GRASSHOPPER

Grid Assisting Modular Hydrogen PEM Power Plant

D8.5: Mid-term Summary of Project results

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Executive Summary

The deliverable D8.5, prepared by Abengoa, is a public document of the GRASSHOPPER project, produced in the context of WP8, Task 8.1 Dissemination activities. The scope of this deliverable is to collect the main publishable results generated by each partner in the first period of the project, protecting the confidential information and the intellectual property of commercial value for the consortium. Likewise, besides the summary of the work performed from the beginning to the end of the period, the deliverable includes a revision of the expected results at the end of the project, as well as the potential impacts.

As per agreement with the Project Officer, this deliverable is replaced with the summary for publication uploaded in the System for Grant Management (SyGMa) portal, specifically in the Project Periodic Report section for period Nº 1. The public information submitted in SyGMa is also published in the website of the Community Research and Development Information Service (CORDIS) from the European Commission:

https://cordis.europa.eu/project/rcn/213052/factsheet/en

The final GRASSHOPPER results will be also published in the project's public website:

www.grasshopperproject.eu

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List of Acronyms and Abbreviations

Abbreviation	Definition
FCPP	Fuel Cell Power Plant
TRL	Technology readiness level
MRL	Manufacture readiness level
CAPEX	Capital expenditure
DEMCOPEM	Demonstration, Combined heat and power (or Cogeneration), PEM fuel cells
MW	Megawatt
MEA	Membrane Electrode Assembly
GH	GRASSHOPPER
CCM	Catalyst coated membrane
JMFC	Johnson Matthey Fuel Cells Limited
BoP	Balance of plant
ZBT	Zentrum für Brennstoffzellen Technik Gmbh
FCPP2G	Fuel Cell Power Plant to Grid
WP	Work Package

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

The FCPP technology has progressed significantly in the TRL and MRL levels, but with insufficient reduction of CAPEX. Taking DEMCOPEM-2MW in 2017 as the starting point, a reduction from 3,000 €/kWe to 1,500 €/kWe is required to meet the 2023 FCH-JU cost targets for MW sizes. GRASSHOPPER project aims to achieve this cost reduction while including the dynamic operating capability to participate in renewable energy markets. The final objective is to create a cost-effective, flexible, MW-size FCPP unit based on the learnings from a 100 kW pilot plant design, implementing newly developed stacks and MEAs.

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

- WP2: a voltage of 0.68 V at 1 A cm^2 can only be achieved if the flow fields cause minor losses and ensure an almost ideal supply of the MEA. Towards this target, the basic geometry of the channels and landings were developed based on the results from a small test cell (25 cm^2 active area). Initial forecasts for the operating point of the later Grasshopper stack have been derived based on this. The multiphysical numerical investigations of the flow field using the commercially available Software AVL Fire were prepared, which form the basis for the numerical investigations on the large 300 cm^2 flow field of GH stack. The completely constructed 300 cm^2 bipolar plates of the new stacks are being investigated using AVL Fire.
- WP3: a catalyst coated membrane (CCM) with a great reduction in Pt content, and an intermediate-thickness membrane electrolyte, has been developed. The slightly thinner membrane compared to previous stationary power MEAs has lower ionic resistance and is equipped with features to resist chemical and mechanical degradation, confirmed in accelerated stress tests. The MEAs also had acceptable power density. The resistance of the new membrane electrolyte to common failure modes has been also assessed, as well as the cathode resistance to degradation through potential cycling. A mixed stack, with a standard CCM and an existing JMFC stationary power MEA design alongside the GH

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MEA design, has been tested. The new MEA was designed to be manufacturable in high volume on JMFC production equipment and has a platform designed to increase material yields by reducing waste material. Manufacturing trials to scale up the process of MEA production were carried out, and JMFC is now able to manufacture the required quantity of MEAs via a high-volume process.

- WP4: the target is to develop a new stack platform with increased nominal stack power with the MRL of 6 and capability of operating in pressurized conditions to improve the power density. The new concept stack design is finalized and being verified. It incorporates a larger active area, new flow fields with a novel sealing technology from ZBT and lower cost MEAs from JMFC. The stack operating conditions for different load points have been defined based on ZBT tests. The durability test of the Grasshopper MEAs has been started at the current Nedstack power plant in Delfzijl with performance results available already for about 2,000 hours. A single-cell short stack has been constructed and tested. The cell plates were milled at ZBT followed with stack assembly at Nedstack. Further tests are planned in the coming months to verify and finalise the GH stack design. Moreover, the cell plate handling at Nedstack has been partly automated, thereby improving the reproducibility and the MRL.
- WP5: steady-state simulations of the 100 kW pilot plant, under various scenarios of configuration and component integration, have been performed to assess the design activities and the plant layout. In all these cases, detailed mass and energy balances were calculated with Aspen Plus®, using a model of the plant built as a network of connected components. MW-scale plant simulations are being carried out to explore possibilities of efficiency improvement in plant scale-up. The setup of a plant dynamic model has been initiated.
- WP6: the detailed design of the balance of plant (BoP) of a pilot-scale FCPP of 100 kW has been completed. The BoP components were selected and received in the workshop facilities for the construction. Most of the components are commercial off-the-shelf products to reduce the costs. The selected technologies are suitable for MW sizes. The BoP 3D model is finished, and the construction drawings approved. The headers for the fuel cell module have been designed in a new material to reduce manufacturing costs. The pilot plant final site location in Nouryon to a

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new site with fewer utilities led to a stand-alone unit that only requires hydrogen and nitrogen supply. The construction activities have started in parallel to the design activities to speed up the planning. A base unit of 2 MW size has been chosen for the MW design and cost assessment.

- WP7: the target is to develop and integrate an interface, named Fuel Cell Power Plant to Grid (FCPP2G), that allows the participation of the FCPP in the flexibility trading platform (KIBERnet) possible. The requirements and specifications for the development of the interface have been defined. The communication protocol between FCPP2G and FCPP was defined with a detailed exchange table. HW for FCPP2G and KIBERnet was defined, purchased and sent to partner Abengoa to be installed into FCPP container.
- WP8: The webpage (www.grasshopperproject.eu) is active since M6. An informative leaflet has been produced and distributed. The obtained results in the first period have been presented in different congresses/events from the hydrogen sector (2 conferences), the scientific community (3 conferences) and grid market (2 attendances).

3. Progress beyond the state of the art and expected potential impact (including the socio-economic impact and the wider societal implications of the project so far)

The FCPP technology has progressed significantly in the TRL and MRL levels, but with insufficient reduction of CAPEX. To take this step, important innovations are essential: new durable lost cost MEA (>65% in €/kW) using automative industry CCM construction, new larger size low-cost fuel cell stacks (25 kWe and 450 €/KW @ 25 MW/yr), and system BoP material and labour cost reduction by standardisation and automated manufacturing.

The main expected result is the construction and validation of a 100 kW pilot plant in a real industrial environment using by-product hydrogen from chlorine production at the Nouryon site in Delfzijl, the Netherlands. The consortium intends to keep operating the pilot plant on site for five years after the project end to showcase the technology for interested parties.

The overall path to exploitation envisages a next step of the project where the FCPP MW scale design is constructed, installed and validated in an operational environment (TRL 7,8). In this way, further cost optimization can take place, and the suppliers and manufacturing chain can be further developed to MRL7.

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