GRASSHOPPER

Grid Assisting Modular Hydrogen PEM Power Plant

D8.9: Project workshop

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Fuel Cells and Hydrogen Joint Undertaking (FCH JU),
now Clean Hydrogen Partnership
Project 779430

European Commission

Clean Hydrogen Partnership

March 2022

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Executive Summary

Under Horizon 2020 funding, dissemination activities should be promoted and should be envisaged to reach the scientific community, industry, civil society, policy makers, investors, customers. Dissemination activities, in this case, of GRASSHOPPER project are focused in spreading the project philosophy, objectives, challenges, progress and results outside the consortium of this project.

This public deliverable, D8.9, called "Project workshop" is the one foreseen for reporting the GRASSHOPPER workshop including its objectives, attendance list, summary of the findings and feedback obtained. As it was decided in the Second Amendment, and due to the restriction caused by the COVID-19 pandemic, it wasn't possible to organize the expected workshop, which will be replaced with an online event. Instead of this workshop, an online webinar was celebrated on 29th March 2022, virtual conference to show the main results and learnings from the Grasshopper project, including a virtual visit to the pilot plant in Seville and showing the results obtained.

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Document History

Version	Date	Status	Author	Comment
1.0	31/03/2022	Draft	ABENGOA	
1.1	18/05/2022	Review and Sub-mission	INEA	
1.2	28/11/2022	Review and Sub-mission	ABENGOA	
1.3	05/12/2022	Review and Sub-mission	ABENGOA	

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List of Acronyms and Abbreviations

Abbreviation	Definition
DP	Dissemination Plan
DSM	Demand Side Management
DSO	Distribution System Operators
FCPP	Fuel Cell Power Plant
INEA	Informatizacija Energetika Avtomatizacija
IPR	Intellectual property
JMFC	Johnson Matthey Fuel Cells Limited
MEA	Membrane Electrode Assembly
NFCT	Nedstack Fuel Cell Technology B.V.
P2P	Power to power
Polimi	Politecnico di Milano
RTD	Research and Technological Development
TSO	Transmission System Operator
ZBT	Zentrum für Brennstoffzellen Technik Gmbh

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1. Introduction

The objective of GRASSHOPPER project 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 MEA's. This pilot plant is large enough to implement cost savings as well as to validate operation flexibility and grid stabilization capability via fast response. This unit will be validated under a real industrial environment using by-product hydrogen from chlorine production and will be operated continuously for several months for engaging grid support modulation as part of an established on-site Demand Side Management (DSM) programme.

This deliverable (D8.9) is the report which includes the main information about the online webinar organized on 29th March 2022 by Abengoa with the participation of GRASSHOPPER consortia. Due to the Covid limitations, the preliminary workshop was replaced by this online event. Through the GRASSHOPPER webinar, the main results and learnings from the project were shown. The webinar finalized with a virtual visit to the GRASSHOPPER 100 kW pilot plant and a set of questions from the audience.

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2. GRASSHOPPER webinar

2.1 Invitations to the webinar and registration

The diffusion of GRASSHOPPER webinar took place via different channels:

- Website: the information and registration form concerning the webinar was published in:
    - GRASSHOPPER website
        - https://www.grasshopperproject.eu/project-webinar-it-is-time-to-meet-the-team/
    - The partner ZBT also shared it in its corporate website https://zbt.de/nc/aktuell/news-anzeige/detail/News/grasshop-per-project-webinar/

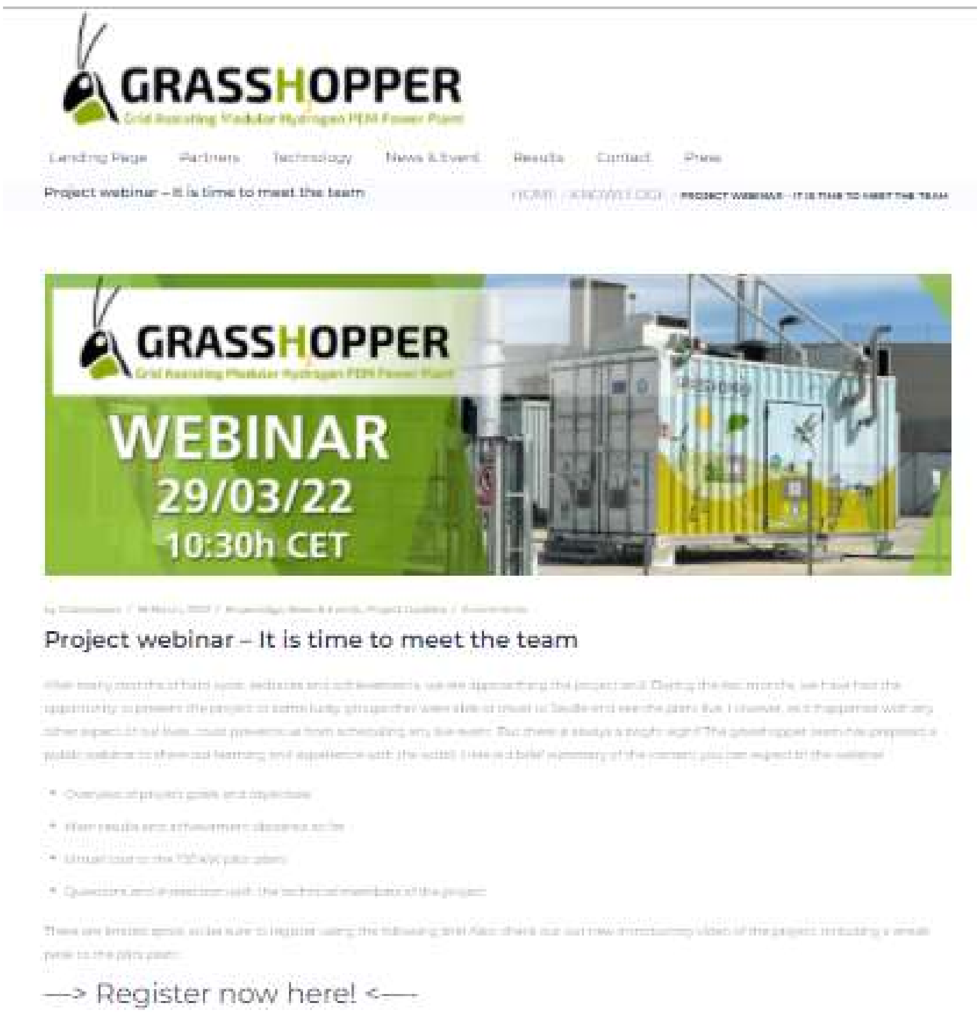

Figure 1. Webinar announcement in the GRASSHOPPER website

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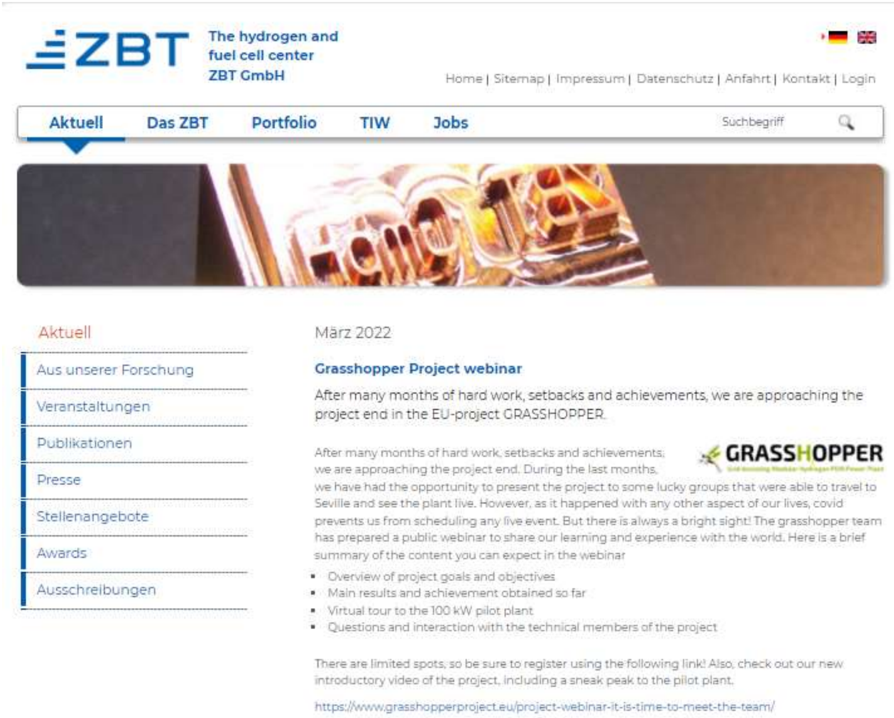

Figure 2. Webinar announcement in the ZBT website

- LinkedIn: the webinar was published in:
  - GRASSHOPPER LinkedIn Group

    https://www.linkedin.com/feed/update/urn:li:activity:6910226725784199168/?utm_source=linkedin_share&utm_medium=member_desktop_web
  - Abengoa corporate´s LinkedIn

    https://www.linkedin.com/posts/abengoa_grasshopper-webinarregistration-activity-6914130267695644672-i7NZ/?utm_source=linkedin_share&utm_medium=member_desktop_web
  - Abengoa´s project manager LinkedIn profile

    https://www.linkedin.com/posts/mariatejadamtv_webinar-grasshopperproject-hydrogen-activity-6910226506975731712-vrmP/?utm_source=linkedin_share&utm_medium=member_desktop_web)
  - Corporate ZBT LinkedIn
    https://www.linkedin.com/posts/zbt_grasshopper-project-

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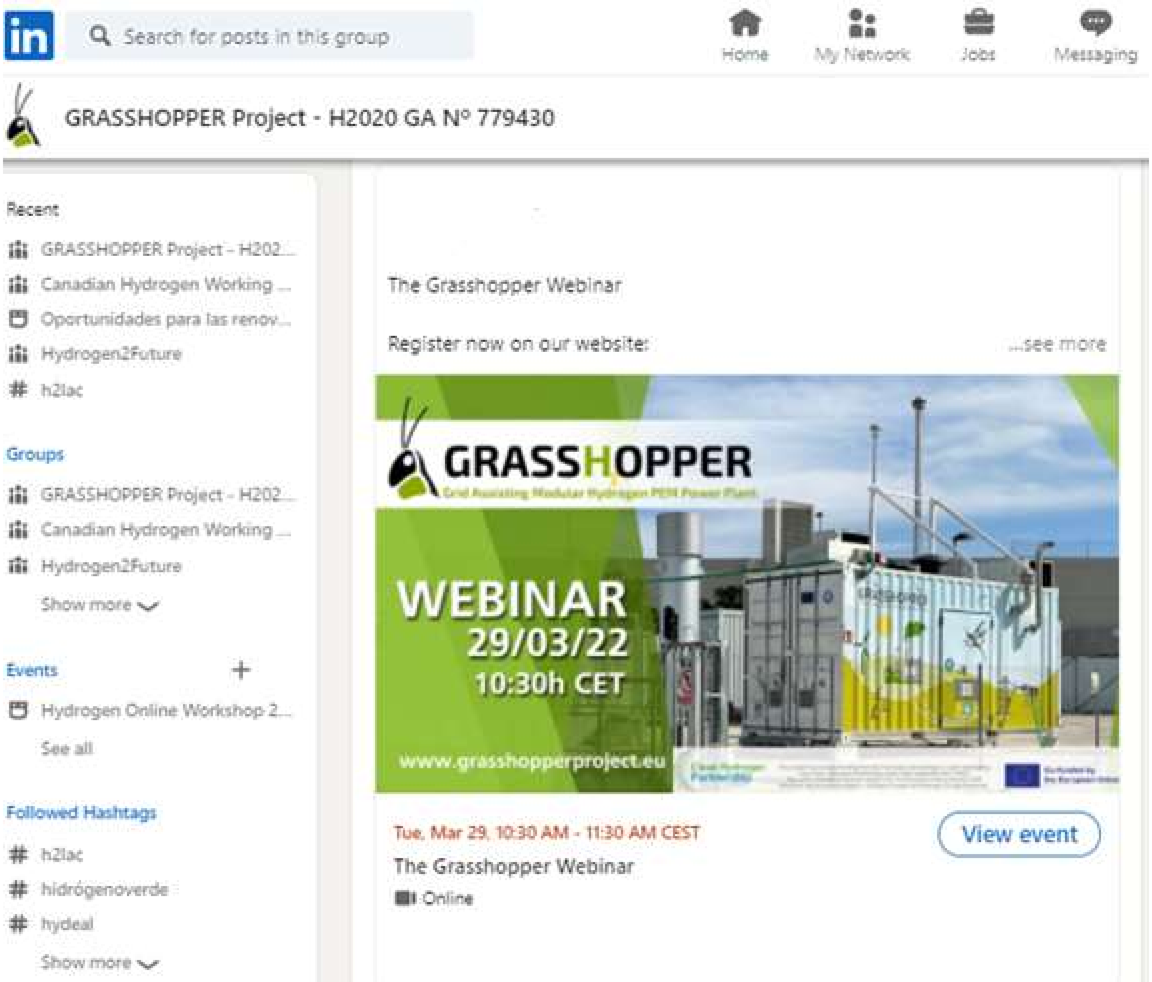

Figure 3. Webinar announcement in the GRASSHOPPER LinkedIn Group

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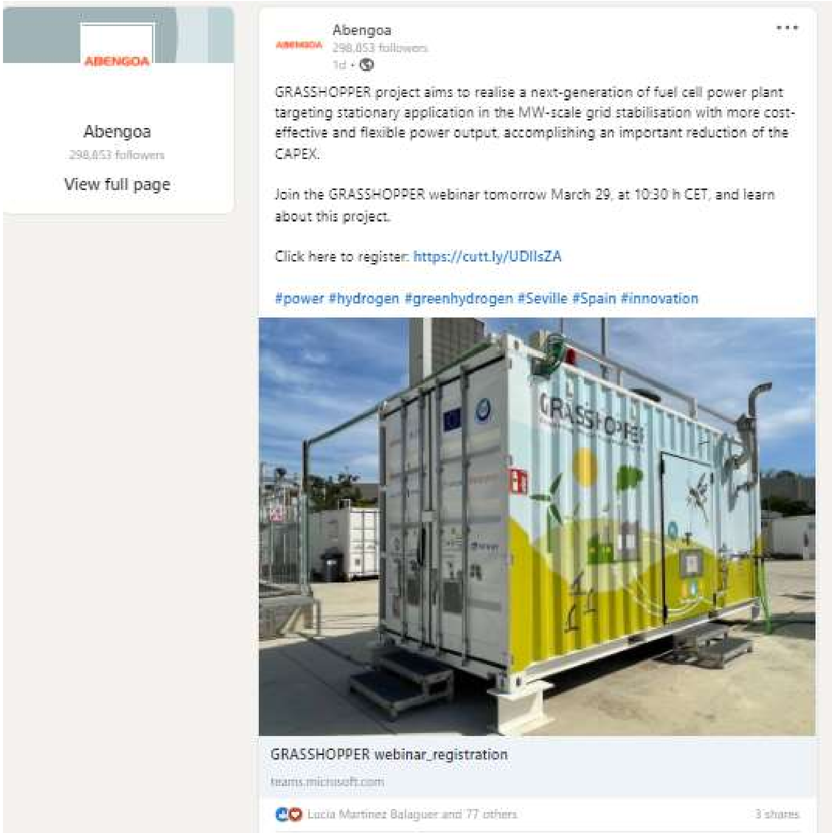

Figure 4. Webinar announcement in the Abengoa´s LinkedIn

Figure 5. Webinar announcement in the Abengoa´s project manager LinkedIn profile

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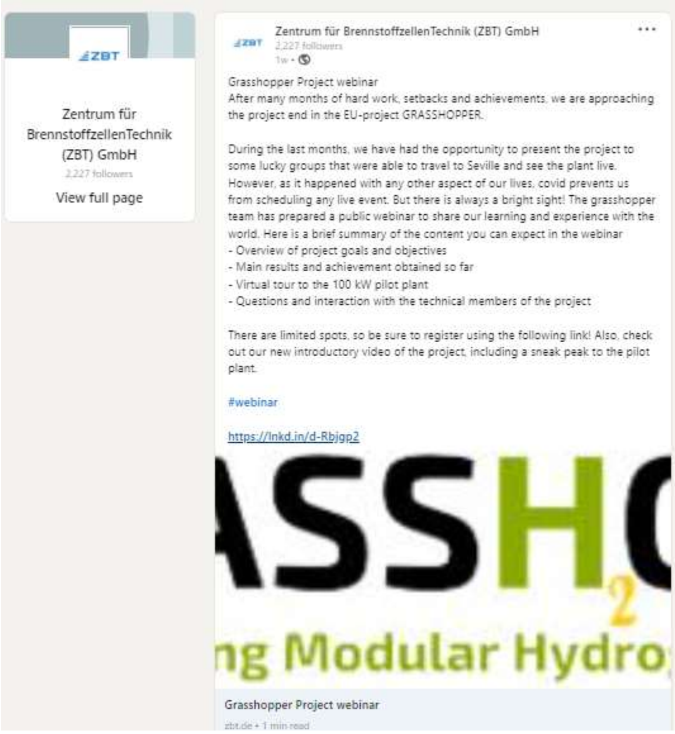

Figure 6. Webinar announcement in the ZBT LinkedIn

- Emails: a list of distribution was prepared for announcing the webinar. Two formal notes were prepared and sent to inform the audience about the upcoming webinar. The potential attendees were selected from energy key players companies, universities, authorities, suppliers and hydrogen associations. Additionally, the partners of the Consortium sent the webinar information to their adequate contacts.

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GRASSHOPPER
Grid Assisting Modular Hydrogen PEM Power Plant
WEBINAR
29/03/2022
10:30h CET

The Grasshopper Webinar

GRASSHOPPER Project tries to contribute solved societal challenges relating to the sustainability, affordability and security of supply hydrogen production technologies.

GRASSHOPPER project aims to realise a next-generation of fuel cell power plant targeting stationary application in the MW-scale grid stabilisation with more cost-effective and flexible power output, accomplishing an important reduction of the CAPEX.
This kind of power plant has a novelty compared to conventional fuel cell plants, which allows a dynamic and flexible operation that could run from 20 to 100% power for a demand-driven operation. This, together with its rapid response capacity, allows it to participate in electricity reserve markets, where the €/MW is higher.

The MW-size unit is based on learnings from a 100 kW pilot plant, which is now running in Seville in a start-up stage. When the FAT test period finishes, the plant will be transported to The Nedherlands, where it will use the Hydrogen produced as a byproduct of the Chlor-alkali industry.

Would you like to know how it became a reality to have this next-generation fuel cell power plant targeting stationary applications in grid stabilisation?

Join us at this webinar and learn about this exciting and ambitious project. The registration is free, but the space is limited, so book your now here:

Register now here!

Project webinar - It is time to meet the team - Grasshopper Project

If you can't join us, sign up to receive the recording and presentations a few days later.

Thank you, and for any questions or comments, don't hesitate to get in touch with us by replying to this email.

info@grasshopperproject.eu

Share this event on your social networks!

www.grasshopperproject.eu

Clean Hydrogen Partnership

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Figure 7. Note 1 for Webinar diffusion

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Figure 8. Note 2 for Webinar diffusion

2.2 Webinar objective, agenda and content

As it is indicated in the introduction of this deliverable, the GRASSHOPPER workshop was replaced by an online webinar due to pandemic concerns.

The objective of the webinar was to disseminate a general vision of the aims of the Grasshopper project and how the consortium has worked to achieve them.

The webinar took place on 29th March 2022 and the key issues of GRASSHOPPER project were reviewed. This online event lasted approximately 1 hour via online Microsoft Teams. During the event, it was used a beginning presentation and a video for virtual visit was shown. The webinar was finished with a section of questions and answers. This webinar was completely recorded for distribution and dissemination purposes.

The agenda of the event was the following one indicated below. Each partner of the Consortium participated as speaker for introducing their representative activities carried out during the project and their main results.

1. Introduction. Project manager, Abengoa
2. Flow Field development. Leader of simulation and control group, ZBT

3. MEA development. Lead Scientist, Johnson Matthey Fuel Cell.
4. Stack development. Manager customer development & projects, Nedstack.
5. System modeling. PhD student, Politecnico di Milano.
6. Platform to grid Integration. Projects Group Manager, INEA.
7. 100 kW pilot plant. Project manager, Abengoa.
8. Pilot Plant Results. Process engineer and FCPP test specialist, Abengoa.
9. Next steps. Process engineer and FCPP test specialist, Abengoa.
10. Applications. Process engineer and FCPP test specialist, Abengoa.
11. Pilot Plant Virtual Visit.
12. Q&A.

2.3 Webinar material

The main material produced for organizing the webinar are, as it is indicated before, a beginning presentation (please find in Annex C, GH-PRE-F34-740-700-0001 Webinar presentation) and a video for virtual visit.

The recorded session of the webinar and its dedicated presentation were sent to registrants some days after the webinar and published in GRASSHOPPER website and YouTube (youtube.com/GrasshopperProject).

2.4 Webinar registrants

A list of GRASSHOPPER webinar registrants is included as Annex D.

A total of 95 people was registered to the GRASSHOPPER webinar. As it is shown in the figure below, around the 22% of the registrants were women while most of the registrants were men.

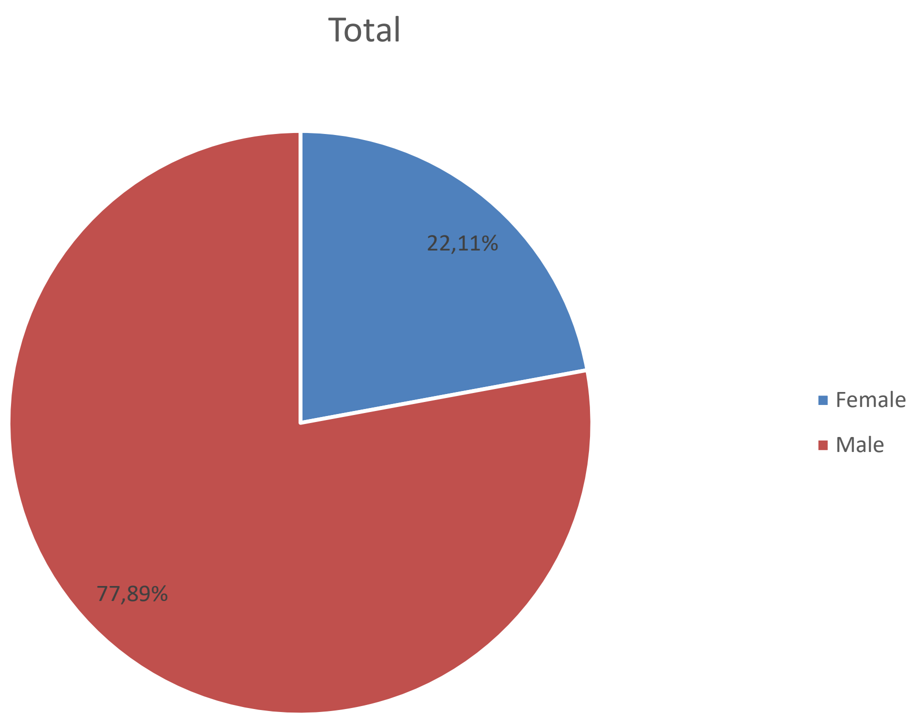

Figure 9. Gender analysis of the registrants

As it is shown in the geographical analysis of registrants (followings Table and Figure), 58% of the registrants are from Spain and the others come from different countries mostly in Europe (France, Belgique, Czech Republic, Germany, Italy, Netherlands, Poland, Portugal, Slovenia, United Kingdom) while some registrants are located in Korea, Japan, India, Brazil, Peru, Turkey and Russia.

Table 1 – Geographical analysis of the registrants

Country	Nº Registrants per country
Spain	55
Italy	5
United Kingdom	5
Germany	4

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Country	Nº Registrants per country
India	4
Slovenia	3
Poland	3
Turkey	2
France	2
Portugal	2
Netherlands	2
Belgium	2
Russia	1
Brazil	1
Japan	1
Czech Republic	1
Peru	1
Korea	1
Total	95

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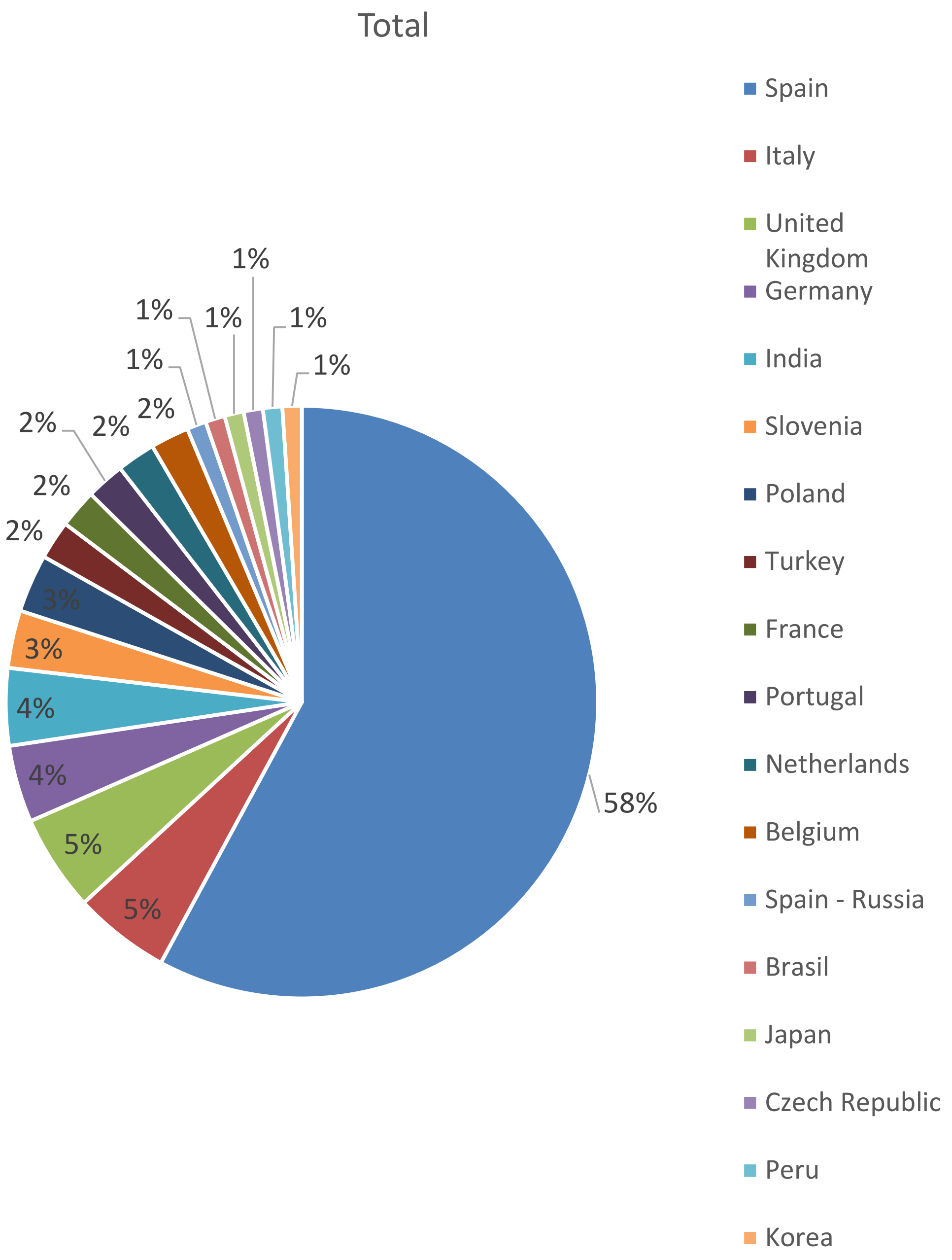

Figure 10. Geographical analysis of the registrants

2.5 Webinar participants

The list of GRASSHOPPER webinar attendees can be also found in Annex D.

64% of the registrants participated in the webinar, a total of 61 people attended the GRASSHOPPER webinar where 25% are female and 75% are male. 56% of attendees come

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from Spain while about half of attendees are from outside Spain: Italy, UK, Poland, Slovenia, France, India, Germany, Netherlands, Portugal, Czech Republic, Turkey, Belgium and Japan. In the following figures and tables, the gender and geographical information about the attendees is shown.

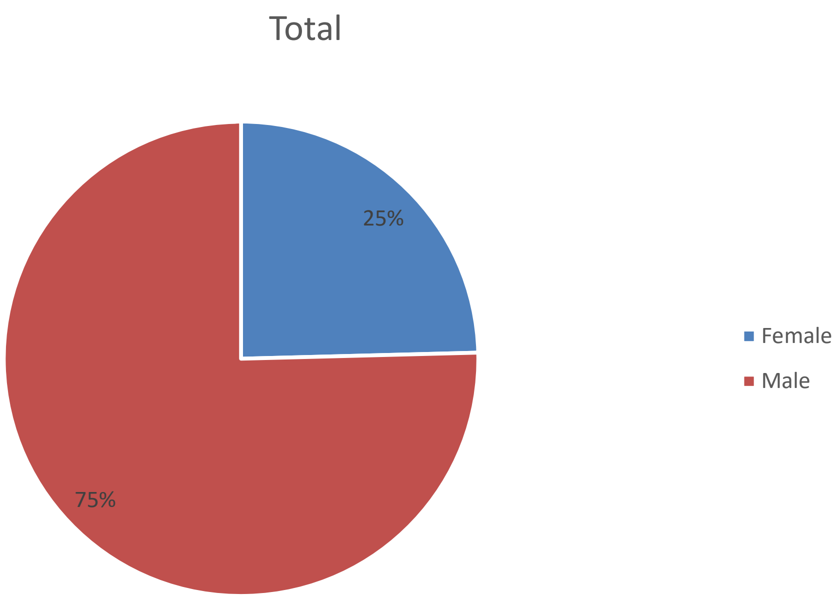

Figure 11. Gender analysis of the attendees

Table 2 – Geographical analysis of the attendees

Country	Nº Registrants per country
Spain	34
Italy	4
United Kingdom	4
Poland	3
Slovenia	3
France	2
India	2

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Country	Nº Registrants per country
Germany	2
Netherlands	2
Portugal	1
Czech Republic	1
Turkey	1
Belgium	1
Japan	1
Total	61

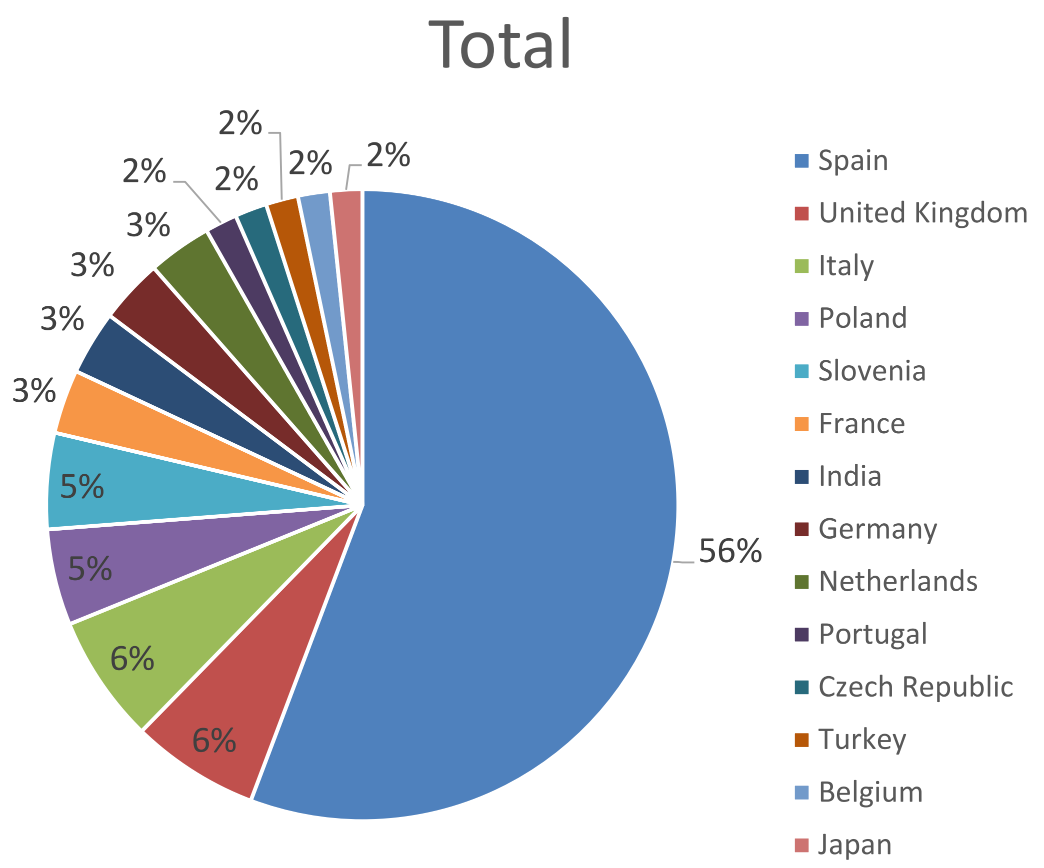

Figure 12. Geographical analysis of the attendees

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3. Conclusions

Despite having to cancel the initial GRASSHOPPER workshop, an online webinar was organized on 29th March 2022 by Abengoa with the participation of all the GRASSHOPPER partners. The main results and knowledge from the project were shown through a presentation and a virtual visit to the GRASSHOPPER 100 kW pilot plant.

The GRASSHOPPER webinar had a successful impact considering the number of registrants and participants and the geographical distribution of them. This webinar was recorded, and this video was published in the GRASSHOPPER website to guarantee the continuous dissemination of the project. The contact of each GRASSHOPPER partner was also included in the presentation in order to guarantee the potential future contacts.

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4. Annexes

4.1 Annex A: Consortium

Table 3 – Consortium.

Participant organization name	Short name	Country
INEA INFORMATIZACIJA ENERGETIKA AVTOMATIZACIJA DOO	INEA	Slovenia
NEDSTACK FUEL CELL TECHNOLOGY BV	NedStack	Netherlands
JOHNSON MATTHEY FUEL CELLS LIMITED	JMFC	United Kingdom
ABENGOA INNOVACIÓN SOCIEDAD ANÓNIMA	Abengoa, AI	Spain
ZENTRUM FUR BRENNSTOFFZELLEN-TECHNIK GMBH	ZBT	Germany
POLITECNICO DI MILANO	Polimi	Italy

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4.2 Annex B: GH-PRE-F34-740-700-0001 Grasshopper webinar presentation

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GRASSH2OPPER
Grid Assisting Modular Hydrogen PEM Power Plant
www.grasshopperproject.eu
WEBINAR
29/03/22
10:30h CET
Clean Hydrogen Partnership
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Agenda

1. Introduction. Project manager, Abengoa
2. Flow Field development. Leader of simulation and control group, ZBT
3. MEA development. Lead Scientist, Johnson Matthey Fuel Cell
4. Stack development. Manager customer development & projects, Nedstack
5. System modeling. PhD student, Politecnico di Milano.
6. Platform to grid integration. Projects Group Manager, INEA
7. 100 kW pilot plant. Project manager, Abengoa
8. Pilot Plant Results. Process engineer and FCPP test specialist, Abengoa
9. Next steps. Process engineer and FCPP test specialist, Abengoa
10. Applications. Process engineer and FCPP test specialist, Abengoa
11. Pilot Plant Virtual Visit
12. Q&A

1. Introduction

Why Grasshopper?

ZBT

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Nedstack
PEM FUEL CELLS

POLITECNICO
MILANO 1863

INEA

ABENGOA

Start date: 1 January 2018

Final date: 31 March 2022

Total budget: 4,4 M€

EC funding: 4,4 M€

EC contract: 779430

WP1: Coordination (INEA)

WP2: Flow field modeling and validation (ZBT)

WP3: Realization of improved MEAs with long lifetime and lower costs (Johnson Matthey

WP4: Improved stack design and pilot production (Nedstack)

WP5: System modeling and performance optimization (Politecnico di Milano)

WP6: Development and validation of modular, low-cost power plant (Abengoa Innovación

WP7: Platform for FCPP to Grid integration (INEA)

WP8: Dissemination and explotation (Abengoa Innovación)

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Partners

- Zentrum für BrennstoffzellenTechnik (ZBT) GmbH, Duisburg, **Germany**
- Develop a large area flow field for stationary applications capable of high-power densities with high uniformity of current distribution in constant and load following operation

- Johnson Matthey, Swidon, **United Kingdom**
- Develop highly durable stationary MEAs with a significant cost reduction

- Nedstack Fuel cell Technology, Arnhem, **The Netherlands**
- Development of new stack platform with increase in nominal stack power, while reducing costs and maintaining FC efficiency > 55%

- GECOS group (Group of Energy COnversion systems) at Politecnico di Milano, Italy
- Development and validation of a dynamic model of the PEM FC plant to support design, operation and scale-up

- INEA doo, Ljubljana, **Slovenia**
- Project coordinator
- Develop a tool for a validate integration between FCPP and distribution grid management system
- To assess the business models for integration of FCPP for grid support services.

- Abengoa Innovación, Seville, **Spain**
- Design, construction and validation of a modular, 100 kW pilot plant, include operational flexibility and grid stabilization capability.
- Design of a modular highly flexible MW size based on pilot plant learnings.
- Diffusion activities

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Grasshopper Project Characteristics

Grasshopper project aims to realize the next-generation FCPP targeting stationary application in the MW-scale grid stabilization In that way it has to be cost-effective and flexible in power output, accomplishing an estimated CAPEX below 1500 €/kWe at a yearly production rate of 25 MWe.

The MW-size FCPP unit will be based on learnings from a 100 kW pilot plant design, which is currently testing in Seville

Flexible and Dynamic

A flexible and dynamic operation range (20-100%) for a demand-driven operation

FC Cost Reduction

- MEA: reduce %Pt with long lifetime and lower manufactured costs
- New stacks: larger sizes and higher power density (25kW, ↑ operación pressure, 400 cm^2)

BOP Cost Reduction

- Commercial equipment
- Reduction the number of connections and elements
- Materials optimisation
- Manufacturing standardisation

Remote Operation

Smart autonomous control lets the plant operation and maintenance management from a remote site, with no need operator.

Contenerised Solution

"Plug and play", easily transportable and modular power plant for temporal or remote locations

Versatility

Adaptable for many different applications such as:

- Power to power
- Off-grid
- Emergency generatos
- Grid balancing
- etc

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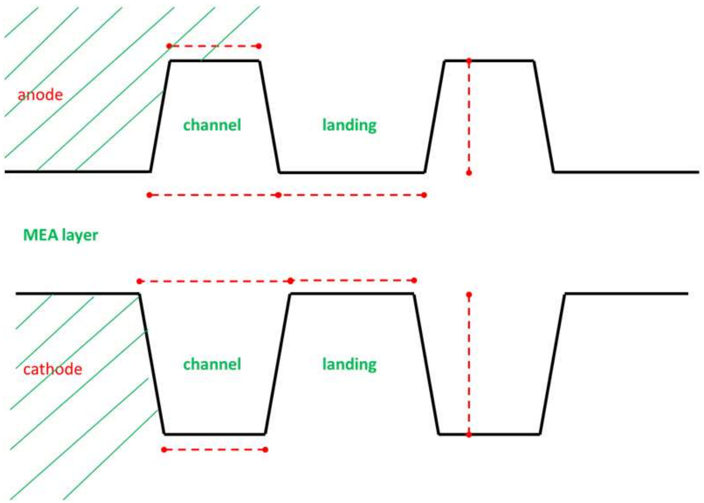
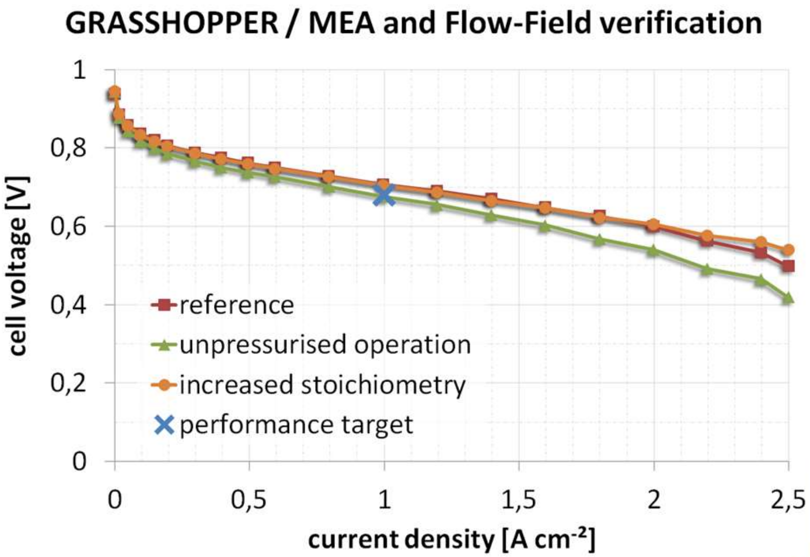
ZBT

2. Flow field development

Flow field development (1)

- ZBT has designed the flow field for the GRASSHOPPER stack based on various measurements and simulations.
- The operating point was developed in close collaboration with the relevant partners.
- The targeted operating performance has been reached and even exceeded under certain operating conditions.





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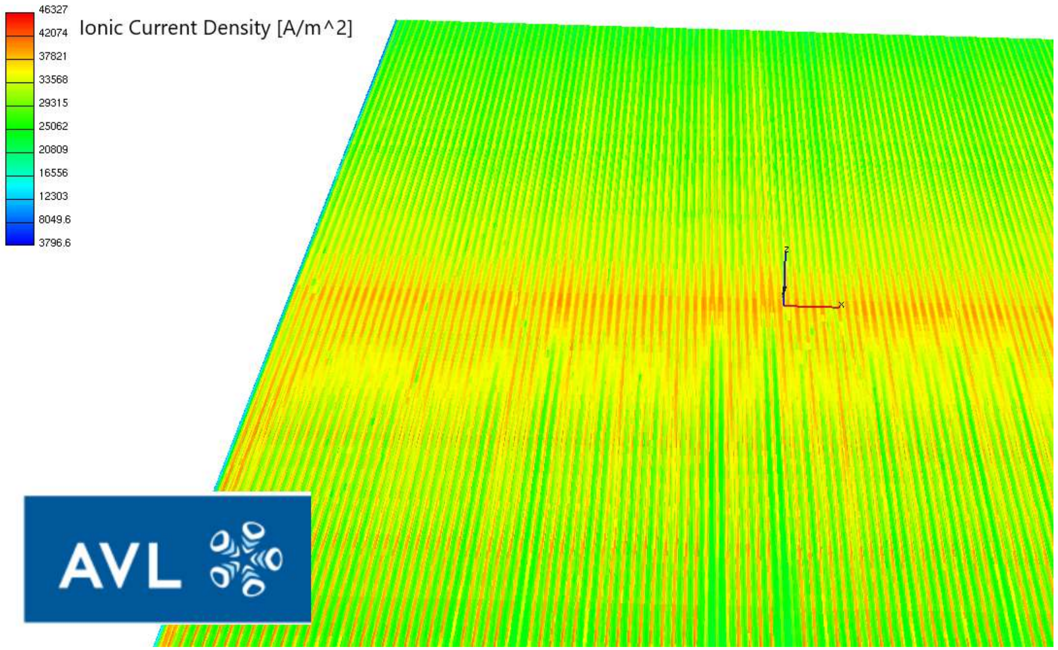
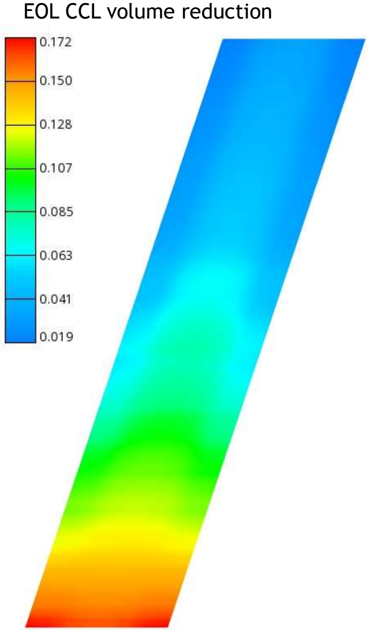
Flow field development (2)

- The flow field has successfully been adapted for the 300 cm^2 stack and the performance has been validated
- A simulation based degradation analysis has been performed to prevent local hotspots





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3. MEA development

MEA Development

- JMFC developed a high-performance, high durability membrane electrode assembly, (MEA) building on:
  - Previous stationary power MEAs – hand built, high costs including high Pt loading.
  - Emerging catalyst coated membrane (CCM) production methods – high volume, reduced costs, optimised for automotive MEA design and manufacture.
- JMFC's prototypes were approved NFCT for inclusion in the GRASSHOPPER stacks.
  - Optimised for stationary grid support, with enhanced chemical and mechanical stabilisation – the GH3 CCM.
- JMFC made 2000 MEAs on high-volume manufacturing equipment.
  - Built into stacks for 100kW, pilot-scale plant at Abengoa.
  - Tested extensively at JMFC for performance and durability.

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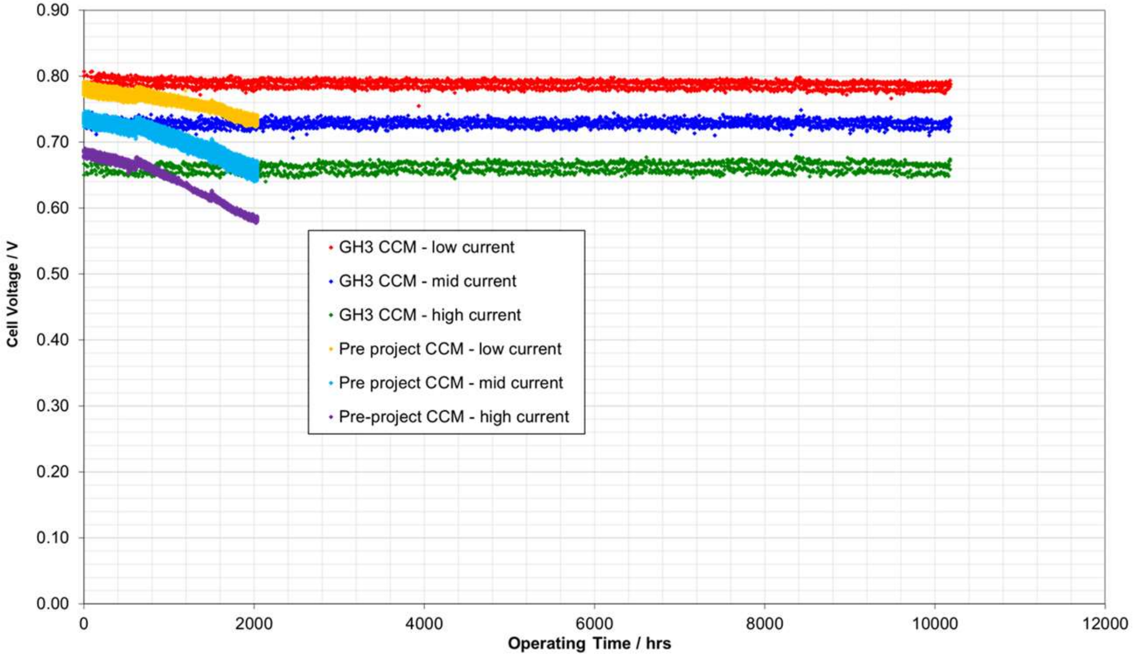
MEA Performance and Durability

- JMFC put the GRASSHOPPER MEA vs the pre-existing CCM design through a drive cycle test:



- The GRASSHOPPER MEA showed minimal decay over 10kHrs testing.

- JMFC's GRASSHOPPER MEA represents a significant durability improvement over pre-project designs, delivering longer lifetime and lower costs.

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking under grant agreement No 779430. This Joint Undertaking receives support from the European Union's Horizon 2020 research and innovation programme, Hydrogen Europe and Hydrogen Europe research.

Johnson Matthey
Inspiring science, enhancing life

Nedstack
PEM FUEL CELLS

4. Stack design

Stack development

- Nedstack designed a next generation fuel cell stack for stationary applications. Based on the experience of design and operation of a 2 MW FCPP in the DemcoPEM-2MW project, key optimisations were addressed in the new design:
  - Increase of the power output per stack to more than 25 kW in nominal conditions
  - Decrease of stack cost by decrease of the MEA cost and improvement of cell plate and seal design for series manufacturing.
  - Improved flowfield for dynamic behaviour for grid support operation

- Nedstack built and tested several short stacks using the newly developed materials. Currently the design of scaled-up manufacturing and process automation is in progress.

- Nedstack also built fuel cell stacks for equip the pilot plant for the first period of operation.

Nedstack
PEM FUEL CELLS

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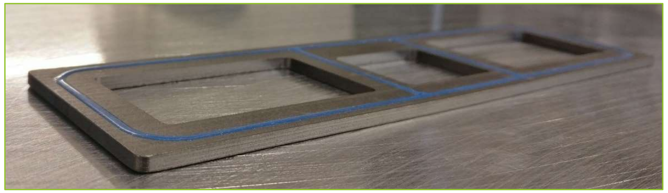
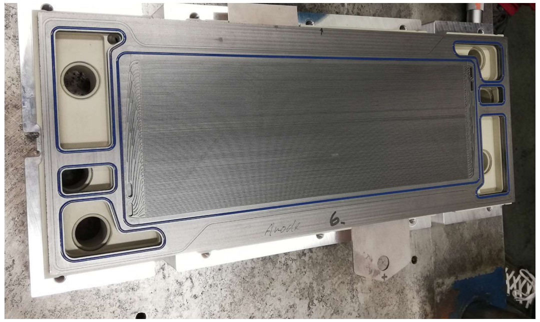
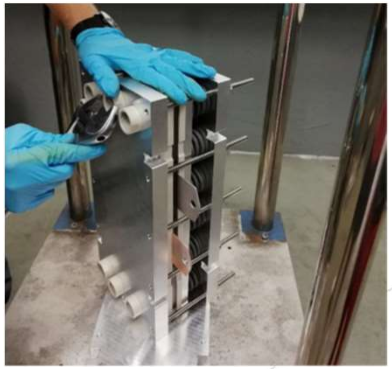
Stack development

- With the assistance of simulations a new flowfield has been designed. Integration of a dispensed seal in cooperation with ZBT lead to a design suitable for volume manufacturing.





- Several short stacks have been built to validate the performance of both the design and the materials.



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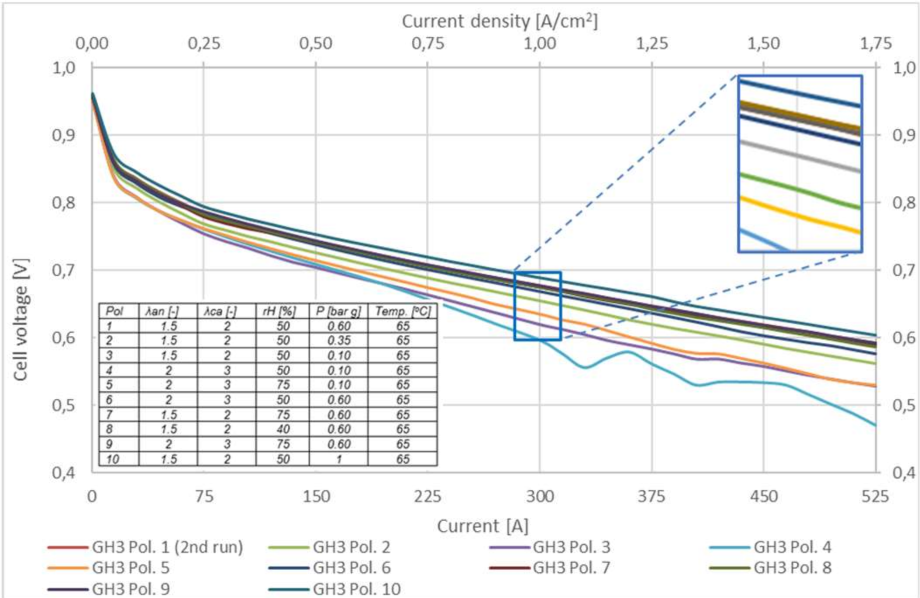
Performance testing

- Polarization curves show stable operation of the stack in a broad range of conditions. The most relevant conditions (curves 7,8) for the Grasshopper FCPP show a performance of more than 0.68V at 1 A/cm^2. Resulting in a nominal stack power of more than 25 kW.



Pol	λan [-]	λca [-]	rH [%]	P [bar g]	Temp. [ºC]
1	1.5	2	50	0.60	65
2	1.5	2	50	0.35	65
3	1.5	2	50	0.10	65
4	2	3	50	0.10	65
5	2	3	75	0.10	65
6	2	3	50	0.60	65
7	1.5	2	75	0.60	65
8	1.5	2	40	0.60	65
9	2	3	75	0.60	65
10	1.5	2	50	1	65

Nedstack PEM FUEL CELLS

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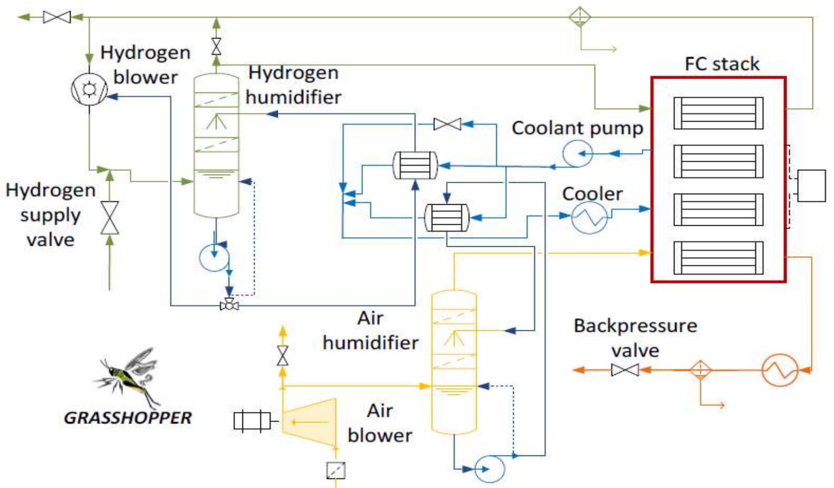
POLITECNICO
MILANO 1863

5. System modeling

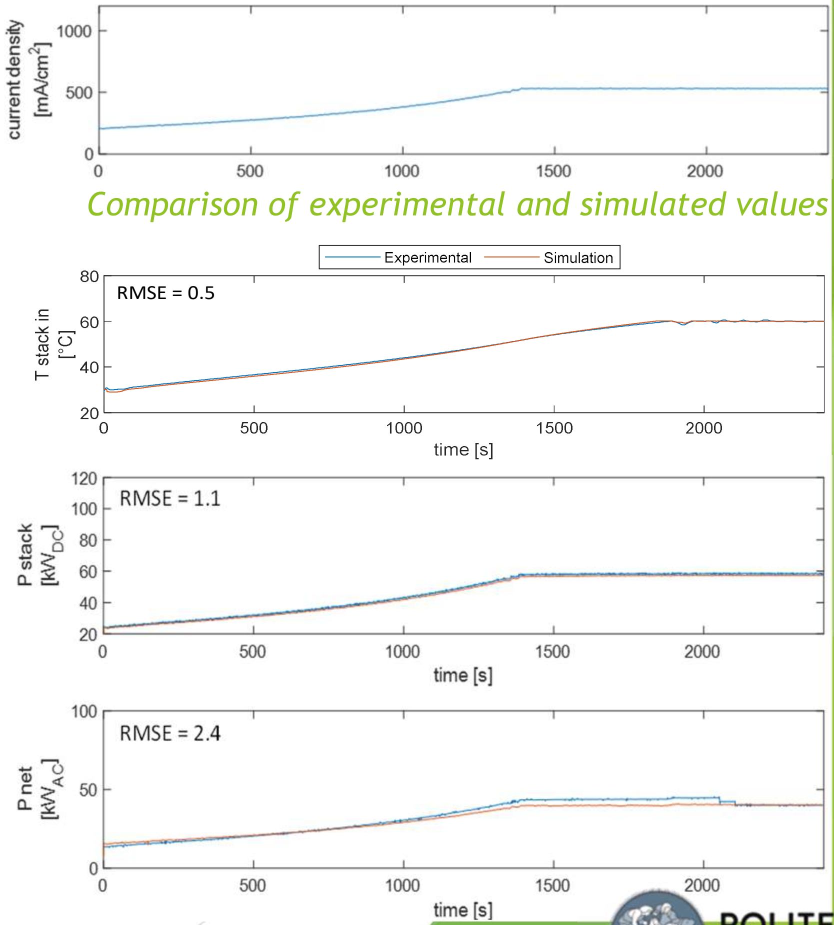
System modelling and performance optimization

- Dynamic modelling of the PEM FC power plant:
  - Model of each component, solving mass and energy balances during variable load operation.
  - Semi-empirical polarization curves to reproduce the electrochemical performance.
  - PI-type controllers are implemented.
- Model calibration and validation through experimental data from pilot plant FAT.



Model input

Comparison of experimental and simulated values



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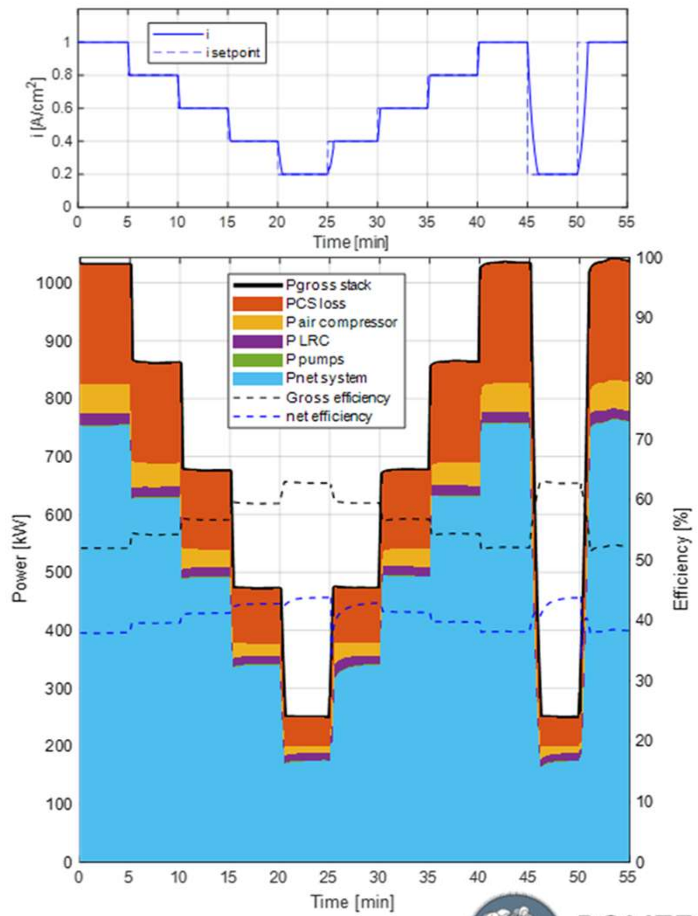
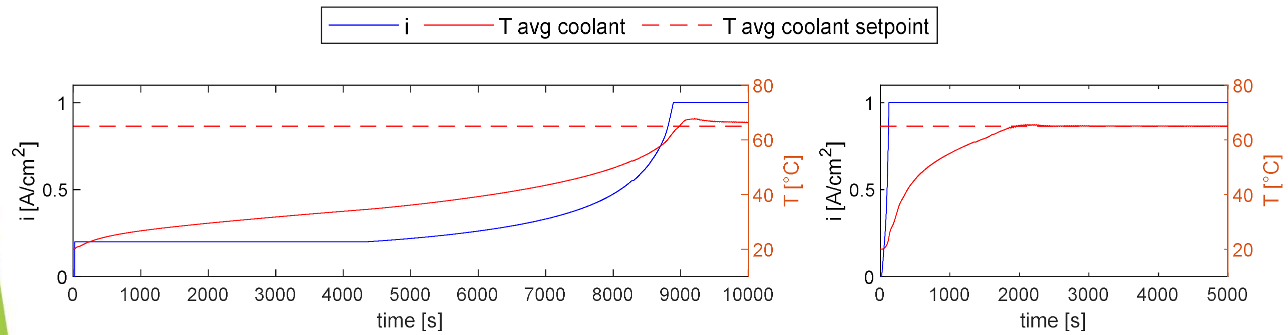
System modelling and performance optimization

- Dynamic simulations to optimize the plant scale up to 1 MW:
  - Warm-up: plant start-up from ambient temperature (20 °C)
  - Load-following operation: load step changes spanning through the entire operation range
- Comparison of plant efficiency adopting:
  - Different warm-up and operation strategies
  - Different plant configurations

1 MW system - example of load-following simulations



1 MW system - example of dynamic during warm-up:
comparison of temperature variation with different current density profiles



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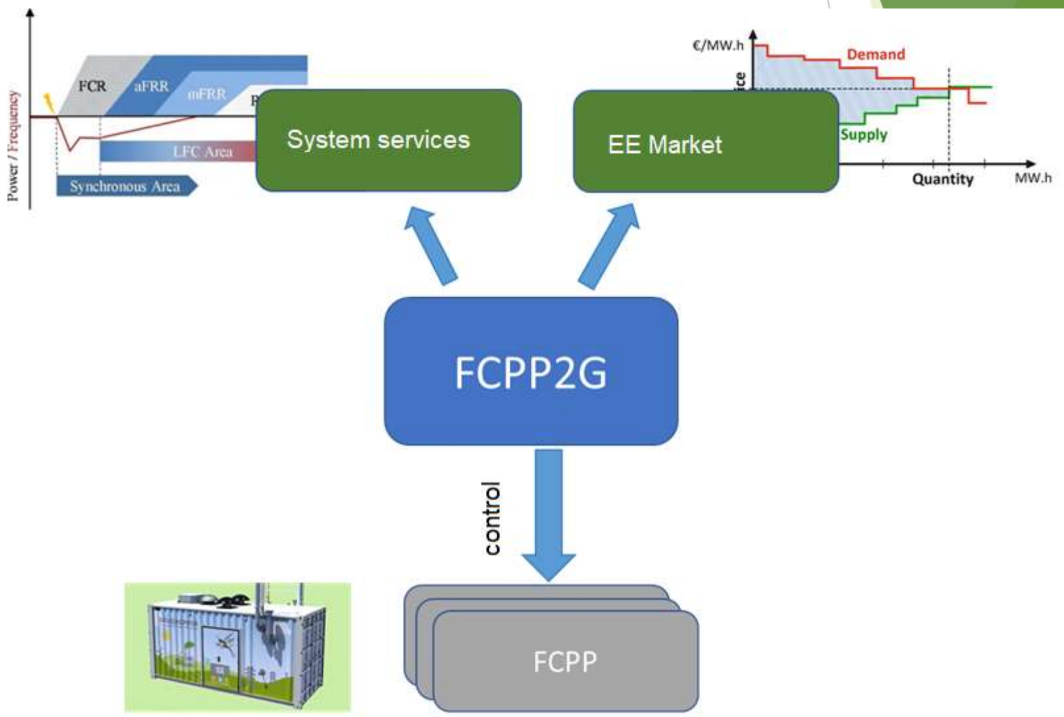
6. Platform to Grid integration

FCPP2G Features

FCPP2G grid balancing interface

- Selling energy in organized market
- System services aFRR & mFRR
- Automatic demand response for grid balancing
- Real-time data exchange with service provider



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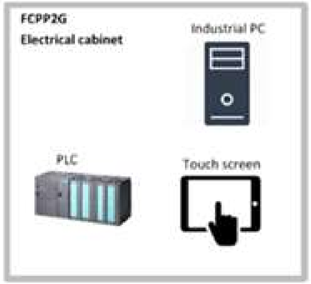
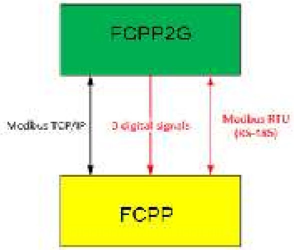
INEA

FCPP2G Scalability



Features

- Simple integration of the module
- Adaptable interface to FCPP
- Control based on economic optimisation
- Support of the modular design – control of multiple FCPP



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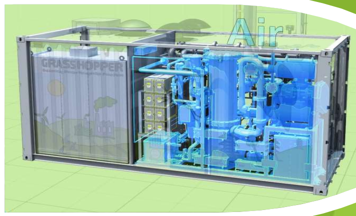
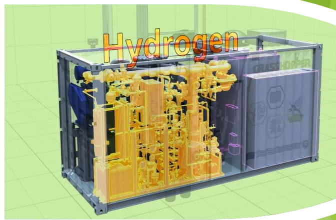
7. Pilot Plant 100 kW

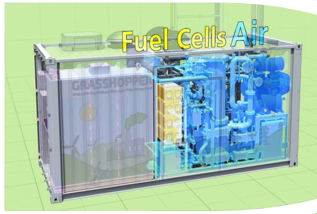
Pilot Plan 100 kW



Air
- Inlet flow management
- Pressurization of the incoming air
- Remove pollutants
- increase %RH and T



Hydrogen
- Inlet flow management
- Pressure point tracking
- Remove pollutants
- Increase RH% and T



Fuel cell
- Dynamic operation, 20-100%
- Higher power density (25 kW))
- Long lifetime→ 20,000h
- CVM to cope with grid dynamics

Power conditioning
- A single bidirectional power interface
- Quick response time for electricity or power demand
- Power self-supply
- Warm standby mode

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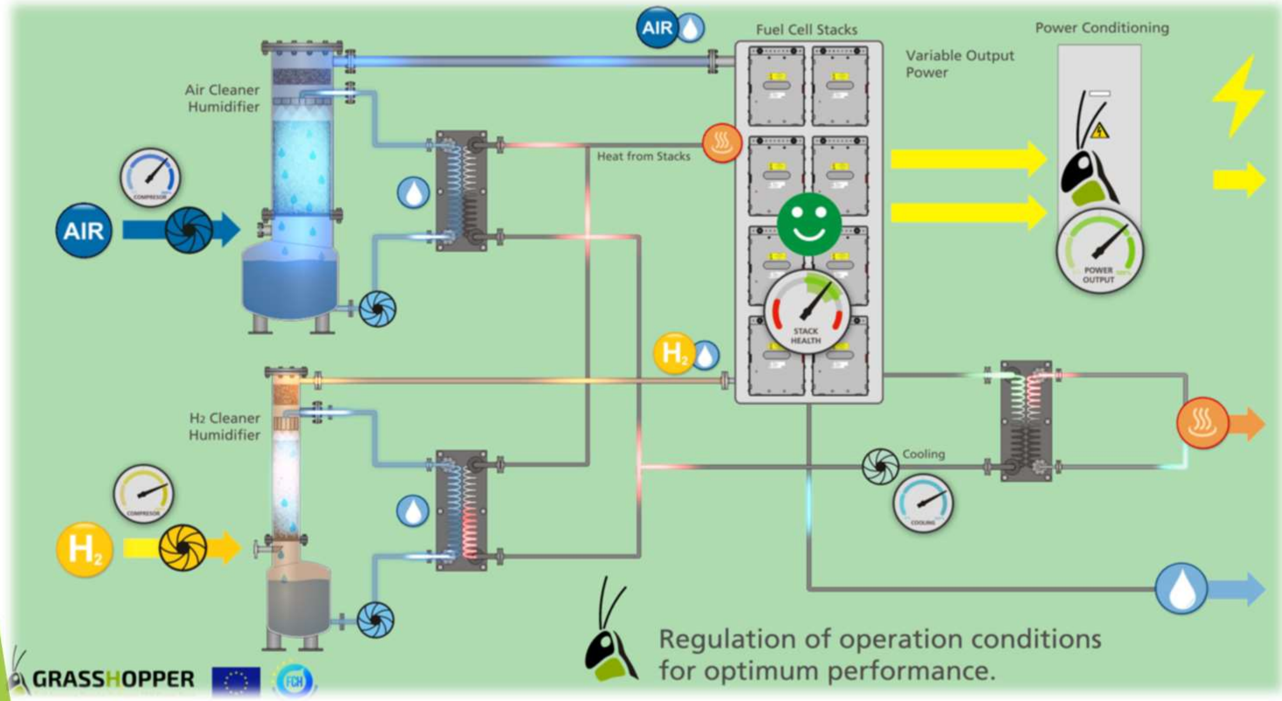
Pilot Plant 100 kW



Humidification stage

- Both air and H_2 must enter the stack with a controlled relative humidity so that rotors can pass through it → MEA must be suitably humidified so that the protons can pass through it
- Water from water generated in the fuel cell (no water consumption only in the first start-up)

Temperature control

- Fuel cell has to work at constant temperatura to avoid termal degradation. → Internal cooling circuit
- Heat produced in the chemical reaction is recovered for preheating the air and hydrogen
- Excess heat is disperse into the atmosphere with an aircooler

Dynamic operation

- A precise control of flow, pressure, temperature and humidity,allows to dynamically change operation setpoint maintaining efficiency.
- Rapid response to load change demands.

Maximization of lifetime

Implement strategies to maximize lifetime:

- Dynamic control of inlet relative humidity and temperature
- Continuous supervision of individual cell voltages
- Controlled shutdown
- Inertisation after operation

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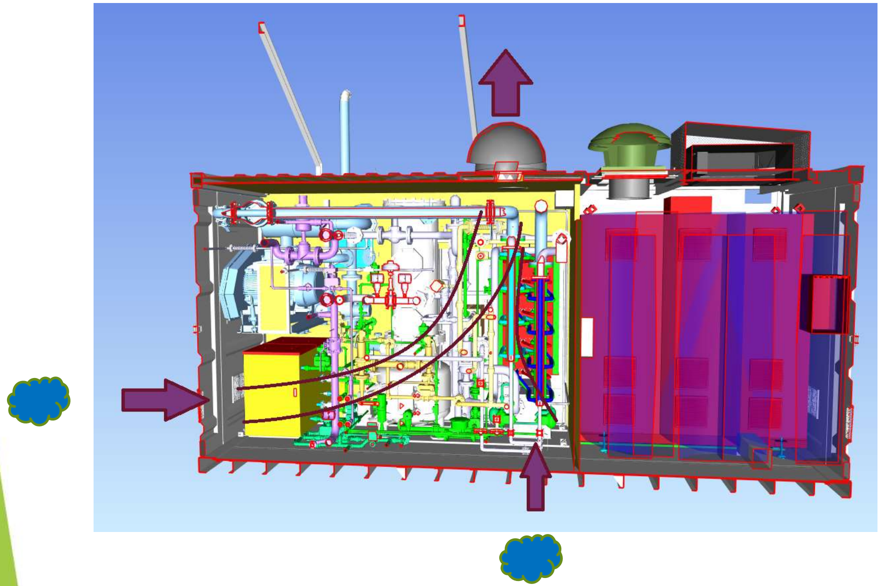
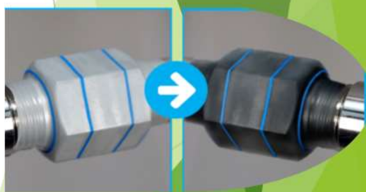
Pilot Plant 100 kW - Safety



ATEX studies

- Electric compartment isolated from H_2 Zone
- IEC 60079. Hazard area classification result: NE
- Forced ventilation system
- Equipment with ATEX certification
- Intrinsic safety in cabling
- Fixed H_2 Detection Detectors (LEL)
- Automatic purges in case of SD, trip or ESD
- H_2 Leak Detector Tapes
- Execution of automatic and programmed leak tests from PLC
- Personal protective equipment and work restrictions



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Pilot Plant 100 kW - Maintenance

Design towards maintenance

- Defined maintenance plan.
- Accessible equipment for easy maintenance
- Accessible equipment for easy maintenance
- PLC with telematic warnings (maintenance plan).
- Electrical and control connections arranged in accessible connection boxes and quick connectors
- Removable skids to carry out a “major overhaul”.

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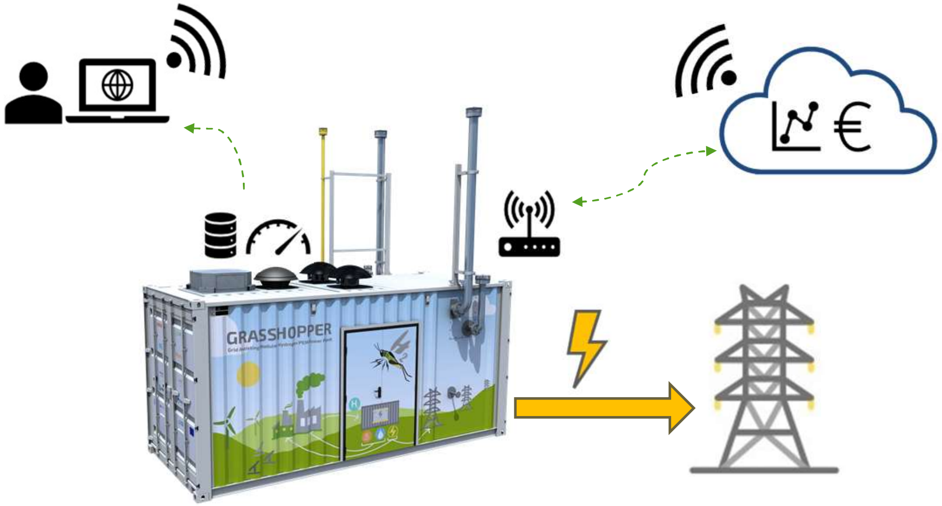
Pilot Plant 100 kW

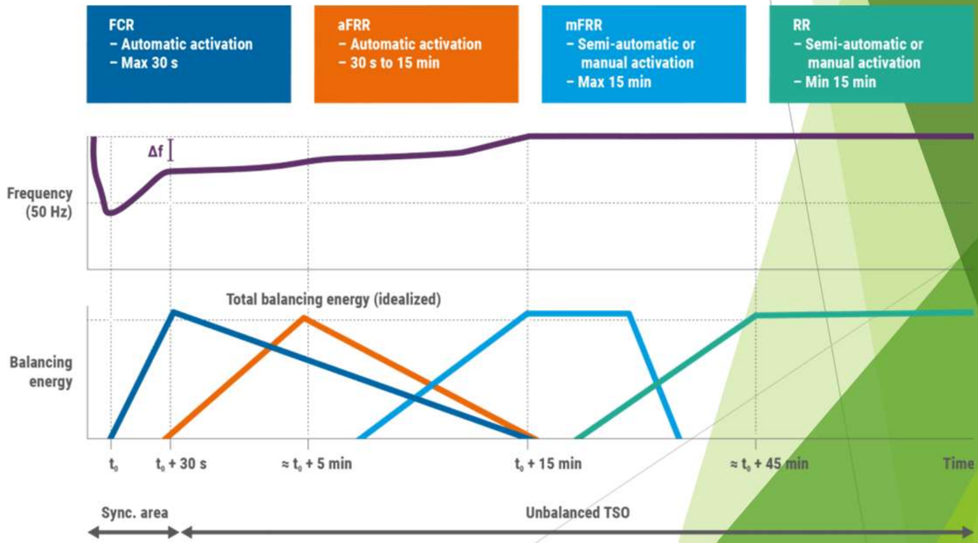


Dynamic and quick answer

- Allows participation in reserve markets where the € / MW is higher → mFRR
- It can offer a symmetrical product, that is, both up and down in power.
- From a “warm standby" mode, the plant has zero net electricity consumption and could potentially participate in more demanding reserve markets such as aFRR

Autonomous Operation and “Smart grids” integration

- Bidirectional communication with the electricity market through the KIBERnet platform, offering capacity and receiving electricity or power requests.
- Automated control without the need for operator intervention
- It can operate from instantaneous power or accumulated energy requests.



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8. Pilot Plant Results

Results

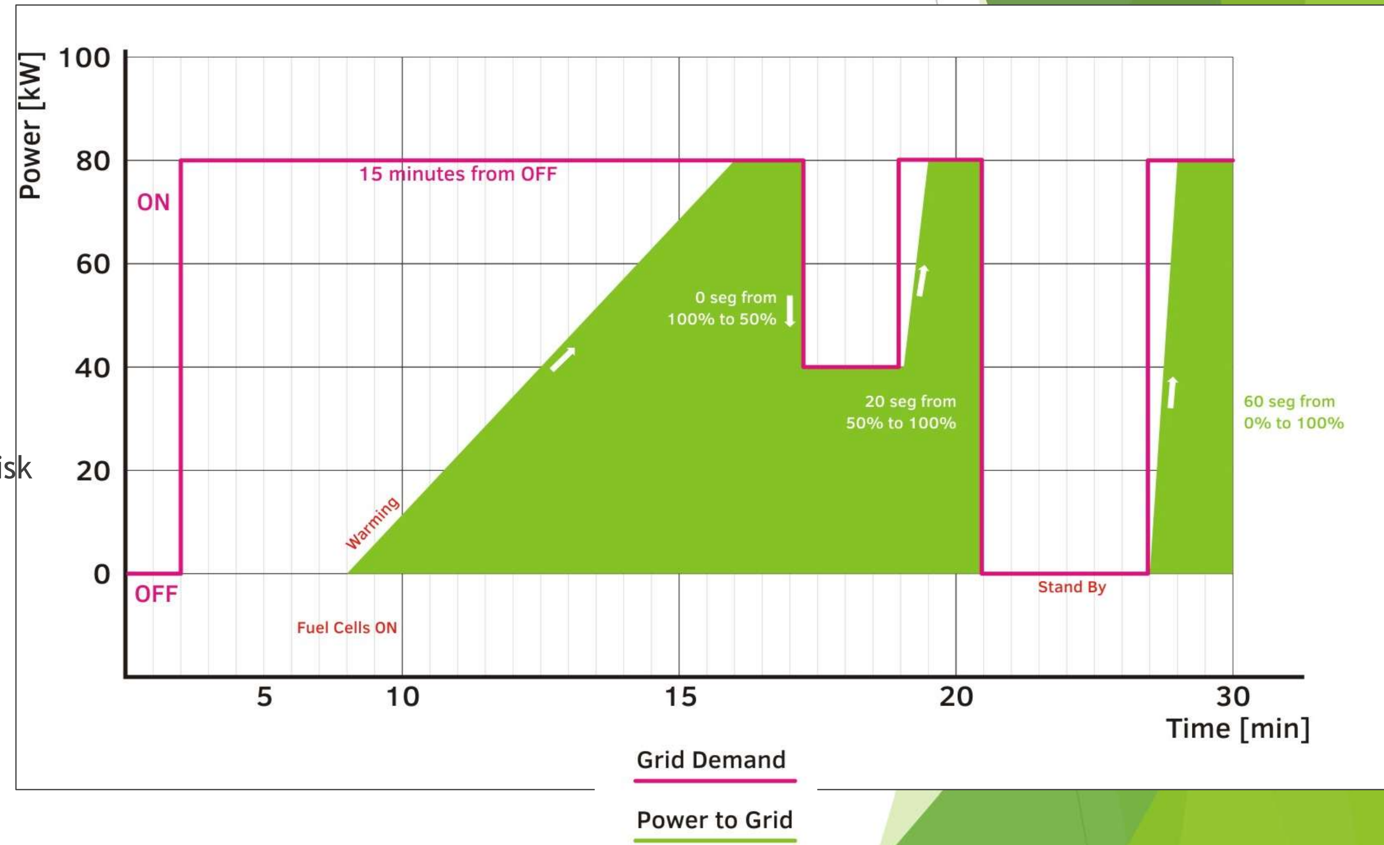
Dynamic operation and power production

- Full power achieved over time successfully (100 kW gross, 80 kW net).
- Steps in demand from 50 to 100% in 20 seconds,

even at dynamic operation.

- Steps in demand from 0 to 100% in 60 seconds.
- 50% Electrical efficiency
- Automatic power demand adaptation without any risk for the stacks
- No need external water consumption, even surplus which could be stored for its use in another process

Great potencial to participate in store electrical market and grid balancing!!



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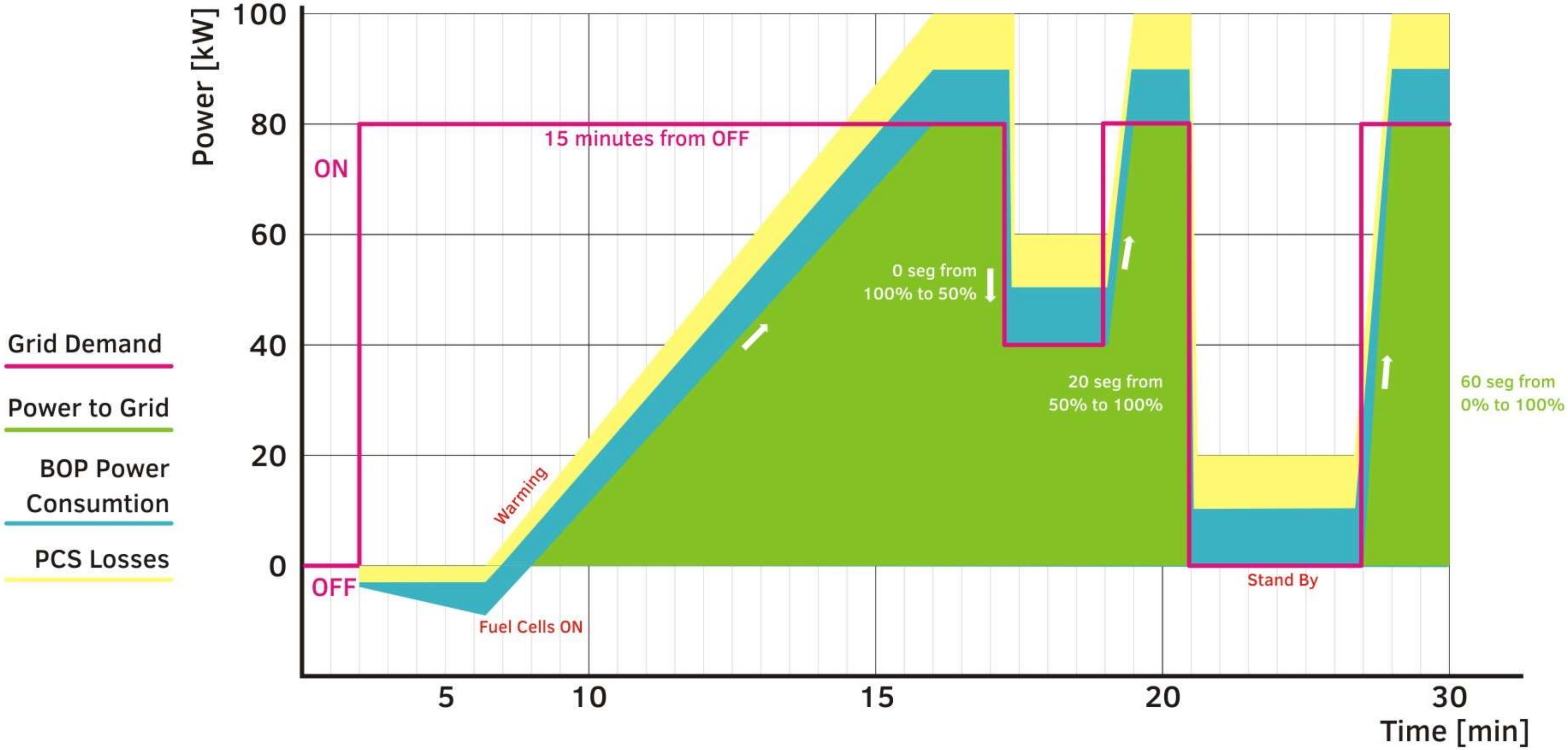
Results



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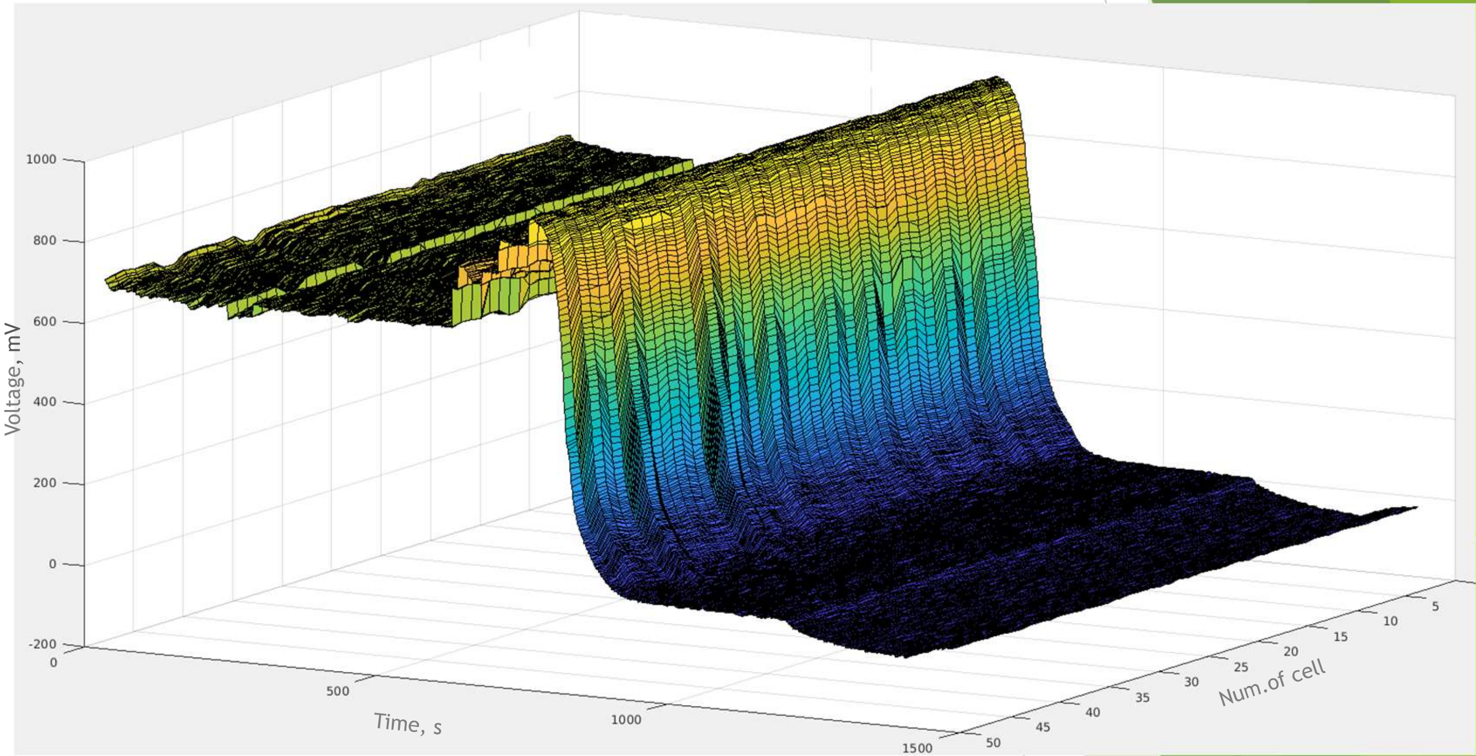
Results

Stacks strategies for increasing their lifetime

- Recovery of the catalytic membrane during the shutdown
- Less aggressive start-up.
- Optimum relative humidity to every load point.



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9. Next steps


GRASSHOPPER
Grid Assisting Modular Hydrogen PEM Power Plant

Next steps

Transfer to Nouryon, Delfzijl

- Pilot plant connection to a residual H2 stream from Nouryon, the chlor-alkali chemical plant.
- Developmento of the Site Acceptance Test.
- Keep operating on site for 5 years after the project end, to demonstrate the viability of the technology in the medium-term and serve as experimental validation of the operational costs for the system

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Next steps

Design of a MW scale comercial power plant

- Implementation of innovation validated with the pilot plant.
- Cost reduction to reach CAPEX of 1500 €/kWe
- Market analysis for Grasshopper applications. Both in short and long term basis.
- Definition of system limits, garantees...

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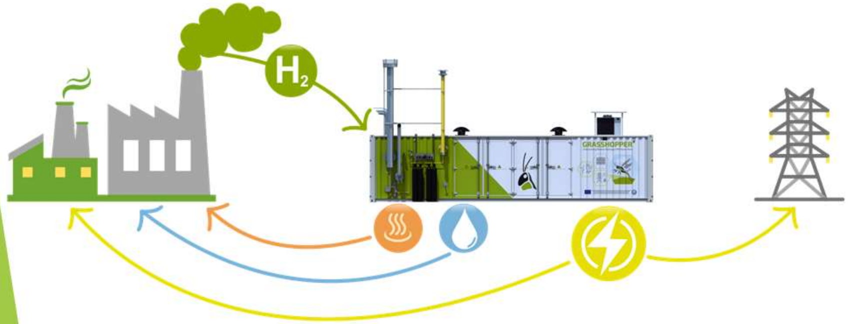
10. Applications

Applications

Usage of residual H_2 from chemical process

- Such as refineries, chlor-alkali, and others.
- Provide power according to the H_2 available.
- Return of high purity water.
- Low temperature cogeneration.



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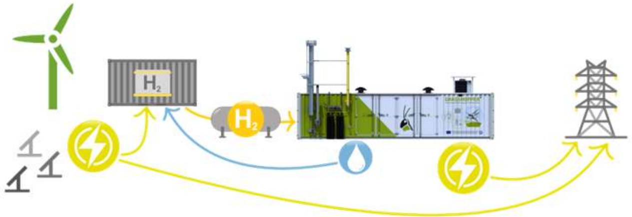
Applications

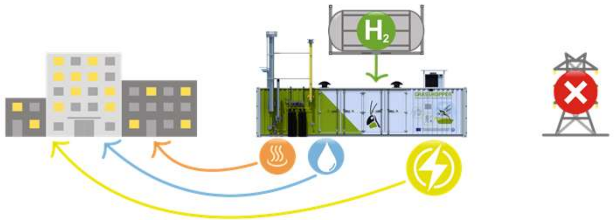
Power to Power

- Large scale energy storage
- Rated power independent from energy capacity required.
- Allows management of renewable energy



Microgrid

- As baseload load or peak generator .
- With local production of H_2 or imported



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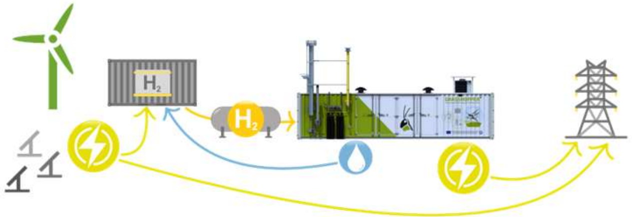

Microgrid

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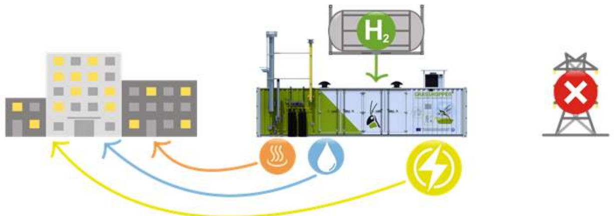
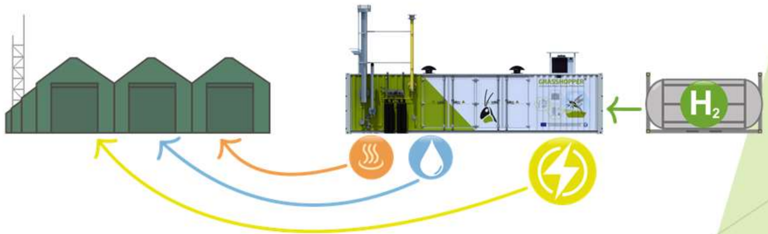


Replace of heat engines

- As emergency generator for critical loads as hospitals, data centers, etc
- Cogeneration with a heat/electricity ratio of 1
- Temporary facilities or camps.



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11. Pilot Plant Virtual Visit

Pilot Plant Virtual Visit

https://youtu.be/5mKHnZlR3Ek

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THANK YOU!

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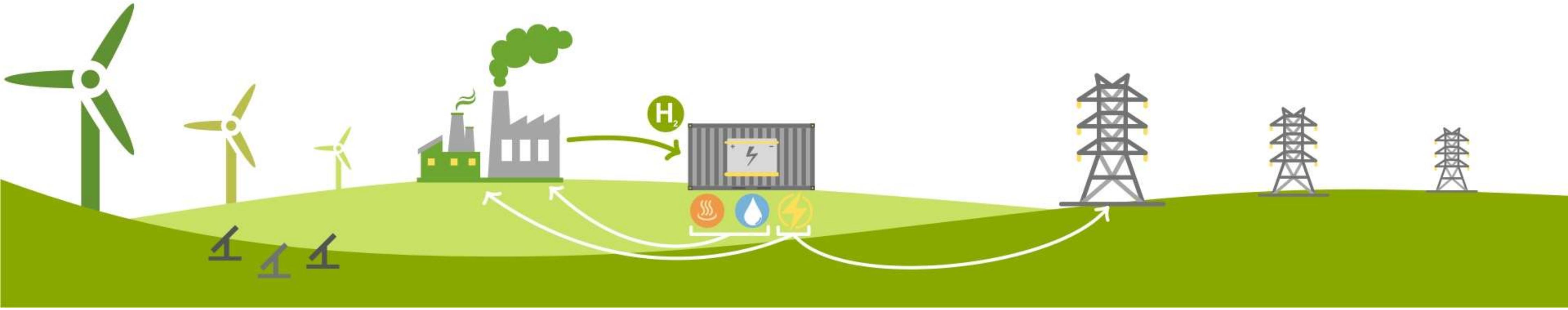
Nedstack PEM FUEL CELLS

Johnson Matthey Inspiring science, enhancing life

ZBT

info@grasshopperproject.eu



4.3 Annex C: List of GRASSHOPPER webinar registrant

Table 4 – List of GRASSHOPPER webinar registrants

ID	Gender	Webinar attendance	Organization	Country
1	Female	Organizer	Abengoa Innovación	Spain
2	Female	Attendee	Abengoa Innovación	Spain
3	Male	Presenter	Abengoa Innovación	Spain
4	Male	Attendee	Ingeniería 3D - Marketing Industrial - Simulación (Josu3D)	Spain
5	Male	Attendee	Area Paper Japan	Japan
6	Female	Presenter	Politecnico di Milano	Italy
7	Male	Attendee	Politecnico di Milano	Italy
8	Male	Presenter	ZBT GmbH	Germany
9	Female	Attendee	Abengoa Innovación	Spain
10	Male	Presenter	Inea	Slovenia
11	Male	Presenter	Nedstack fuel cell technology	Netherlands
12	Male	Presenter	Johnson Matthey	United Kingdom
13	Male	Attendee	Enmaro	Poland
14	Male	Attendee	MYPEGASUS	Germany
15	Male	Attendee	ENMARO	Poland

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ID	Gender	Webinar attendance	Organization	Country
16	Male	Attendee	The Fourth D SL	Spain
17	Male	Attendee	Enaire	Spain
18	Male	Attendee	JRC-EU	Spain
19	Male	Attendee	Brainboxes	United Kingdom
20	Female	Attendee	Instituto Tecnológico de Galicia	Spain
21	Male	Attendee	INEA	Slovenia
22	Male	Attendee	Johnson Matthey	United Kingdom
23	Male	Attendee	European Commission	Spain
24	Female	Attendee	Kiwa Technology	Netherlands
25	Male	Attendee	Smartenergy	Portugal
26	Male	Attendee	Abengoa Innovación	Spain
27	Male	Attendee	Université Catholique de Louvain	Belgium
28	Female	Attendee	EC JRC - EIPPCB (Seville)	Spain
29	Female	Attendee	JM	United Kingdom
30	Male	Attendee	JRC - SEVILLE	Spain
31	Male	Attendee	Enmaro	Poland
32	Male	Attendee	INEA	Slovenia
33	Male	Attendee	Chart Ferox a.s.	Czech Republic

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ID	Gender	Webinar attendance	Organization	Country
34	Male	Attendee	ISE	Spain
35	Male	Attendee	Abengoa	Spain
36	Female	Attendee	Agencia Andaluza de la Energía	Spain
37	Female	Attendee	Abengoa	Spain
38	Male	Attendee	ABG	India
39	Male	Attendee	Abengoa	India
40	Male	Attendee	TotalEnergies	France
41	Male	Attendee	Proinsener	Spain
42	Male	Attendee	Sacen	Spain
43	Male	Attendee	MSA	France
44	Male	Attendee	Capgemini	Spain
45	Female	Attendee	Klinger Spain	Spain
46	Male	Attendee	Abengoa	Spain
47	Male	Attendee	AENA SME	Spain
48	Female	Attendee	ingeteam	Spain
49	Male	Attendee	Kelvion Thermal Solutions,S.A.U	Spain
50	Male	Attendee	Klinger Spain	Spain
51	Male	Attendee	Ineco	Spain

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ID	Gender	Webinar attendance	Organization	Country
52	Male	Attendee	Politecnico di Milano	Italy
53	Female	Attendee	Proinsener	Spain
54	Male	Attendee	ATA	Spain
55	Male	Attendee	Nubenergy	Spain
56	Female	Attendee	Autónoma	Spain
57	Female	Attendee	Abengoa Innovación	Spain
58	Male	Attendee	Digital Five Investment	Spain
59	Male	Attendee	Tekfen Engineering	Turkey
60	Male	Attendee	cesi	italy
61	Male	Attendee	Universidad de Sevilla	Spain
62	Male	Not attendee	Cade soluciones de ingenieria	Spain
63	Female	Not attendee	Alight	Spain
64	Female	Not attendee	Interesado	Spain
65	Female	Not attendee	INSS	Spain
66	Female	Not attendee	Abengoa Innovación	Spain
67	Male	Not attendee	Currently Unemployed	India
68	Male	Not attendee	Red Electrica de España	Spain
69	Male	Not attendee	Hyundai Motor Company	Korea

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ID	Gender	Webinar attendance	Organization	Country
70	Male	Not attendee	Abengoa Innovación.	Spain
71	Male	Not attendee	Abengoa Energía	Spain
72	Male	Not attendee	Abengoa Innovación	Spain
73	Male	Not attendee	Lean Hydrogen	Spain
74	Male	Not attendee	Instalnox	Spain
75	Male	Not attendee	Eisenhuth GmbH	Germany
76	Female	Not attendee	AGBAR	Spain
77	Male	Not attendee	Clean Hydrogen Partnership	Belgium
78	Male	Not attendee	Politecnico Di Milano Italy	Italy
79	Male	Not attendee	Smartenergy	Portugal
80	Male	Not attendee	MGIMO	Spain - Russia
81	Male	Not attendee	DENSO	Germany
82	Male	Not attendee	ESL	India
83	Male	Not attendee	Proinsener	Spain
84	Male	Not attendee	Independiente	Spain
85	Male	Not attendee	Abengoa	Spain
86	Male	Not attendee	ISE	Spain

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ID	Gender	Webinar attendance	Organization	Country
87	Male	Not attendee	ACOM	Spain
88	Male	Not attendee	AEC	Spain
89	Male	Not attendee	Gama Power Systems	Turkey
90	Female	Not attendee	Keraben	Spain
91	Male	Not attendee	Situ Plan	United Kingdom
92	Male	Not attendee	Pfisterer Brasil	Brasil
93	Male	Not attendee	Aena	Spain
94	Male	Not attendee	Edpr	Spain
95	Male	Not attendee	unprg	Peru

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