First Strategy Plan for Commercial exploitation of the Results

Deliverable 6.5

GRANT AGREEMENT
700359

D6.5 First Strategy Plan for Commercial Exploitation of the Results

Grant agreement	Fuel Cells and Hydrogen 2 Joint Undertaking
Project no.	700359
Project full title	PEM ElectroLYsers FOR operation with OFFgrid renewable facilities
Project acronym	ELY4OFF
Deliverable no.	6.5
Title of deliverable	First Strategy Plan for Commercial Exploitation of Results
Contractual date of delivery	M22 (January 2018)
Actual date of delivery	M24 (March 2018)
Author(s)	Dr Rachel Smith
Participant(s)	Pilar Molina (EPIC), Estanis Oyarbide (EPIC), Guillermo Matute (INYCOM), Pedro Casero (FHA)
Work Package contributing to the deliverable (WPx)	WP6
Dissemination level (PU/CO/CI)	PU
Type (R/DEM/DEC/OTHER)	R
Version	1
Total number of pages	21

Executive Summary

This report looks at the potential markets for an off-grid energy solution for isolated areas devoid of an electricity grid network. It will selectively target commercial end users that are looking for innovative solutions in off-grid environments. Each project partner will contribute to the exploitation strategy and will generate their own exploitable results; along with being responsible for defining their IPR and standardisation strategies to develop a successful business and financial mode. This will lead to a road map on how best to exploit all the available dissemination activities outlined in the exploitation plan to achieve the best commercial, economic and scientific research opportunities that have materialised from the project's outputs for PEM Electrolysis in the production of a primary energy source from off-grid; that is, standalone renewable electricity generation applications for the production and storage of green hydrogen.

TABLE OF CONTENTS

1. INTRODUCTION

The main objective of a strategy plan for commercial exploitation is to provide a route to ensure successful exploitation for IPR, with respect to foreground and exploitable results generated during the project, in order to developing an EU and internationally replicable business model for off-grid electrolysers connected to renewable energy sources, characterizing specific business cases, to ensure wide implementation. This will be a working document for the partners to review and adapt throughout the project. This report is the first strategy plan, which will be formally updated in month 30 (September 2018).

At this stage in the project the demonstration kit is not yet operation in the field. At the next report we will have a number of months of data which will strengthen the exploitation strategy and enable engagement with the hydrogen community, the Exploitation Working Group, and potential stakeholders.

Throughout the project each partner will generate exploitable results and be responsible for the exploitation; however, the most important synergies can be achieved by a common and long term exploitation strategy aimed at wider implementation of the electrolyser components and systems developed.

An Exploitation Booster Workshop was held in November 2017 in Huesca (Spain) in order to assist in the development of a business plan.

2. OVERVIEW OF EXPLOITABLE RESULTS

Exploitable Foreground (description)	Exploitable product(s) or measure(s)	Sector(s) of application	Timetable, commercial use	Patents or other IPR exploitation (licenses)	Owner & Other Beneficiary (s) involved
1. Electrolyser stack design for low cross over membranes	Water electrolysers	Off Grid electrolysers	2020	Possible IP if significant stack modifications are needed	ITM
2. Low Energy Balance of Plant for Electrolysers	Water electrolysers	Potentially some modifications applicable to all ITM systems	2020	Know how	ITM
3. DC/DC Converter	Converter for coupling PEM to PV panels	Off Grid electrolysers	2020	Possible IP	EP
4. Peripheral component integration for managing essential back up power provision	Robust, efficient and optimised management of energy required for back-up essential consumers	Off Grid electrolysers	2020	Possible IP	FHA
5. Intelligent overarching control systems to maintain efficiency and autonomy	Intelligent control can help to reduce the balance of plant requirements	Off Grid electrolysers	2020	Possible IP	INYCOM
6. Safety system management for off grid applications	Water electrolysis	Off Grid Electrolysers	2020	Potentially some modifications to allow very low and very high current densities which are needed for Off Grid systems	ITM

3. CHARACTERISTICS OF EXPLOITABLE RESULTS

An initial overview of the characteristics of each of the exploitable results is given below, this will continue to be developed by exploitation partners over the coming months and presented in a final strategy plan (D6.6) in September 2018.

Electrolyser stack design for low cross over membranes (ITM)

Describe the innovation content of the result	A low cross over membrane in a stack allows the plant to operate within the system safety design criteria at very low current densities, and therefore maximise the take up of renewable energy as soon as it becomes available.
Who will be the customer?	Off grid applications where the electrolyser is directly coupled to the renewable electricity source. Possible customers include: Energy systems for isolated areas Replacement of diesel engines in off grid locations in high sunlight areas. Backup systems for weak grid areas in the event of gird failures Off grid FCEV fuel generators Power to Gas applications – large scale off grid electrolyser to enable new renewable assets to be developed in areas where no electricity grid connection is available (e.g. tip of Norway, Remote Scotland, North Sea rigs). Fertiliser production on farms where renewable energy is available
What benefits will it bring the customer?	A higher capture of the renewable output
When is the time to market?	2020 for small scale applications 2022 for large scale applications

What are the costs to be incurred after the project and before exploitation?	It is envisaged that at the end of this project the results of the stack will be exploitable in small systems (<100kW), the larger systems would require significant further investment to enable the technology to transfer into ITMs MEGASTACK platform.
What is the market is in M€ for this result and relevant trend? Each of the markets identified above will be investigated in more detail for the next report (D6.6) further details are in the next section with only an outline here.	Difficult to estimate with so many potential markets, over the next periods the markets will be studied further with the top 3 or 4 identified and quantified.
How will this results rank against completing products in terms of price and performance?	
Who are the competitors for this result?	Hydrogenics, Siemens, NEL
How fast and in what ways will the competition respond to this result?	
Who are the partners involved?	ITM
Who are the industrial partners interested in the results?	ITM
Have you protected or how will you protect the result?	Stack design is using ITM background IP, specific design details and manufacturing knowledge will be kept confidential trade secrets.

Low Energy Balance of Plant for Electrolysers (ITM)

Describe the innovation content of the result	A low energy balance of plant improves the efficiency of the electrolyser system, and can also reduce costs. The Ely4Off project concentrates on off grid systems, but the ability to test the balance of plant reduction may result in design improvements throughout the complete ITM electrolyser platform where efficiency can be improved.
Who will be the customer?	Off grid applications where the electrolyser is directly coupled to the renewable electricity source. Possible customers include: Energy systems for isolated areas Replacement of diesel engines in off grid locations in high sunlight areas. Backup systems for weak grid areas in the event of gird failures Off grid FCEV fuel generators Power to Gas applications – large scale off grid electrolyser to enable new renewable assets to be developed in areas where no electricity grid connection is available (e.g. tip of Norway, Remote Scotland). Fertiliser production on farms where renewable energy is available Standard electrolyser applications could also benefit, bringing in markets for on grid electrolysers – to include HRS, chemical plants, and more Power to Gas opportunities.
What benefits will it bring the customer?	A lower OPEX during operation due to improved efficiency.
When is the time to market?	2020 for small scale applications 2022 for large scale applications
What are the costs to be	It is envisaged that at the end of this project the

incurred after the project and before exploitation?	results of the stack will be exploitable in small systems (<100kW), the larger systems would require significant further investment to enable the technology to transfer into ITMs MEGASTACK platform.
What is the market is in M€ for this result and relevant trend? Each of the markets identified above will be investigated in more detail for the next report (D6.6) further details are in the next section with only an outline here.	Difficult to estimate with so many potential markets, over the next periods the markets will be studied further with the top 3 or 4 identified and quantified.
How will this results rank against completing products in terms of price and performance?	
Who are the competitors for this result?	Hydrogenics, Siemens, NEL
How fast and in what ways will the competition respond to this result?	
Who are the partners involved?	ITM
Who are the industrial partners interested in the results?	ITM
Have you protected or how will you protect the result?	Specific design details and manufacturing knowledge will be kept as confidential trade secrets.

DC/DC Converter (EP)

Describe the innovation content of the result	The developed DC/DC converter will link directly the photovoltaic solar panels with the electrolyser stack. It will be able to manage the MPPT in the input side and regulate the output voltage in the other side. It will include two operating modes related to the output load: a) stack connected and b) only ancillary loads connected. Additionally it will be possible to connect the input port to a non-controlled three-phase AC/DC rectifier, so it will be able also to feed the stack from an AC mains connection. The power capability is scalable, as it is possible to connect in parallel as many converters as required (in the case of the ELY4OFF project there will be 13 DC/DC converters in parallel) Thanks to the innovative conversion topology the achieved efficiency is above 93% along all the operating range.
Who will be the customer?	Any industrial manufacturer that aims to feed the electrolyser stack from photovoltaic panels.
What benefits will it bring the customer?	The customer will receive a plug & play, flexible, redundant and scalable way to connect photovoltaic panels to electrolyser stacks.
When is the time to market?	After the experimental on-site test, the product will be ready to market in 6 months (end 2019).
What are the costs to be incurred after the project and before exploitation?	There will be some EMI-EMC tests to perform, around 30k€.
What is the market is in M€ for this result and relevant trend? Each of the markets identified above will be	The need of flexible and efficient DC/DC converters is increasing due to the energy generation and management strategies. Thus solar, battery storage and other markets could be of interest. It is almost impossible to provide a logically justified value in M€

investigated in more detail for the next report (D6.6) further details are in the next section with only an outline here.	
How will this results rank against completing products in terms of price and performance?	In the best of our knowledge, there is not an equivalent commercial product, so it will be a premiere.
Who are the competitors for this result?	There are not competitors
How fast and in what ways will the competition respond to this result?	Some qualified manufacturers are able to offer a similar product after 12-24 months of development. But they are large companies that goes into new developments only in the case a clear and large market is assured.
Who are the partners involved?	Epic Power Converters S.L.
Who are the industrial partners interested in the results?	Epic Power Converters S.L, ITM, INYCOM
Have you protected or how will you protect the result?	Specific design details and manufacturing knowledge will be kept as confidential trade secrets

Peripheral component integration for managing essential back up power provision (FHA)

Describe the innovation content of the result	Robust, efficient and optimised management of energy required for back-up essential consumers
Who will be the customer?	Same as other results
What benefits will it bring the customer?	Optimised tapping of the hydrogen produced in the system, to be used by the customer. Confidence in that the system is well back-up
When is the time to market?	2020 for small scale applications 2022 for large scale applications
What are the costs to be incurred after the project and before exploitation?	The outcome of the project will provide realistic and representative data for giving a realistic cost of the HSS system. The system is expected to be easily scalable.
What is the market is in M€ for this result and relevant trend? Each of the markets identified above will be investigated in more detail for the next report (D6.6) further details are in the next section with only an outline here.	Difficult to estimate with so many potential markets, over the next periods the markets will be studied further with the top 3 or 4 identified and quantified.
How will this results rank against completing products in terms of price and performance?	The main competitor technology is a hybrid diesel & batteries system. The result may not be always better in terms of price, specific niche markets have to be identified.
Who are the competitors for this result?	The competitors are not specific entities, but the current technological solution applied (diesel & batteries)

How fast and in what ways will the competition respond to this result?	
Who are the partners involved?	FHA, INYCOM
Who are the industrial partners interested in the results?	
Have you protected or how will you protect the result?	The result is not currently protected. It is not clear at this moment if it should be and in that case how.

Intelligent overarching control systems to maintain efficiency and autonomy (INYCOM)

Describe the innovation content of the result	Overarching control and communication system for isolated microgrids with RE generation and energy storage devices with smart operation and predictive maintenance capabilities.
Who will be the customer?	Microgrids with distributed energy resources
What benefits will it bring the customer?	Optimized operation of the microgrid, which brings lower OPEX of the installation.
When is the time to market?	After ELY4OFF execution, the concept is ready for replication to other microgrids.
What are the costs to be incurred after the project and before exploitation?	Adjustments in the control logic should be done to accommodate the system to other configurations considering different optimization targets.
What is the market is in M€ for this result and relevant trend? Each of the markets identified above will be investigated in more detail for the next report (D6.6) further details are in the next section with only an outline here.	This is still a niche market, as the concept of microgrids isolated from the main grid has sense in specific scenarios.
How will this results rank against completing products in terms of price and performance?	
Who are the competitors for this result?	Competitors are ESCO, integrators and ICT companies which may develop similar systems
How fast and in what ways will the competition respond	The competition has put in place already solutions in this field, but not with real isolated microgrids with

to this result?	electrolysers in the range of 50 kW as ELY4OFF. Probably it is question of 3-4 years for other initiatives to take place including overarching C&CS to optimize microgrids with hydrogen through similar systems.
Who are the partners involved?	INYCOM
Who are the industrial partners interested in the results?	INYCOM
Have you protected or how will you protect the result?	Industrial secrecy is the way to protect the system

Safety System Management for Off Grid Applications (ITM)

Describe the innovation content of the result	Identification of appropriate safety measures specific to an off grid electrolyser system, modifications to control system or balance of plant to allow safe operation at very low or very high current densities.
Who will be the customer?	All potential users of off grid electrolysers
What benefits will it bring the customer?	Safe operation is a necessity to enable any installation to take place.
When is the time to market?	2020
What are the costs to be incurred after the project and before exploitation?	
What is the market is in M€ for this result and relevant trend? Each of the markets identified above will be investigated in more detail for the next report (D6.6) further details are in the next section with only an outline here.	Difficult to estimate with so many potential markets, over the next periods the markets will be studied further with the top 3 or 4 identified and quantified.
How will this results rank against completing products in terms of price and performance?	
Who are the competitors for this result?	
How fast and in what ways will the competition respond to this result?	

Who are the partners involved?	ITM, INYCOM, EP
Who are the industrial partners interested in the results?	ITM
Have you protected or how will you protect the result?	Know how developed and exploited

4. TARGET MARKETS

Target markets were identified in D6.3 and are further expanded and refined here.

Telecoms

Increasing growth in the use of mobile telecommunications word-wide for both voice and data has created a significant market for dedicated backup power systems to keep networks functioning during grid power outages. Batteries are used to provide one or more hours of backup power for most mobile telco base station radios, and in areas with reliable power grids, this battery back-up is normally eight hours or less. For extended-run capability, diesel gensets are commonly used, however they generally have disadvantages of low efficiency, noise, pollution, high weight and vibration, high maintenance requirements and poor reliability – issues which hydrogen fuel cells can address.

This is a big potential market in terms of production volume at ~10kW scale. More than 3,000 fuel cell backup systems totalling 16.3MW were installed in the US through 2013. Hydrogen is typically trucked in to fuel the PEMFC but with the increasing amount of solar and wind power an off grid solution becomes more feasible.

Ballard had deployed 2,500 telecom back up power systems by 2014 totalling 9MW of power – with the majority installed in Asia and Australia.

P2G

On land conversions: Viability for off grid Power to gas applications depends on where the gas transmission pipes are, but potentially there is a huge market for remote/rural areas with lots of solar and wind potential (parts of Germany, Italy, Spain and Scotland). Remote regions of very high renewables where more renewables could be exploited but the electricity grid is saturated and curtailment is prevalent (Orkney, West Coast and South West Scotland, Norway, parts of Italy). Also where a region commits to decarbonising it's gas grid by producing very large quantities of hydrogen and synthetic methane (such as the ONTRAS study for Eastern Germany), it is likely that a substantial part of this production will be achieved off-grid because of the need otherwise to massively expand the electricity grid at high expense in order to produce sufficient hydrogen.

Off shore conversions: On the North Sea, two clear trends evolve in the energy landscape: on the one hand the process of gradually decommissioning about 600 oil and gas installations, and on the other hand the massive investment from all North Sea countries in offshore wind activity. One potentially promising area is using oil and gas platforms to house off grid electrolysers to convert off grid wind into hydrogen removing the requirement to install new electricity grid systems. The Energy Delta Institute report[1] concluded that a typical large platform would house up to about 250 MW electrolyser capacity, based on the modern generation of electrolysers currently under development. A much smaller satellite platform could host up to about 60 MW of electrolyser capacity. The report showed that offshore conversion can be economically promising, but typically if the combination of a platform-for-conversion with a wind farm can fully replace the e-grid connection to shore, and/or if the 'green' hydrogen will receive a distinctly higher price than the current bulk-level market price for 'grey' hydrogen. Four utility companies TenneT Netherlands, Tennet Germany, Energinet and Gasunie are now involved in studies which investigate this as part of a Sea Wind Power Hub, where it is proposed that surplus electricity is converted to hydrogen for large scale transport to shore.

Energy system for isolated areas (e.g. mountains)

The main driver in these applications is the availability of renewable energy sources, and the availability period (capacity factor). In mountain huts for example, the main aspects to consider are: scarcity of sunlight due to high surrounding mountains, non-steady wind regime (gusts of wind are usual), and availability of hydro turbines. Also the opening periods affect enormously the potential solutions to implement, as some installations are closed during 2/3 of the year. The solution has to be assessed case by case.

Replacement of diesel engines in off-grid installations to support existing/new installed RES isolated installations

Some elements are being identified that may give economic advantage to hydrogen, like locations with higher sunlight hours or type of load demand during day/night. Strong policies penalising air pollution from diesel combustion will also advantage off grid hydrogen applications.

Backup system for failure events in weak grids

The electrolyser would operate on-grid during off-peak periods to produce hydrogen for backing up the grid during peak periods, and to support grid failures. In addition it would have the ability to operate off-grid during peak periods and at other times by being connected to an adjacent renewable power source. The hydrogen produced would be stored as an emergency energy supply and reconverted to power when needed via a FC system. This application is prevalent in several developing countries and regions outside of Europe and North America, which have overstressed grids, weak grids or are still in the process of affording widespread electrification.

Off-grid HRS to supply to FCEVs.

There are many locations along remote highways where there is no grid connection, but where renewables and hydrogen refuelling stations could be located. This would harness renewables in areas otherwise unlikely to integrate wind turbines and/or solar farms due to the lack of a grid connection locally. However, the electricity input is only available ~ 15% of the year for solar and ~ 25% for wind, so a relatively large electrolyser and storage capacity would be required on site to meet a given daily demand for hydrogen from FCEVs. The electrolyser, compression and storage of hydrogen is a high cost component of a HRS, so this market is unlikely to be a significant market for exploitation.

International, including developing countries (low/weakly electrified scenario). (1) Weak grids; and (2) Replacement of diesel engines.

The goal is to take advantage of the great market potential for off-grid installations in developing countries and remote regions to export the EU electrolysis developments, adding value to the member states. Regions for consideration also include remote areas in Australia, Canada and South America as well as developing countries (in Africa and the India subcontinent).

The consideration needed is for sizing into appropriate modules for developing countries. Usually diesel engines of a few hundred kW capacity are deployed, which implies a requirement for multi-MW off grid electrolysers and large hydrogen stores. It will be important to deploy high efficiency fuel cells to reduce the daily hydrogen demand. Overall such a system will be very capitally expensive compared with a diesel engine, so this market may be difficult to develop. Operating a standard electrolyser on-grid during off-peak periods may be more economically viable.

Fertiliser production

Ammonium Nitrate based fertilizers account for 53.7 % of all fertiliser usage in England and Wales (2015). This percentage varies from country to country across Europe with the European average being 59% and this nitrogenous fertilizer market was estimated to grow at ~2.4% between 2014 and 2019. Leading consumers of Ammonium Nitrate include BASF, CF Industries, Israel Chemicals, Laflin & Rand Power Company and Oriental Powder Company.

The 2013-2014 cost of Ammonium Nitrate fertiliser (delivered) varied between £0.816 - £0.873 per kg. In 2015 the European market for nitrogen fertilisers was thought to exceed €10billion. The European consumption of nitrogen fertiliser is thought to constitute approx. 10% of the global market.

The UN has targeted the sustainable intensification of agriculture in developing countries and opportunities to demonstrate the system in use in such areas with the support of the UN and other aid agencies could be one route to exploit the larger off grid systems.