

Reversible solid oxide Electrolyzer and Fuel cell for
optimized Local Energy miX

Dissemination Action Plan (update)

Deliverable D7.3

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking under grant agreement No 779577. This Joint Undertaking receives support from the European Union's Horizon 2020 research and innovation programme and Hydrogen Europe and Hydrogen Europe Research



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Abstract

This deliverable D7.3, the Dissemination Action Plan Update (M18), provides an updated version of the Dissemination Action Plan handed in deliverable D7.2 (M6). Besides the optimised dissemination strategy for the project, and in particular the objectives, activities, target audience, existing communication tools of the consortium partners (e.g. websites, social media channels) and existing professional networks useful to communicate and reach out efficiently; this deliverable also provides adjustments and updates compared to the original Dissemination Action Plan as well as examples of dissemination activities and products such as leaflets, web-site and newsletters.

Introduction

The main objectives of the dissemination activities of the REFLEX project (WP7) are to reach the key relevant communities and ensure high impact of the project results at the European level. This is achieved by promoting communication and exchange within the research community, the private industrial sector and institutional stakeholders.

1. Initial Dissemination Action Plan (DAP)

The initial Dissemination Action Plan (DAP) D7.2 aimed at defining an optimised dissemination strategy, and in particular the objectives, activities, target audience, existing communication tools of the consortium partners (e.g. websites, social media channels) and existing professional networks useful to communicate and reach out efficiently.

A dissemination strategy is set to serve the objectives of the REFLEX partnership, which is to bring to the fuel cell, electrolysis and hydrogen industry innovative solutions and advanced methodologies whose implementation would have a valuable impact on the broad value chain, from fundamental research through market introduction. REFLEX dissemination strategy involves all the partners and target a large part of the fuel cells, electrolysis cell and hydrogen community including scientists and industrials, in particular members of the International Advisory Board.

This dissemination strategy will be - and has been - mainly used by the partners as a guide to plan dissemination activities. It shows some general clues that will need to be adapted throughout the project, in response to changing needs.

The improved knowledge and results obtained during REFLEX will be publicized via one workshop with the International Advisory Board, scientific journal papers, conference participations and contributions, and a final dissemination event on the demonstration site at ENVIPARK. Moreover, this strategy will also include clustering activities (national and international) with ongoing projects/initiatives to foster common accepted solutions and exploit synergies across projects:

- Clustering with projects among other ongoing H2020 or FCH2-JU projects (e.g. ECO, BALANCE and to a lesser extent Insight) or other international initiatives, such as the EERA (European Energy research Alliance) working on H₂ and fuel cells and electrolysis, in which several partners of the project are involved (CEA, VTT, DTU), as well as the RCS (regulation codes and

standards) working group dealing with rSOC testing methods (IEC TC105, working group 13, in which the coordinator participates);

- Presentation of REFLEX results at various events: of course, at specialized events in the field of H₂ and fuel cells and electrolysis (for example review days organised by the FCH2-JU, several workshops, DOE or Asian events), but also events with a much wider audience focusing on energy storage and smart cities (BePositive, Pollutec, SmartEnergyExpo, Innovative Cities, IRES...)

1.1 Dissemination Strategy and Activities

Dissemination activities have been and will continue to be aimed at promoting a fruitful exchange within the research community, the private industrial sector and institutional stakeholders. In order to harmonise the external communication with a unique identity for the project in all channels of communication, the following tasks have been set up at the beginning of the project and will be periodically updated:

- Definition of the project’s graphic identity, including a logo and a colour code,
- Setting-up and update of the project public website (see www.reflex-energy.eu)
- Creation of a project leaflet as illustrated in Figure 1.

These products have already been reported in Deliverable D7.1 “Communication Toolkit” and therefore are only briefly summarized in the following section 1.2.

REFLEX

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The REFLEX project aims at developing an innovative renewable energies storage solution, the “Smart Energy Hub”, based on reversible Solid Oxide Cell (rSOC) technology, that is to say able to operate either in electrolysis mode (SOEC) to store excess electricity to produce H₂, or in fuel cell mode (SOFC) when energy needs exceed local production, to produce electricity and heat again from H₂ or any other fuel locally available.

The challenging issue of achieving concomitantly high efficiency, high flexibility in operation and cost optimum is addressed through improvements of rSOC components (cells, stacks, power electronics, heat exchangers) and system, and the definition of advanced operation strategies.

The specifications, detailed system design and the advanced operation strategies are supported by modelling tasks. An in-field demonstration will be performed in a technological park, where the Smart Energy Hub will be coupled to local solar and mini-hydro renewable sources and will provide electricity and heat to the headquarters of the park. It will demonstrate, in a real environment, the high power-to-power round-trip efficiency of this technology and its flexibility in dynamic operation, thus moving the technology from Technology Readiness Level (TRL) 3 to 6.

Consortium

CEA, Sylfen, DTU, VTT, elcogen, ENGIE, ENVIRONMENT PARK, GPTECH, UFR

The REFLEX project – www.reflex-energy.eu
 FCH2 JU grant agreement number 779577
 Started: 01/01/2018 – Duration: 36 months

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Figure 1: Copy of project leaflet and poster.

Leaflets have been handed out at e.g. Hannover Fair (2018 and 2019), SOFC and SOE Forum (Lucerne, July 2018), Program Review Days 2018, Fuel Cell Expo (Tokyo, February 2019).

The posters have been presented at Hannover Fair (2018 and 2019) and SOFC and SOE Forum (Lucerne, July 2018) (see Annex C).

Dissemination should be tailored to different stakeholders. The REFLEX partners will adapt their contents, using different language register (more or less formal, complex, or specialized, for example) and different means of communication (website, LinkedIn, newsletters, press, printed resources like leaflet and posters, scientific publications etc.) depending on the defined targets.

The presence of key leaders and pioneers in materials, electrochemistry, modelling, process, system, and their integration in the consortium will facilitate the dissemination of knowledge. The consortium will disseminate non-confidential results to the Research, Industrial and Public communities.

The key dissemination stakeholders of REFLEX project are listed below:

- Scientists, Education communities;
- Industrials and SME's;
- Public funding bodies.

Scientists, Education communities

All results not covered by IPR will be presented at international conferences, in journal papers and via the project website (examples here: <http://www.reflex-energy.eu/downloads>). All methodological and applied research results and new findings will be – and have already been - disseminated through university courses at DTU and CEA, post- graduated program activities and dedicated summer schools (Joint European Summer School (JESS) on Fuel Cell, Electrolyser and Battery Technology).

Industrials and SMEs

Several industrials/SMEs are part of REFLEX, covering the whole value chain with cells (Elcogen), power electronics (GPTech), rSOC system (Sylfen), end-user (Envipark and Engie). All together or separately, they can valorize the improvements done in their products or new products developed thanks to the REFLEX project, or they can demonstrate the benefit of such products for new or early markets. Participating in various fairs/shows or events, they can use this dissemination channel to present REFLEX achievements and boost their competitiveness.

Public bodies

Regarding the need for funding, the partners shall disseminate and communicate towards public bodies to show the value of Project results, as well as actively interact with the International Advisory Board. Furthermore, the first half of the project has shown possibilities for several of the partners to interact and influence politicians and public institutions; and such activities will continue in the last half of the project were system integration and demonstration of rSOEC REFLEX system in EnviePark is expected to be of high interest of political bodies and other public institutions.

Dissemination via existing network and contacts

During the first half of the project, several of the partners have disseminated REFLEX concepts and results via their existing network and contacts and this will continue throughout the three year project. Examples of such dissemination activities are: EnviPark utilizes existing internal and external communication office to disseminate REFLEX project to partners already involved in the innovative cluster around EnviPark; VTT uses existing contacts in industry in the technology park to promote the design and modelling of systems; SYLFEN promotes the project towards contacts such as start-up companies, funding agencies/venture capitalists and local communities also including contacts within the building industry; DTU targets both politicians, education system and funding agencies in their dissemination of REFLEX latest in connection with initiatives for starting up of a National Energy

Storage Centre; Engie demonstrates/shows facilities to interested companies and partners from industry; CEA promotes the project e.g. when groups visit lab facilities at CEA.

1.2 Dissemination Tools

The dissemination activities will be performed through planned and standardised promotional materials. External communication will use several ways:

1. A project graphic identity
2. The website
3. Public events
4. Scientific publications
5. Conference presentations
6. Flyer/poster
7. Periodic newsletters (available on project website www.reflex-energy.eu/downloads)
8. Instagram or twitter account (post on the project partners existing accounts)

The project graphic identity is much more than a logo, it is a coordinated way to present the project so that any product (website, deliverable, newsletters) reflects its mission, vision and values. As a first step, the project logo was released, as described in Deliverable D7.1 “Communication Toolkit” and depicted in Figure 2.



Figure 2: Project logo released and described in deliverable D7.1 “Communication Toolkit” and project logo used on product developed by project partner University of Seville and GPTech.

As part of the project brand a visual identity was designed and based on the REFLEX logo, templates were created for PowerPoint presentations and project reports as illustrated in the foot note of deliverables. These dissemination tools have all been described in Deliverable D7.1 “Communication Toolkit”. The partners use the visual identity for homogeneous dissemination using the templates.

The design of the project website enables user-friendly access to the project results. The website is updated every 6 months, or more frequently if needed. Inputs to the website have been and will for the rest of the project be discussed at the periodic meetings every 6 months.

A leaflet/flyer was also designed and handed out at three international fairs and one conference so far, and it was sent to International Advisory Board members. This will be updated as the project proceeds and distributed at various conferences and other events throughout the project.

Three newsletters have been written and are available on the website. They are also shown in Annex A.

2. Scientific Publication Plan

2.1 Scientific publications

Significant results obtained from REFLEX Project will be published in relevant journals according to the conditions set out in the Grant agreement and in the Consortium agreement.

The objectives of scientific publications are as follows:

- Circulate the project results and therefore the ideas;
- Disseminate to the most outstanding research community the project results;
- Get feedback from peers.

The following table lists potential publications that could be relevant for the project (this is not an exhaustive list). This table will be used as inspiration for the publications related to the project. In the first of the project partners have not yet published in the journals listed below; however work to be presented at the SOFC-XVI (September 2019) will be published in a peer-reviewed full journal papers and journal publications from partners such as CEA, EnviPark and University of Seville is expected in the last half of the project.

Description : title of the Event, title of the journal etc...	Address	Dates (year and Day/month if known) and Place	Main R&D topics covered	Comments
Journal of Power Sources	http://www.journals.elsevier.com/journal-of-power-sources/	2018/2019/2020	All aspects of the science, technology and applications of sources of electrochemical power: the science and applications of primary and secondary batteries, fuel cells, supercapacitors and photo-electrochemical cells.	concerning experimental activity, modelling and demonstration
Applied Energy	http://www.journals.elsevier.com/applied-energy/	2018/2019/2020	Analysis and optimization of energy processes, mitigation of environmental pollutants, and sustainable energy systems. Innovative technologies and systems of both fossil and renewable energy to the economic industrial and domestic use of energy with no or minor impact on the environment.	concerning experimental activity and modelling
International Hydrogen energy	http://www.journals.elsevier.com/international-journal-of-hydrogen-energy/	2018/2019/2020	The International Journal of Hydrogen Energy aims to provide a central vehicle for the exchange and dissemination of new ideas, technology developments and research results in the field of Hydrogen Energy between scientists and engineers throughout the world	concerning experimental activity and modelling

Fuel cell bulletin	http://www.journals.elsevier.com/fuel-cells-bulletin	2018/2019/2020	Fuel Cells Bulletin is the leading source of technical and business news for the fuel cells sector. From its international perspective it distils the important information you need to take advantage of the growing opportunities in fuel cells.	concerning experimental activity and modelling
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Table 1. Science and engineering journals that are relevant for publication of REFLEX results.

2.2 Conferences and other public events

Public events represent a great opportunity for REFLEX visibility and to convey the project contents to EU and international fuel cell and hydrogen communities. The objectives to participate to public events are as follows:

- Disseminate the latest results towards fuel cells and electrolysis groups;
- Meet relevant industry players;
- Collect all comments and suggestions concerning the results and eventually the suggested solutions proposed;
- Network face-to-face with some of the leading names in the field;
- Seek international partners and form new alliances;
- Raise REFLEX profile within the scientific community;
- Communicate REFLEX message to a highly qualified scientific community;
- Demonstrate REFLEX results;
- Increase REFLEX awareness and visibility;
- Enhance relationships with existing customers and meet new ones;
- Elevate REFLEX profile in the Global fuel cell, electrolysis and hydrogen research and development community.

Table 2 lists potential conferences or public events that could be relevant for the project. This table will be used and updates on different project partners' participation will be included in the midterm review for WP7 for month 1-18.

Description: title of the Event, title of the journal etc...	Address	Dates (year and Day/month if known) and Place	Participation
14th European SOFC & SOE Forum (with Conference, Exhibition & Tutorial): SOFC & SOE, including Reactors and Separators based on Solid Oxide Membranes	http://www.efcf.com	July 2018 Lucerne/ Switzerland	Presentation of REFLEX poster in CEA booth
FC EXPO 2019, 15th International Hydrogen & Fuel Cell Expo (within World Smart Energy Week 2019)	http://www.fcexpo.jp/en	Every year/Tokyo Japan	leaflets distributed by Elcogen in 2019
NOW GmbH: Hydrogen and Fuel Cell Technology Supplier Marketplace	http://www.now-gmbh.de/en/aktuelles/veranstaltungen	Every year, Germany	To be confirmed for the following years
14th International Hydrogen & Fuel Cell Conference: The Commercialisation of Hydrogen & Fuel Cell Technology	http://www.climate-change-solutions.co.uk	March 2019, UK	no

Materials Research Society Spring Meeting & Exhibit, including Symposia on Mechanics of Energy Storage and Conversion, Grid-Scale Energy Storage, and Hydrogen and Fuel Cell Technologies for Transportation	http://www.mrs.org/spring2017	2020 (USA)	
21st International Conference on Fuel Cells Science and Technology	https://waset.org/conference/2019/01/new-york/ICFCST	January 2019 (USA)	To be confirmed for the following years
Advanced Energy Conference, AEC 2020	http://www.aertc.orgk	2020 (USA)	To be confirmed
23rd World Hydrogen Energy Conference, WHEC 2020	http://www.whec2020.com/	June 2020, location not announced yet.	
SOFC - XVI	http://www.eguchi-lab.ehcc.kyoto-u.ac.jp/SOFC_XVI/index.html	September 2019, Japan	Joint article between DTU, Elcogen and CEA "Optimization of Solid Oxide Cells and Stacks for reversible operation" and presentation/participation by DTU
15th European SOFC & SOE Forum (with Conference, Exhibition & Tutorial): SOFC & SOE, including Reactors and Separators based on Solid Oxide Membranes	http://www.efcf.com	July 2020 Lucerne/ Switzerland	
Hannover fair	http://www.hannovermesse.de/home#	April every year Hannover Germany	Presentation of the leaflets and /or posters on DTU booth
FDFC209	https://fdcf2019.sciencesconf.org/resource/page/id/1	February 2019, Nantes, France	No
European Hydrogen Energy Conference (EHEC)	http://www.ehec.info/	2019	No
European Fuel Cell Technology & Applications "Piero Lunghi" Conference (EFC)	http://www.europeanfuelcell.it/	Every year in December in Italy	
International Renewable Energy Storage Conference (IRES)	http://www.energy-storage-online.com	Every year in spring	
Smart Energy Conversion and Storage	http://forum.hydrogen.edu.pl/	2019	No
Progress in Fuel Cell Systems - Bruges workshop	http://www.birmingham.ac.uk/research/activity/bruges/index.aspx	Every year in May, Belgium	
Conference on Carbon Dioxide as Feedstock for Fuels, Chemistry and Polymers	http://co2-chemistry.eu/programme	Is held every year, Germany	
EU Green Week	https://www.eugreenweek.eu/	Every year, May- June.	The subject changes every year.
Process system engineering conference: ESCAPE	http://efce.info/ESCAPE_E_28-p-20000955.html	Every year in June	

Process system engineering conference: CHISA / PRES	http://www.chisa.cz/	To be checked, normally summer	
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Table 2. List of events and conferences that are expected to be – and have been - relevant for disseminating REFLEX results.

For the conferences finally selected in the provisional list above, or any other identified as meaningful for the project, at least one paper per conference is targeted.

3. Dissemination monitoring

Table 3 lists the initial targets given for objectives at the beginning of the project. It also provides an estimate for the 1st reporting period as suggested in deliverable D7.2. Monitoring of the dissemination activities is done continuously via a shared Excel sheet at the projects share-point site and dissemination activities is discussed between the partners at the plenary project meetings each 6 months. A few notes regarding monitoring and obtaining the targeted dissemination activities as stated in D7.2 in Table 3 is given in the notes in the caption text and elaborated further in the midterm report for WP7.

4. Conclusion

This deliverable D7.3 provides an update of the initial Dissemination Action Plan handed in M6 as deliverable D7.2. Some additions have been made and the variety of possible – and already on-going – dissemination activities have been included when compared to D7.2. Dissemination and communication tools such as templates, website and newsletters has been successfully updated and will continue to be used actively in promoting and disseminating results obtained with in the REFLEX project; as well as coming participation in and contribution to conferences and public events is in the pipeline.

Target groups	Indicators for measuring the effectiveness of the approach	Min target value	Planned M1-M18	Achieved M1-M18	Feedbacks expected
Research community <i>Hydrogen, Fuel Cell and electrolysis researchers and industries</i>	Publications at international conferences (M12 onwards)	10	2	2: Abstracts for SOFC-XVI conference (Kyoto, Sept. 2019) and IECON IEEE 2019 congress (Lisbon, Portugal).	-Disseminate the latest results towards H2 and fuel cells actors -Designing new collaborative research proposals. -MoUs ¹ concluded between research and industrial partners.
	Publications in international journals (M12 onwards)	7	2	2 (ECS Transaction and IEEE conference paper). Full journal papers to follow after M18.	
	Participation with presentation of results at international events with industry	3	1	1: Hannover Fair 2019	
	Workshop with Industrial Advisory Board	1	0	First meeting with IAB planned for September 2019 and to take place at Engie (Paris)	
General public <i>Public and Private</i>	Non-scientific publications (articles, press releases) Participation in national events promoting new solutions for energy storage ad local energy in eco-buildings and districts	10	5	Non-scientific publications can be found here: www.reflex-energy.eu/downloads and newsletters are included in Appendix A in this deliverable.	-Attract attention and to generate interests for an optimal exploitation of the project's results.
	Flyers/Poster: Distributed at Conferences, workshops, exhibitions	1000	300	~400	
	Project Website: Number of Visits All public deliverables will be made available	3000 200	1000 50	1001 (June 26 th 2019)	
Customers <i>Local authorities, Companies Real Estate managers, Buildings industry (architects, engineering and building companies); Suppliers of Renewable Power</i>	Customer request for other projects deployment	50	7	Discussions taking place at DTU booth Hannover Fair 2019. SmarthYes demonstrator (first prototype by Sylfen, prior to REFLEX), being tested at Engie Lab Crigen, has been shown to several customers (energy companies, building and engineering companies), mentioning the on-going REFLEX program. Several requests from customers (energy industry) received by Elcogen on results of rSOC operation of system developed within REFLEX project.	-Discussions at our booth on industrial fairs (mainly Hannover Fair) -Request for specific features
	Interest of industrial customers on Technology Exploitation via license models	10	4		

¹ Memoranda of Understanding

<i>storage solutions & smart grid equipment</i>					
Standards and regulation bodies	Standardisation groups REFLEX will interact with: working group dealing with SOFC/SOEC testing methods (IEC TC105, Working Group 13, where CEA participates)	1	1	Participation of CEA at meeting of the Working Group 13 on rSOC in Milano, on 5-6 November 2018, to work on document IEC 62282-8-101 ED1: Fuel cell technologies - Part 8-101: Energy storage systems using fuel cell modules in reverse mode - Test procedures for solid oxide single cell and stack performance including reversible operation; periodic revision of the document including remarks to be discussed/validated/integrated in the document.	-Promoting the REFLEX results and making sure that they can be integrated and contribute in future standards
	Participation in EU commission's consultation and other worldwide regulatory in the field of interest	1	0		
Education <i>Students (PhD Master students)</i>	Integration of modules with project results in regular courses; Contributions to one relevant Summer School: e.g. European Summer School (JESS) on Fuel Cell, Electrolyser and Battery Technology	1	2	Activities in WP2 has already been exploited as part project work in course 47205 "Energy Technologies" at DTU. Integration of REFLEX concept in 2 courses on hydrogen and fuel cells given by CEA in engineering schools: 1) at PHELMA, Grenoble in November 2018; 2) at ENSCBP in Bordeaux in March 2019: courses given every year will be updated with REFLEX results for the next years.	-Education of future technology users
Final dissemination event	Presentation and Inauguration of the demonstrator when installed on the site Large panel of invitees addressing EU representatives, companies involved in the field of hydrogen and fuel cells, local authorities from several European regions, policy makers, etc. Subsequent guided visits of the demo unit could be arranged.	1	0		- Better knowledge of the potential of the technology
Visits of the Demo Unit	During the last year of the project, visits of the REFLEX Demo Unit will be organised by the project partners	6	0		Education & raising awareness of potential customers.

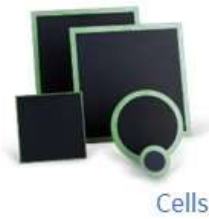
Table 3. REFLEX Dissemination targets and overview of achievements in M1-M18 in relation to set targets. For full listing of dissemination activities, refer to listing in Appendix B.

5. Appendix A – Newsletters

Newsletters available at <http://www.reflex-energy.eu/downloads>



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Cells

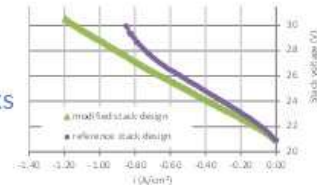


The REFLEX project aims at developing an innovative renewable energies storage solution, the “Smart Energy Hub”, based on reversible Solid Oxide Cell (rSOC) technology, that is to say able to operate either in electrolysis mode (SOEC) to store excess electricity to produce H_2 , or in fuel cell mode (SOFC) when energy needs exceed local production, to produce electricity and heat again from H_2 or any other fuel locally available.

The challenging issue of achieving concomitantly high efficiency, high flexibility in operation and cost optimum is duly addressed through improvements of rSOC components (cells, stacks, power electronics, heat exchangers) and system, and the definition of advanced operation strategies.



Stacks



System demonstration

The specifications, detailed system design and the advanced operation strategies are supported by modelling tasks. An in-field demonstration will be performed in a technological park, where the Smart Energy Hub will be coupled to local solar and mini-hydro renewable sources and will provide electricity and heat to the headquarters of the park. It will demonstrate, in a real environment, the high power-to-power round-trip efficiency of this technology and its flexibility in dynamic operation, thus moving the technology from Technology Readiness Level (TRL) 3 to 6.



The Smart Energy Hub being modular, made of multistacks/multimodules arrangements, scale up studies will be performed to evaluate the techno-economic performance of the technology to address different scales of products for different markets. To reach these objectives, REFLEX is a cross multidisciplinary consortium gathering 9 organisations from 6 member states (France, Italy, Denmark, Estonia, Spain, Finland). The partnership covers all competences necessary: cells and stacks development and testing (ELCOGEN, CEA, DTU), power electronics (USE, GPTech), system design and manufacturing (SYLFEN), system modelling (VTT), field test (Envipark), techno-economical and market analysis (ENGIE).

Consortium



The REFLEX project – www.reflex-energy.eu
 FCH2 JU grant agreement number 779577
 Started: 01/01/2018 – Duration: 36 months



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WP on cells and stack development



In REFLEX it is planned to optimize cells and stack design for reversible Solid Oxide Cell (rSOC) operation. By targeting high fuel utilization (85 %) at high current densities (0.6 A cm^{-2} in SOFC and -1.2 A cm^{-2} in SOEC), the right balance between mechanical strength, fuel diffusion properties and durable electrochemical performance must be obtained.

Results: Cell development

Standardized cell performance evaluation at open circuit voltage (OCV) and targeted operating conditions of various microstructure modifications, i.e. fuel electrodes, oxygen electrodes and barrier layer, have been conducted. In total more than 10 different microstructures and cell layouts have been produced and compared.

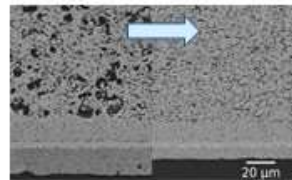


Fig 1. Secondary electron microscopy images of two modified cell microstructures.

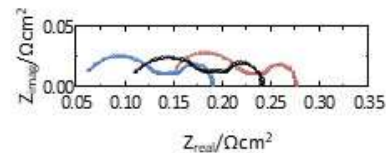


Fig 2. Electrochemical Impedance spectra at $T = 700 \text{ °C}$ at 50/50 $\text{H}_2/\text{H}_2\text{O}$ and air of 3 types of barrier layer modified cells.

Results: Long-term testing under reversible operation

Cells which show initially high performance are further durability tested under reversible operating conditions. The cells were operated galvanostatically over 1000h with cycles made of 16 h in fuel cell and 8 h in electrolysis mode. Thereby it could be shown that the most critical cell degradation evolves under electrolysis mode conditions during the initial (approx. 400 h) of testing.

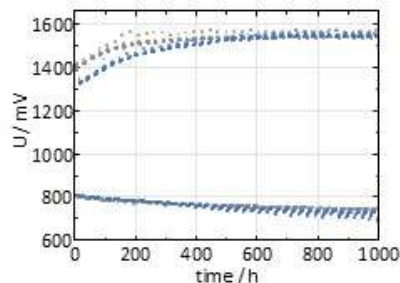
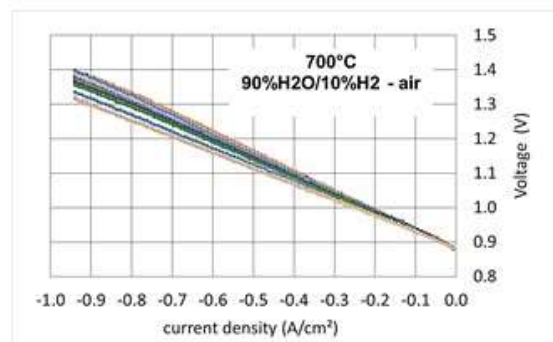


Fig 3. 1000 h durability tests of two modified cell structures at $T = 700 \text{ °C}$, 0.6 A cm^{-2} (SOFC) and -1.2 A cm^{-2} (SOEC) and 85 % FU.

Results: Stack development

For rSOC operation, stack design has been optimized. A minimization of the internal air pressure drop (by a factor of 2) and an improvement of the sealing resistance towards higher pressure could be achieved while maintaining the electrochemical performance.

Fig 4. i-V curves at 700 °C of the 25-cell short stack





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Objectives

The REFLEX project aims at developing an innovative renewable energies storage solution, the “Smart Energy Hub”, based on reversible Solid Oxide Cell (rSOC) technology, able to operate either in electrolysis mode (SOEC) to store excess electricity to produce H₂, or in fuel cell mode (SOFC), when energy needs exceed local production, to produce electricity and heat again from H₂ or any other fuel locally available. The challenging issue of achieving concomitantly high efficiency, high flexibility in operation and cost optimum is addressed through improvements of rSOC individual components and system, and the definition of advanced operation strategies.

Power electronics induce losses, generally around 5% at near vicinity of the nominal point, that rapidly increase as system evolves away the nominal point. The operation at high currents and low voltages as well as with large power modulations requires work on power electronics to enlarge the high efficiency domain in all operating modes. A global control system is developed for the set of storage systems with the help of power electronics devices.

System design

The overall Smart Energy Hub design has been defined, with an electrical architecture selected among several possible options to maximize the electrical efficiency in all operating modes. The electrical components have been selected, purchased/or manufactured. The thermal management components have been specified as well. Various scenarios for the demonstration at Envipark have been defined, taking into account production and consumption profiles.



Power electronics and storage system developments

DC-DC converters & Battery system



- **DC-DC converters:** >90% Hi-efficiency reversible power electronics converters allow the injection of low DC voltage from the rSOC [34-68 V] to the Hi-Voltage bus [380 V] and, in the fuel cell mode operation; the converters inject the power from the Hi-Voltage bus to the rSOC to produce Hydrogen in electrolysis mode.
- **Battery Storage System:** >50kWh Li-Ion energy storage system in a compact 42U height cabinet working as backup energy system.

DC-AC converters



DC AC Converters: A turn-key bidirectional Power converter to integrate a Li-Ion battery and an autonomous Power Converter to connect the DC bus created by DCDCs Power Converters of the Fuel Cells to the AC main grid.

6. Appendix B – Summary of already conducted dissemination

Partner	Participant(s)	Event	Place/date	Type of activity	Title/Topic	Comment
DTU	Karl Thyden	Hannover Fair 2018	Hannover, 23-27/04/2018	booth	presentation of REFLEX overall concept and objectives	REFLEX flyer and poster
CEA	Julie Mougín	4th Symposium - SOFCs for next generation power plants / BALANCE workshop	Delft, 01.02.2018	Invited talk	Development and operation of a reversible solid Oxide Cell system and its application to store intermittent renewable energies	REFLEX mentioned in the perspectives
CEA	Jérôme Aicart	Workshop Series: Fuel Cell Systems, 12th Workshop 2019, Fuel Cell and Electrolyser Systems	29-30 May 2018, Bruges	Invited talk	rSOC developments and testing at CEA	REFLEX mentioned in the perspectives
CEA	Julie Mougín	EFCF 2018	Lucerne, 3-6/07/2018	booth	presentation of REFLEX overall concept and objectives	REFLEX flyer and poster
Elcogen	Enn Ounpuu, Marek Roostar, Henri Kaar	FC EXPO 2019 - 16th Int'l Hydrogen & Fuel Cell Expo	27.02.19-01.03.19, Tokyo	Booth	Presentation of fuel cells and stacks	REFLEX flyer
DTU	Xiufu Sun, Karl Thyden	Hannover Fair 2019	Hannover, 01-05/04/2019	booth	presentation of REFLEX overall concept and achievements	REFLEX flyer and poster, leaflet
DTU	Anne Hauch (substitut	SOFC XVI	Kyoto, Japan, 8-13/09/2019	Poster or oral	Optimization of Solid Oxide Cells and Stacks for reversible operation	Presentation/poster focused on DTU part of submitted proceeding paper

	e for Alexandra Ploner)			presentation		
USE	Guillermo Perez, Eduardo Galvan, Juan Manuel Carrasco	IECON IEEE 2019 Lisbon	Lisbon, Portugal October 2019	oral	DC-DC DAB converter with high voltage-ratio transformation for smart-grids and automotive application	Conference paper: oral presentation
CEA	Julie Mougin	Colloque Hydrogène décarboné: Enjeux et solutions ?	Paris, 13 June 2019	oral	presentation of the SOC technology (in French)	rSOC concept and REFLEX project mentioned
Sylfen	Nicolas Bardi	Colloque Hydrogène décarboné: Enjeux et solutions ?	Paris, 13 June 2019	oral	presentation of Sylfen product (in French)	rSOC concept and REFLEX project mentioned
CEA	Julie Mougin	Workshop Production décarbonée d'hydrogène: vision et perspectives	Cadarache, 28 June 2019	oral	presentation of the SOC technology (in French)	rSOC concept and REFLEX project mentioned
CEA	Julie Mougin	Energy-X Workshop : Research needs towards sustainable production of fuels and chemicals	Brussels, 2-3 June 2019	oral	presentation of the SOC technology	rSOC concept and REFLEX project mentioned
Sylfen	François Eudes Ruchon	Intersolar fair	Munich, 20-22 June 2018	Booth	presentation of the Sylfen product technology	rSOC concept and REFLEX project mentioned
Sylfen	François Eudes Ruchon	Smart Building Gimelec fair	4 juillet 2018	Oral	presentation of Sylfen product (in French)	rSOC concept and REFLEX project mentioned
Sylfen	François Eudes Ruchon	Nobatek/Inef4 meeting days	5 juillet 2018	Oral	presentation of Sylfen product (in French)	rSOC concept and REFLEX project mentioned

Sylfen	François Eudes Ruchon	Hydrogen days in territory (Afhypac)	26-27 Septembre 2018, Paris	Booth	presentation of the Sylfen product technology	rSOC concept and REFLEX project mentioned
Sylfen	François Eudes Ruchon	The Business Booster fair	17-18 Octobre 2018, InnoEnergy, Copenhagen	Booth	presentation of the Sylfen product technology	rSOC concept and REFLEX project mentioned
Sylfen	François Eudes Ruchon	Ecotech meeting days	19 décembre 2018	Oral	presentation of the Sylfen product technology	rSOC concept and REFLEX project mentioned
Sylfen	François Eudes Ruchon	Hydrogen conference(ENSGTI)	15 mars 2019, Pau, France	Oral	presentation of the Sylfen product technology	rSOC concept and REFLEX project mentioned
Sylfen	François Eudes Ruchon	Event InnoEnergy	4 mars 2019, Milano	Oral	presentation of the Sylfen product technology	rSOC concept and REFLEX project mentioned
Sylfen	François Eudes Ruchon	BePOSITIVE fair	13-15 février 2019	Booth	presentation of the Sylfen product technology	rSOC concept and REFLEX project mentioned
Sylfen	François Eudes Ruchon	Press conference Challenge construction tech	15 janvier 2019	Oral	presentation of the Sylfen product technology	rSOC concept and REFLEX project mentioned
Sylfen	François Eudes Ruchon	Smart-up Gimélec	3 juin 2019	Oral	presentation of Sylfen product (in French)	rSOC concept and REFLEX project mentioned
Sylfen	François Eudes Ruchon	Smart Energies Expo	5-6 juin	Booth	presentation of Sylfen product (in French)	rSOC concept and REFLEX project mentioned
EnviPark	Envipark	website Envi	24 January 2019	Written	presentation of REFLEX overall concept and objectives	Webpage: https://www.envipark.com/en/?s=Reflex
EnviPark	Sabina Fiorot	newsletter and website Envi	7 February 2019	Written	Project meeting presentation	Webpage: https://www.envipark.com/?s=Reflex

EnviP ark	EnviPark	Press release	19 January 2018	Written	Project start-up	https://www.envipark.com/2018/01/19/al-via-al-progetto-reflex-lo-stoccaggio-energia-prodotta-fonti-rinnovabili/
EnviP ark	EnviPark	First newsletter	18 January 2018	Newsletter	General info of the project and project launch	first newsletter to 3700 Italian contacts (SMEs, Universities, Institutes, FCH stakeholders) mainly Companies involved in Energy&Cleantech cluster coordinated by Envipark.
EnviP ark	EnviPark	Second newsletter	18 July 2018	Newsletter	Project progress	3700 Italian contacts (SMEs, Universities, Institutes, FCH stakeholders) mainly Companies involved in Energy&Cleantech cluster coordinated by Envipark.
Envip ark	Envipark	Third newsletter	21 June 2019	Newsletter	project progress	3700 Italian contacts (SMEs, Universities, Institutes, FCH stakeholders) mainly Companies involved in Energy&Cleantech cluster coordinated by Envipark.
DTU	Anne Hauch	Course 47205 "Energy Technologies"	May 2019	Lecture/stu dent project work	Electrochemical characterization of rSOEC	Bachelor course at DTU, course description here: www.kurser.dtu.dk/47205

7. Appendix C – Posters presented at 13th European SOFC & SOE FORUM 2018 (left) and Hannover Fair 2019 (right)

