermediate scale test bench in the project, done at FHA facilities. For this purpose, a dedicated test bench able to operate at high pressures and current densities has been erected by FHA. Besides, FHA has developed an accelerated stress protocol to test the materials under highly extreme and dynamic conditions in order to check and extrapolate the materials performance. IHT will provide the stacks to be tested with the materials coming from task 3.2 and the most promising materials will be tested in WP5

Figure 2. Pilot test bench, intermediate scale, erected at FHA facilities

Furthermore, to deal with the design of different cell topologies at market size able to work under high dynamic profiles, a dedicated test bench at market cell size has been erected at IHT facilities in Task 3.4. To accomplish the goals of this task a CFD model is being developed in order to extrapolate the behaviour to MWs electrolysers under dynamic operation.

3.3 WP4

Regarding the communication and control system (C&CS) of the electrolyser, a study was conducted in Task 4.1 defining the communication protocols and information needed to be exchanged with the actors involved to provide grid services, being analysed in a general way for the EU.

During Task 4.2, a dedicated C&CS is being developed for the specific case of ELYNTEGRATION, based on the findings of requirements for grid services and working beyond the dynamic control system developed for the intermediate test bench. The C&CS will be tested in the framework of WP5.

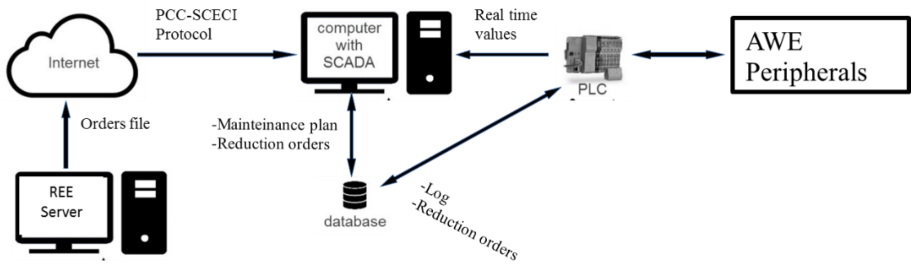

Figure 3. Schematic representation communication of AWE with grid operator

In Task 4.3 a computer model simulation based on Python to study the behaviour of the electrolysers' balance of plant (BOP) has been developed by FHA. The obtained results are positive, but still there is room for improvement, especially in the dynamic response of the model to accommodate to real behaviour of components at industrial scale. The model is now being updated with the incoming results of the pilot scale test benches. It will serve to help the design of the industrial scale BOP, and specifically towards its use for grid services applications.

Also relating to the balance of plant design, a first assessment of the components for dynamic operation was conducted in Task 4.4, analysing which ones (heat exchangers, pumps, gas separators etc.) would be affected and how in the case of changing conditions in the plant. Furthermore, a study on different methods to assess the costs of the equipment has been carried out, in order to provide updated information on costs for the BOP components to the LCC analysis.

3.4 WP6

During this WP the goals related to exploitation of results and dissemination have been followed up. The main results of WP6 are expected to be achieved during the second half of the project. The main outcomes nowadays are described as follows.

In Task 6.1, an analysis of the main market potentials was conducted, taking into account the information provided by the analysis of grid services from WP2. A sensitivity analysis has been carried out in order to assess the influence of key parameters (H2 price, NG price, electricity cost etc.) in the potential deployment of hydrogen business. Results are presented in Deliverable 6.4 (available at elyntegration.eu)

In Task 6.2 first steps were taken to define the key exploitable results of ELYNTEGRATION. The methodology was later refined with the support of external company

META Group (support service which is facilitated by European Commission, DG Research and Innovation, and implemented by external consultants) and it will be further used during the second half of the project.

Regarding communication and dissemination, the Communication, Dissemination and Awareness Plan of the project has been developed and updated once. Tools and materials have been released, such as projects' website, flyers, and a press kit. ELYNTEGRATION has been also presented in two conferences and several forums and workshops.

4 PROGRESS BEYOND THE STATE OF THE ART AND EXPECTED POTENTIAL IMPACT (INCLUDING THE SOCIO-ECONOMIC IMPACT AND THE WIDER SOCIETAL IMPLICATIONS OF THE ACTION SO FAR)

The project has a clearly oriented to market approach, so the expected potential impact of the results are focused on satisfying the potential needs of new markets and business models while complying with the existent requirements for connection to grid and provision of balancing or grid services. It is expected that results from WP2 and WP6, which have been made public through two deliverables, pave the way towards a set of recommendations for policy makers and regulators.

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 Nm3/h of hydrogen at 32 bar. ELYNTEGRATION results and improvements, both in materials and in cell, balance of plant design and C&CS will increase the competitiveness of this kind of systems (Multi Megawatt production with a single stack), providing services to the grid operators as potential improvement to be considered as additional aspect of the business model.

These improvements are aligned with the specific objectives of the Multi Annual Work plan (MAWP 2014-2020) for electrolysers producing hydrogen from renewable electricity for energy storage and grid balancing.

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

The results on dynamic testing and the test protocols developed will contribute to the development of harmonized test design, in order to stablish the requirements for dynamic operation and AST for AWE providing grid balancing services.

Finally, the project is very oriented to integrate the electrolysers in the electricity grid providing grid balancing. The results have shown that the most promising markets would be those with a high penetration of RES. Therefore, the results obtained could pave the way to the deployment of RES in the electricity mix in Europe.