eLY4OFF

PEM ELECTROLYSERS FOR OPERATION WITH OFFGRID RENEWABLE INSTALLATIONS

Document for media and press

GRANT AGREEMENT
700359

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking under grant agreement No 700359. This Joint Undertaking receives support from the European Union's Horizon 2020 research and innovation programme.

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1. Objective

The objective of this document is to compile information about ELY4OFF project, rules for communication and general information that shall be useful for media and press to cover the developments and milestones of the project.

The document is divided in several sections providing answers and information about the most critical concepts related to the project.

This document shall be updated, translated and included in the official press kit of ELY4OFF. The last version of the document will be uploaded to the project website.

2. General rules

ELY4OFF dissemination activities, under Gran Agreement 700359, have to follow some general rules which are detailed below. The partners must promote the project and its results, but always under the obligations agreed with the programme office.

Any communication activity related to the project, including electronic form must:

a) Display the JU logo,
b) Display the EU emblem (included in the press kit and below) and
c) Include the Gran Agreement number

About the use of European Emblem:

http://ec.europa.eu/dgs/communication/services/visual_identity/pdf/use-emblem_en.pdf

3. Project's description and goals

The ELY4OFF project has, as its main objective, the design and manufacturing of a PEM (polymer electrolyte membrane) electrolyser that is robust, flexible, competitive and highly efficient. It is exclusively fuelled by means of photovoltaic power and is isolated from the power grid. It will be controlled automatically by means of cutting-edge technologies so that is highly dynamic renewable generating source can be optimally managed. The equipment's final design will be available thanks to the development, validation and demonstration of a 50 kW industrial prototype composed of a cylindrical stack able to produce pressurized hydrogen; balance of plan; power electronics; advanced communication and control systems, peripheral and final applications of the hydrogen produced.

These applications will be mainly the supply of hydrogen to two buses formed by a system of fuel cell and batteries, which will drive along Huesca, a city close to the facilities where the prototype will be installed (FHA).

Also, a detailed and flexible business model, replicable to EU and international environments, will be developed for the integration of electrolysers in off-grid installations, integrating LCC results (CAPEX/OPEX) and possible financial incomes. The business model will identify the key actors and their relationships, the roles and involvement of end users, incentives, safety issues, barriers and target markets.

Funds for this project come from the Fuel Cells and Hydrogen Joint Undertaking (FCH 2 JU) under agreement No 700359. This Joint Undertaking gets support from the European Research and Innovation Programme Horizon 2020m and from Hydrogen Europe.

ELY4OFF started in April 2016 and its duration is three years.

4. Project partners: the Consortium

The project will be carried out by a multi-disciplinary Consortium with a well-balanced distribution including a PEM electrolyser manufacturer (ITM Power), research organizations to develop and integrate the whole installations and develop an appropriate business model and exploitations strategy (CEA TECH, FHA) and two companies including a SME specialized in power electronics (EPIC Power) and a large company specialized in control and communication systems (INYCOM). This partnership structure provides to the Consortium with complementary expertise and enough critical mass to accomplish the project goal successfully in terms of timing, costs and quality.

Foundation for the Development of New Hydrogen Technologies in Aragon, FHA (www.hidrogenoaragon.org)

The Foundation for the Development of New Hydrogen Technologies in Aragon is a private non – profit organization promoted by the Regional Government, other public bodies and private companies. Currently the Board of the Foundation is formed by more than seventy stakeholders belonging to all the economy sectors: automotive, chemistry, power generation, financial, educational, engineering, research and development centres and real estate. Its team of young professionals performs R&D as well as consultancy projects, in cooperation or assisting local and national companies.

Over the last fourteen years, FHA has been supporting the regional strategy for the uptake of H2 and FC technologies, publishing the Hydrogen Master Plan in Aragón (2007-2010, 2011-2015 and 2016-2020), and showcasing the whole hydrogen chain (production, management and efficient use), obtaining the primary energy from renewable sources by means of processes currently available (photovoltaic and wind). The facility includes hydrogen production means (PEM as well as alkaline electrolysers), storage, dispensing and final use in fuel cells, including vehicles (BEV and FCEV).

More than 1000 people visit yearly the FHA premises, mainly from schools and universities, hence contributing to the wider awareness and dissemination to the society.

ITM POWER (www.itm-power.com)

ITM Power is a dynamic, innovative company committed do clean sustainable energy solutions based on water electrolysis using Polymer-Electrolyte-Membrane (PEM) technologies. ITM has grown from its original platform of novel hydrophilic polymeric electrolytes (for water electrolysis and hydrogen fuel cells) to that of a technology provider. ITM now has both a strong base of intellectual property and engineering expertise for providing hydrogen solutions.

Founded in June 2001, the company floated on the Alternative Investment Market in 2004 and was the first United Kingdom-based fuel cell company to go public. ITM Power operates out of two premises in Sheffield, UK with further offices in Germany, France the USA and Canada.

ITM has a broad experience in national and international project in FCH technologies and presence in the market of PEMWE. It also has knowledge in manufacturing process, test bench design and exploitation, technology business development and cost assessment and monitoring.

ITM will be heavily operationally involves in the conception, design and optimizations of the PEMWE stack and balances of plant.

INYCOM: innovation technologies (www.inycom.es)

Inycom is a Spanish technology company headquartered in Zaragoza. It was founded in 1982, so it has more than 30 years of experience. Inycom provides high quality services and solutions with added value in IT and Communications, Energy, Laboratory Equipment, Electronics and Medical Equipment. It has a staff of more than 350 professionals in 9 offices in Spain, 2 of them in Technology Parks, and 1 in Enschede, in the Netherlands.

Inycom R&D Department has a wide experience delivering products for telecommunication companies and electric utilities based on software development and electronic design, focused on scientific and technical applications. They provide a strong expertise especially in renewable energies research.

In the Energy Sector, Inycom is an ESCO, offering services and products in the fields of measurement and data acquisition, energy efficiency, intelligent SCADAs, demand and generation forecasts and electricity markets assessment. Inycom has been dedicated for more than ten years to R&D in energy, more specifically in renewables and their integration in the power grid. After developing several commercial measurement equipment and software applications to automate validation of international standards, in the last 5 years Inycom has participated in the implementation of different microgrids, especially in large industries and Technology Parks, integrating renewable energy sources and energy storage (including hydrogen) to improve the quality in power supply, energy efficiency and energy trading profitability.

The main role in ELY4OFF will be the design and engineering of an overarching control system for the different components involved in the project and their integration.

EPIC POWER (www.epicpower.es)

Epic Power is a Spanish SME devoted to the application of power electronic technologies to energy efficiency and microgrids. Their technologies rely on robust DC/DC and DC/AC converters that guarantee that the bidirectional efficiency is high enough to grant a reasonable ROI in retrieving and returning the energy.

Epic Power technologies are also being applied to several fields thanks to their state-of-the-art conversion capabilities. They are a spin-off company of the University of Zaragoza and their research roots and constant interaction with other research centres keep us at the most current level. As an example, they have been able to achieve ultra-high efficiency at reasonable costs thanks to their early adoption of Silicon Carbide transistor technology.

On the other hand, they are producers of systems that need to be sold. Therefore, their designs, from early stages take into account the restrictions that would apply: Smooth production, norms and certifications, usability and most relevantly, costs.

The main role of Epic Power will be the development of the DC/DC converter with MPPT to couple the PEMWE to the PV generation, under the overarching control system.

CEA TECH (www.cea.fr)

CEA TECH (16 000 employees) is a French government technological research organization. The CEA is active in four main areas: low-carbon energies, defence and security, information technologies and health technologies. In each of these fields, the CEA maintains a cross-disciplinary culture of engineers and researchers. CEA Liten (Laboratory of Innovation for New Energy Technologies and Nanomaterials) is one of most important European research centres on new technologies for energy.

The team joining the project is the Laboratory of techno-economic and Environmental Evaluation and Demonstration of Energy processes (L2ED) within the Biomass and Hydrogen Department of the CEA LITEN. The lab holds a strong expertise on hydrogen production technologies both from technical and economic points of view.

L2ED is currently managing several demonstration projects related to hydrogen production and its integration with renewable energy and the electricity grid. Within these projects, L2ED has developed competencies in characterization, evaluation and modelling of electrolysis systems

CEA will offer his expertise in the development of new business models and marker potential assessment studies and will contribute to develop the RCS analysis and proposals. Furthermore, CEA will implement a monitoring plan dedicated to development activities under European and member states regulations, standards, codes and end-user's specifications related to off-grid installations.

5. THE FCH 2 JU and H2020 Programme

The Fuel Cells and Hydrogen Joint Undertaking (FCH JU) is a unique public private partnership supporting research, technological development and demonstration (RTD) activities in fuel cell and hydrogen energy technologies in Europe. Its aim is to accelerate the market introduction of these technologies, realising their potential as an instrument in achieving a carbon-lean energy system.

Fuel cells, as an efficient conversion technology, and hydrogen, as a clean energy carrier, have a great potential to help fight carbon dioxide emissions, to reduce dependence on hydrocarbons and to contribute to economic growth. The objective of the FCH JU is to bring these benefits to Europeans through a concentrated effort from all sectors.

The three members of the FCH JU are the European Commission, fuel cell and hydrogen industries represented by Hydrogen Europe and the research community represented by the Research Grouping N.ERGHY.

Description from http://www.fch.europa.eu/page/who-we-are

More information about the FCH 2 JU and its activities can be found at http://www.fch.europa.eu/

Horizon 2020 is the financial instrument implementing the Innovation Union, a Europe 2020 flagship initiative aimed at securing Europe's global competitiveness.

Horizon 2020 is the biggest EU Research and Innovation programme ever with nearly €80 billion of funding available over 7 years (2014 to 2020) – in addition to the private investment that this money will attract. It promises more breakthroughs, discoveries and world-firsts by taking great ideas from the lab to the market.

More information can be found at https://ec.europa.eu/programmes/horizon2020/en

6. General Concepts

6.1 Hydrogen: application, uses

Hydrogen is a widely-used molecule. Hydrogen, at atmospheric temperatures and pressures, is a gas. As element, it is abundant on Earth but as part of compounds, such as water, alcohols or hydrocarbons.

Nowadays, hydrogen is used in chemical and petrochemical industries, and it also has several applications in electronics industries.

Hydrogen has been used mainly as reactant, as it is a good reduction agent and other properties as low viscosity and density, which it is of key importance for example in metal treatment.

Hydrogen is also crucial to other processes such as fertilizers production (to produce ammonia), refineries (for converting heavier crude fractions into other fuels by hydrocracking), petrochemical industries as the polymer and plastics production (hydrogen is used in the basis of these industries to produce methanol)

6.2 Hydrogen production

The most used large scale production method is steam reforming of light hydrocarbons, usually, steam reforming of natural gas (methane). Steam methane reforming is the process where a stream of steam reacts with the hydrocarbons producing syngas (a mixture of CO and H2). This gas receives the name of syngas because it is a mixture widely used as basic in the synthetic chemical production of other compounds. In a second stage, the carbon monoxide (CO) is converted into CO_2 with the action of a catalyst (Nickel, Platinum) and high temperature.

Another process to produce hydrogen is the partial oxidation (with or without catalyst), by means of using oxygen to partially oxidise the hydrocarbons, producing carbon monoxide and hydrogen. Other method to produce hydrogen includes gasification, based on the partial oxidation also, where the raw material can be coal or biomass instead of methane or biogas.

All these methods are based on the reaction of hydrocarbons, while the production of hydrogen by water electrolysis requires water and electricity, so there is no production of carbon monoxide or carbon dioxide directly linked to the process.

Other methods to produce hydrogen could be the thermochemical cycles (I-S cycle) the photo catalysis (water plus sunlight) or biological process (by algae or other microorganisms)

6.3 What is electrolysis?

Electrolysis is an electrochemical process by which the pass of a direct electrical current (DC) causes a chemical change in which this substance loses and/or gains electrons. The losing of electrons is called oxidation while the gaining is the reduction.

An electrolytic cell is the device having two electrodes (where the change of electrons take place) separated by an electrolyte (the solution which conducts the electrons between the electrodes). The electric direct current enters through the negative electrode (cathode), causing the gain of electrons of positive ions, while the negative ions move through the electrolyte to the positive electrode (anode) losing electrons, being oxidised thus at this electrode (anode).

Therefore, the electrolysis requires species being oxidised and reduced, an electrolyte between the electrodes and the use of an electrical direct current.

6.4 Polymer Electrolyte Membrane Electrolysis

Polymer electrolyte membrane (PEM) electrolysis is the electrolysis of water in a cell equipped with a solid polymer electrolyte that is responsible for the conduction of protons, separation of product gases, and electrical insulation of the electrodes.

The ability of the PEM electrolyser to operate, not only under highly dynamic conditions, but also in part-load and overload conditions is one of the reasons for the recently renewed interest in this technology. This is one of the largest advantages to PEM electrolysis, its ability to operate at high current densities. This can result in reduced operational costs, especially for systems coupled with very dynamic energy sources such as wind and solar, where sudden spikes in energy input would otherwise result in uncaptured energy. The polymer electrolyte allows the PEM electrolyser to operate with a very thin membrane while still allowing high pressures, resulting in low ohmic losses, primarily caused by the conduction of protons across the membrane and a compressed hydrogen output.

6.5 The potential of H2 in mobility

Hydrogen is an ideal replacement for fossil fuels such as coal, oil and natural gas in furnaces, internal combustion engines, turbines and jet engines.

Today, environmental pressures are concentrating hydrogen research and development efforts on hydrogen as an alternative fuel to power our mobility and transportation needs. In electrified vehicles, for example, it is used to run fuel cells which convert hydrogen efficiently (back) to electricity.

The application spectrum of fuel cells is vast. They have the potential to replace conventional power generators such as combustion engines or even large batteries in cars, buses, forklift trucks (FLTs), submarines, and backup and power plants.

Hydrogen has a very low volumetric energy density at ambient conditions, equal to about one-third that of methane. Even when the fuel is stored as liquid hydrogen in a cryogenic tank or in a compressed hydrogen storage tank, the volumetric energy density is small relative to that of gasoline. It has a three times higher specific energy by mass compared to gasoline.

7. Annex. Reglas generales (Español)

Cualquier actividad comunicativa relacionada con el Proyecto, debe incluir lo siguiente:

a) El logo de la FCH JU
b) El emblema de EU
c) El número del Grant Agreement

Este proyecto ha recibido financiación de la Fuel Cells and Hydrogen 2 Joint Undertaking bajo el acuerdo número 700359. Esta iniciativa conjunta recibe el apoyo de la Unión Europea a través del programa de investigación e innovación Horizonte 2020.

8. Annex. Información sobre el proyecto (Español)

El proyecto ELY4OFF tiene, como su principal objetivo, el diseño y construcción de un electrolizador PEM (electrolito de membrana polimérica) que sea robusto, flexible, competitivo y altamente eficiente. Será exclusivamente alimentado mediante potencia fotovoltaica y estará aislado de la red. Será controlado automáticamente mediante tecnologías de vanguardia en el sector para que la generación renovable altamente dinámica sea correctamente controlada.

El equipo final diseñado estará disponible gracias al desarrollo, validación y demostración de un prototipo industrial de 50 kW formado por un stack cilíndrico capaz de producir hidrógeno presurizado; balance de planta, electrónica de potencia, comunicaciones avanzadas y control de sistemas, sistema periférico y aplicaciones finales para el hidrógeno producido.

Dichas aplicaciones serán principalmente para suministrar hidrógeno a dos autobuses formados por un sistema de pila de hidrógeno y baterías, que circularán por Huesca, la ciudad próxima a las instalaciones dónde se instalará el prototipo.

Así mismo, un plan de modelo detallado y flexible, aplicable a Europa y a medios internacionales, será desarrollado para la integración de electrolizadores en instalaciones aisladas de red, integrando resultados LCC (CAPEX/OPEX) y posibles ingresos financieros. El modelo de negocios identificará los puntos clave y sus relaciones, los roles y participaciones de los usuarios finales, cuestiones de seguridad, barreas y objetivos de mercados.

ELY4OFF comenzó en abril de 2016 y tiene una duración de 3 años, para finalizar en marzo de 2019.

9. Annex. Conceptos general (Español)

Aplicaciones y usos del hidrógeno:

El hidrógeno se utiliza constantemente en la actualidad. En condiciones de temperatura y gas atmosféricas, es un gas. Como elemento, es abundante en la Tierra, pero como parte de otros compuestos, como el agua, el alcohol o los hidrocarburos.

Hoy día, el hidrógeno es usado en la industria química y petroquímica, y tiene también numerosas aplicaciones en la industria de la electrónica.

El hidrógeno se utiliza principalmente como reactive, debido a sus buenas cualidades reductoras, su baja viscosidad y densidad, lo hacen de vital importancia para por ejemplo el tratamiento de metales.

El hidrógeno es también crucial para otros procesos como la producción de fertilizantes (para producir amoniaco), refinerías (para convertir fracciones pesadas en otros combustibles mediante el hidrocraqueo) e industria de polímeros y plásticos (el hidrógeno es usado como la base para producir metanol).

Producción del hidrógeno:

El método de producción a gran escala más utilizado es el reformado con vapor de hidrocarburos ligeros (como el metano, gas natural). El reformado con vapor se basa en la reacción de los hidrocarburos con vapor de agua para producir monóxido de carbono e hidrógeno. Este gas, conocido como syngas o gas síntesis, tiene una amplia aplicación en la base de la industria de proceso. En una segunda etapa el monóxido de carbono (CO) se convierta a CO2 e hidrógeno mediante el vapor de agua y catalizadores como Níquel o Platino.

Otro proceso para producir hidrógeno es la oxidación parcial (con o sin catalizadores) en la que, mediante el uso de oxígeno, se oxida parcialmente el hidrocarburo, produciendo hidrógeno y monóxido de carbono. Otro método es la gasificación, basado también en el anterior, pero en este caso las materias de partida pueden ser carbón o biomasa.

Todos estos métodos están basados en la reacción de los hidrocarburos (compuestos con hidrógeno y carbono), mientras que la producción de hidrógeno mediante electrolisis de agua requiere agua y electricidad, por lo que no hay generación directamente asociada de CO o CO2.

Otros métodos a considerar son los ciclos termoquímicos (S-I), la fotocatálisis (agua y luz solar) o los procesos biológicos (algas u otros microorganismos).

¿Qué es la electrolysis?

La electrolisis es un proceso electroquímico, en el cual la aplicación de corriente continua produce un cambio químico en una sustancia, la cual pierde o gana

electrones. La pérdida de electrones se conoce como oxidación, y la ganancia reducción.

Una celda electroquímica es el dispositivo con dos electrodos (donde se produce el cambio de oxidación de las especies). Separados por un electrolito (que conduce los electrones entre electrodos). La corriente continua entra por el electrodo negativo (cátodo) provocando que los iones positivos ganen electrones, mientras que los iones negativos se mueven por el electrolito hacia el electrodo positivo (ánodo), perdiendo electrones y oxidándose.

Por tanto, la electrólisis requiere de especies que se oxiden/reduzcan, electrolito entre los electrodos y el uso de corriente eléctrica continua.

Electrolisis de electrolito con membrana polimérica:

Es la electrolisis del agua en una celda equipada con un polímero solido (electrolito) que es responsable de la conducción de protones, separación de producto de gases, y asilamiento eléctrico de los electrodos.

La habilidad del electrolizador PEM de operar no solo bajo altas condiciones dinámicas, sino también bajo condiciones de sobrecarga y media carga, es una de las razones por las que hay un interés especial por esta tecnología. Esta es una de las grandes ventajas de los PEM, su habilidad de operar a altas densidades de corriente. Esto puede resultar en costes de operación reducidos, especialmente para sistemas con fuentes de energía muy dinámicas como la solar o la eólica, donde picos repentinos de energía resultarían no ser aprovechados en otros sistemas. El electrolito polimérico permite al electrolizador operar con una membrana muy fina mientras permite presiones muy altas, lo cual resulta en bajas pérdidas óhmicas, causadas principalmente por la conducción de protones a través de la membrana y la salida de hidrógeno comprimido.

El potencial del hidrógeno en movilidad:

El hidrógeno es un reemplazo ideal de los combustibles fósiles como el carbón, el petróleo o el gas natural, tanto en hornos como en motores de combustión interna, turbinas o motores de avión.

Hoy en día, los esfuerzos se están concentrando en la investigación y el desarrollo del hidrógeno como una alternativa de los fósiles para alimentar nuestra movilidad y nuestra necesidad de transporte. En vehículos eléctricos, por ejemplo, es usado mediante pilas de combustible para convertir hidrogeno eficientemente a electricidad.

El espectro de aplicación de las pilas de combustible es muy amplio. Tienen el potencial de reemplazar los generadores convencionales como los motores de combustión o incluso las grandes baterías que hay en los coches, autobuses, carretillas elevadoras, submarinos y plantas de respaldo de energía.

El hidrógeno tiene una densidad de energía volumétrica muy baja en condiciones ambientales, igual a aproximadamente un tercio de la del metano. Incluso cuando el combustible es almacenado como líquido en un tanque criogénico o en un tangue de hidrógeno comprimido, la densidad de energía volumétrica es reducida respecto de la gasolina. El hidrógeno posee tres veces más de energía especifica por masa que ésta.

10. Annex. FCH 2 JU y programa H2020 (Español)

La FCH JU es un partenariado público privado que apoya actividades de investigación, desarrollo tecnológico y demostración en Europa sobre tecnologías de hidrógeno y pilas de combustible. Su objetivo es acelerar la llegada al mercado de dichas tecnologías, demostrando su potencial como herramienta que contribuya a un sistema energético actual sin carbón.

Las pilas de combustible (como sistema eficiente de conversión hidrógeno-electricidad) y el hidrógeno (como vector energético limpio) tienen un gran potencial para ayudar en la reducción de emisiones de dióxido de carbono, reducir la dependencia de los hidrocarburos y contribuir al crecimiento económico. El objetivo de la FCH JU es acercar dichos beneficios a Europa aunando esfuerzos de diferentes sectores.

Los tres miembros de la FCH JU son la Comisión Europea, industrias relaciones con las pilas de combustible y el hidrógeno (representadas por Hydrogen Europe) y la comunidad científica de investigación (representada por N.ERGHY).

Horizonte 2020 es el programa que financia proyectos de investigación e innovación de diversas áreas temáticas en el contexto europeo, contando con casi 80.000 M€ para el periodo 2014-2020.

Investigadores, empresas, centros tecnológicos y entidades públicas tienen cabida en este programa.