ELY4OFF

PEM ELECTROLYSERS FOR OPERATION WITH OFFGRID RENEWABLE INSTALLATIONS

Midterm project report (technical and financial)

Deliverable1.3

GRANT AGREEMENT
700359

D1.3 Midterm Project Report

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.	1.3
Title of deliverable	Midterm Project Report (technical and financial)
Contractual date of delivery	M18 (Sept 17)
Actual date of delivery	M23 (Feb 18)
Author(s)	Pedro Casero (FHA)
Participant(s)	All
Work Package contributing to the deliverable (WPx)	WP1
Dissemination level (PU/CO/CI)	PU
Type (R/DEM/DEC/OTHER)	R
Version	1
Total number of pages	10

TABLE OF CONTENTS

1. Summary of the context and overall objectives of the project....4
2. Work performed from the beginning of the project to the end of the period covered by the report and main results achieved so far....5
3. Progress beyond the state of the art expected results until the end of the project and potential impacts....6

Anex A. Illustration with the main elements of the ELY4OFF system....8

Anex B. 64.2 kWp PV field recently built to feed the PEMWE....9

Annex C. Picture of the container housing all the components of the PEMWE....10

1. Summary of the context and overall objectives of the project

Population density and urbanization rates are key parameters on planning electricity grid extension. If certain thresholds are not reached, it is not cost effective to provide access to the electricity grid for a large part of the population. On the other hand, the addition of renewable power soon becomes limited in locations where there is no grid, a weak grid or a grid which is already saturated with renewables due to the unpredictable or unsteady character of RES (Renewable Energy Sources) generation causing grid stability issues. This is a major obstacle to achieve further decarbonisation locally or at distributed levels.

Nowadays, mainly diesel generators are used as an off-grid solution for backup power, but this causes CO2 and GHG emissions (especially NOx and particulates), noise emissions and the effects of the volatile diesel market influences operating costs. Renewable energy, such as solar or wind, is becoming increasingly competitive with traditional solutions for off grid applications. Unlike grid-connected systems, their economic justification is not influenced by prevailing electricity tariffs or fuel supply costs, but supply intermittency and availability have to be matched with suitable storage systems to provide a good alternative to the classic diesel generators.

Green hydrogen production by means of water electrolysis has been proposed as a feasible solution to fill the gaps between demand and production. Off-grid electrolysis and hydrogen storage have the key advantage of being able to manage both the long term and short term transient variations in renewable supply, whereas batteries cannot manage the seasonal variations unless very large battery stores are specified.

The main underlining purpose of the ELY4OFF project is the development and demonstration of an autonomous off-grid electrolysis system linked to renewable energy sources. The PEMWE (Polymer Electrolyte Membrane Water Electrolyser) industrial prototype will be sized to respond to 50 kW, and will be directly linked to track the solar photovoltaic power source producing over 1.5 tonnes of hydrogen per year for different end uses ensuring cold start and rapid response to changes. The specific objectives related to the electrolyser will be high system efficiency and low cost, very high efficiency cell, robustness and safety (20 bar), flexibility for direct coupling to RES, durability, and communication and control capabilities. The demonstration period in a relevant environment (TRL 6) will last 8 months and will take place in Huesca, Spain.

Other additional objectives of the project are optimized design, CAPEX competitiveness, the study of relevant regulations, codes and standards, detailed cost analysis, new business models, assessment of potential target markets, analysis of specific business models, and dissemination and exploitation of project results.

2. Work performed from the beginning of the project to the end of the period covered by the report and main results achieved so far

The outcomes achieved during the first mid-term period can be summarized as follows:

- Compilation of Regulations, Codes and Standards aligned with the system demonstration
- Fine-tuning of the techno-economic objectives for the project, which provides targets for the system and each subsystem to achieve during the project
- Establishment of the main specifications for each component, as well as a clear identification of the interfaces between each partner' scope. Special attention was given to the demo-site weather conditions and other aspects that could affect the design of the system.
- The reference for the LCA has been defined (at functional level), and the boundaries of the system to assess have been selected.
- A computer model of the ELY4OFF system was developed to simulate the behaviour of the system and contribute to the design, sizing and strategy definition.
- The first assessment of thin membranes was carried out, showing low hydrogen diffusion properties, and good efficiency levels.
- A detailed reengineering design of the electrolyser plant is underway to maximise the available power for electrolysis, by improving the efficiency of the balance of plant. By now, a large-scale reduction of kilowatt hours required for frost protection has been achieved.
- Steady-state testing of the membrane and stack components at large-scale has been completed.
- An in depth assessment of the best options available for the DC/DC conversion linking the PV plant with the stack has been conducted. One prototype module has been built for testing.
- There is a preliminary topology for the architecture of the micro-grid. Most of the overarching control signals are clear and the communication protocols with the micro-grid equipment have been defined.
- Several energy storage architectures have been assessed. The following elements will be part of this system: 36 kWh lead acid batteries to supply safety loads up to 20 hours, 4.5 kW stationary low temperature PEM fuel cell to cover safety loads when the lead acid batteries are discharged, and a H2 capacity of 7 kg at low pressure tank (20 bar), and 23 kg at high pressure tank (350 bar).
- Difficulties and barriers related to RCS that may exist for off-grid hydrogen production and applications were identified through literature study and discussion with hydrogen stakeholders.

- A cost survey assessment of the most-promising and mature energy storage technologies was done, to be used as a decision-making input to detect when water electrolysers can be more competitive than other technologies.
- One specific business case related to "electrification of isolated areas" has been evaluated through time-step simulations.
- A detailed dissemination, communication and awareness plan was elaborated at the beginning of the project. In it, the basic and communication objectives are presented, the stakeholders and target audiences are identified, 10 main messages to disseminate are listed and linked to the intended target audience, and finally, the criteria and tools for assessment of results are also outlined.
- The website of the project (www.ely4off.eu) is launched in September 2016 with a practical and easy to navigate structure.

3. Progress beyond the state of the art expected results until the end of the project and potential impacts

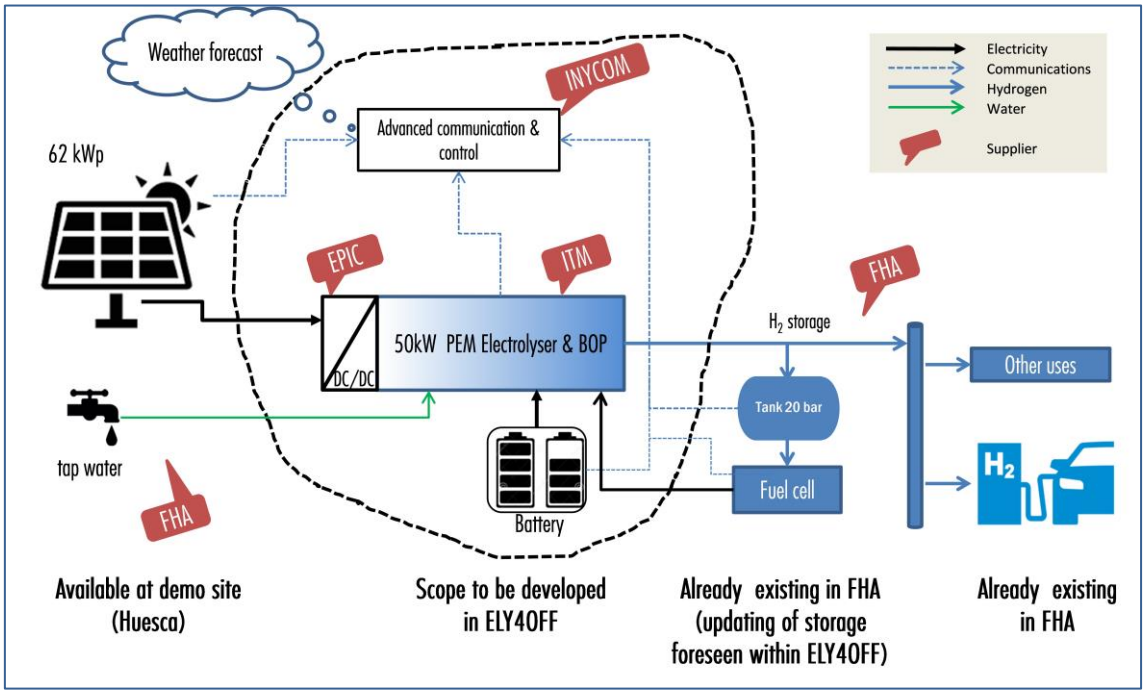
ELY4OFF's ambition is to provide breakthroughs in Polymer Electrolyte Membrane water electrolyser (PEMWE) technology coupled to an off-grid energy source. The project expects to achieve a series of significant techno-economical advances pushing PEMWE technology well beyond its today's capabilities looking for off-grid deployment into existing and new immerging markets. The most significant improvements expected from ELY4OFF are related off-grid operation, which is directly associated with the following topics: increase of stack and system efficiency, Capex in novel system aligned with programme objectives, dynamic capabilities, reduction of tolerable minimum part load, acceleration of ramp-up from minimum to full load, acceleration of ramp-down from full load to min, acceleration of cold start from min to max power, and direct connection with the PV source. These topics have been considered within the specifications set up for all the elements of the system, and they will be checked during the demonstration period scheduled for the last 8 months of the project.

The potential impacts of the project can be classified into the following groups:

- Objectives and targets are expected to achieve and in some cases, surpass the targets for 2017 in terms of efficiency and costs for PEMWE. As regards to efficiency, lifetime and dynamic operation, the targets of the project are totally aligned with the expected contribution of these systems to reach the targets in horizon 2017 and 2020. ELY4OFF targets are expected to be more exigent than the key performance indicators expressed in the topic in order to pave the way for future developments aimed to reach the targets in the horizon 2020.
- 6 target markets will be covered through the assessment of specific business cases applied to real installations. One of them has already been done, covering the electrification of isolated sites.

- The system proposed within ELY4OFF has a direct impact on reduction of CO_2 emissions in Hydrogen production

Annex A. Illustration with the main elements of the ELY4OFF system



Annex B. 64.2 kWp PV field recently built to feed the PEMWE

Annex C. Picture of the container housing all the components of the PEMWE