



//EU HYDROGEN  
RESEARCH DAYS  
15-16 NOVEMBER

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

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CEA

<https://www.reflex-energy.eu>

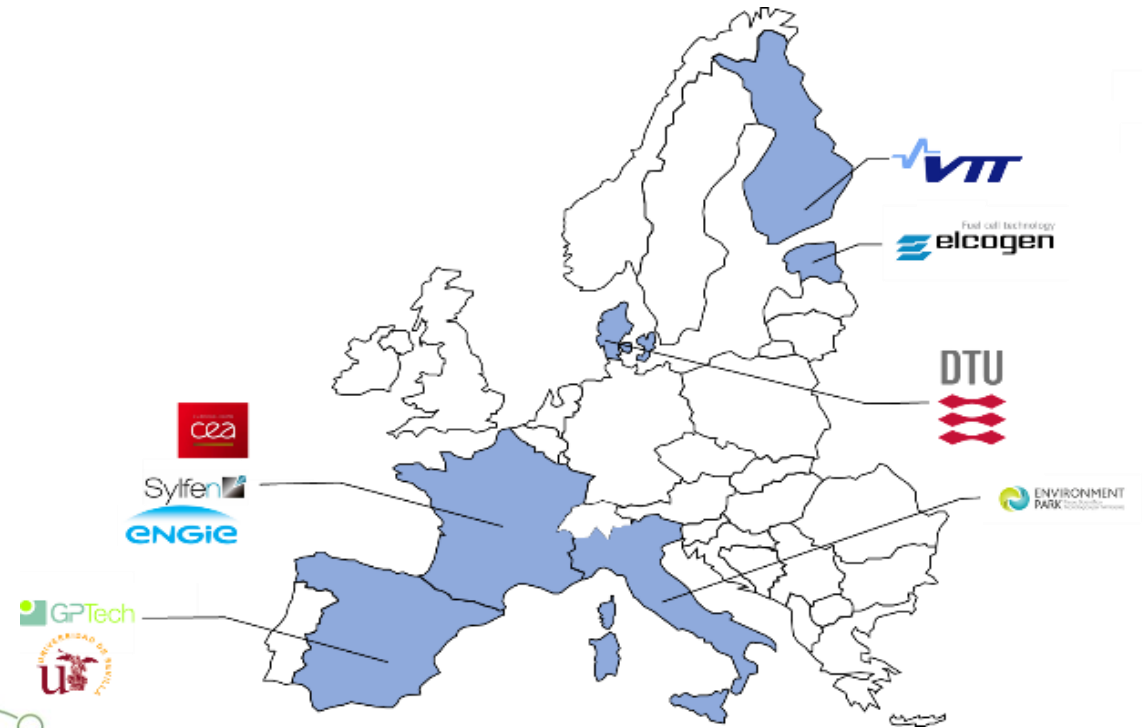
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Co-funded by  
the European Union

# Project Overview

- Call year: 2017
- Call topic: FCH-02-3-2017 Reversible Solid Oxide Electrolyser (rSOC) for resilient energy systems
- Project dates: 01/01/2018-30/06/2023
- % stage of implementation 01/11/2023: 100%
- Total project budget: 2 999 575 €
- FCH JU max. contribution: 2 999 575.25 €
- Other financial contribution: 0 €
- Partners: CEA, DTU, VTT, GPTech, ELCOGEN, SYLFEN, ENGIE, ENVIPARK, Univ. Seville

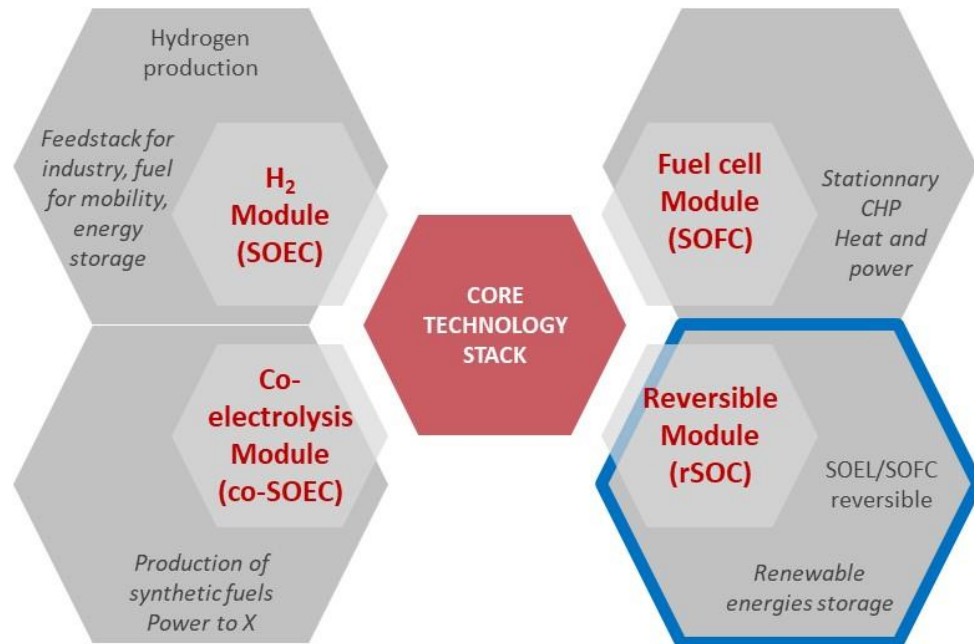


# Project Summary

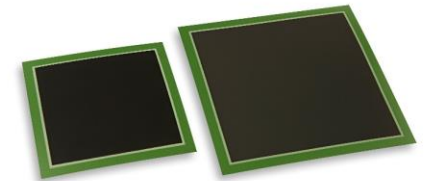
## Main objectives



- Developing an innovative renewable energies storage solution, so-called “**Smart Energy Hub**”,
  - based on reversible **rSOC** technology
  - completed with an electrochemical storage solution allowing fast response to the electrical energy needs



- rSOC core technology:
  - Ceramic cells assembled in stacks
  - rSOC= reversible solid oxide cell
- Operates at high T: 700°C
- Main advantages:
  - Flexibility of usage
  - High efficiency in all modes
  - Fuel flexibility



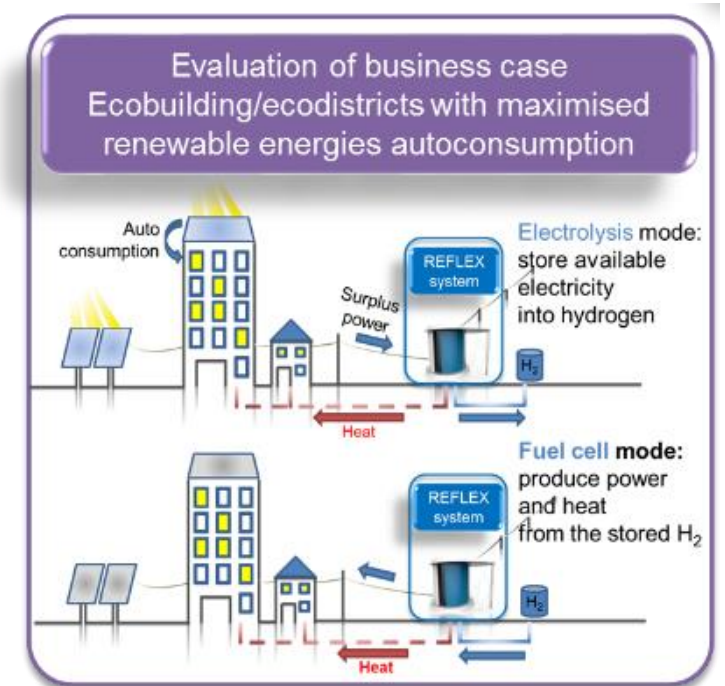
# Project Summary

## Main objectives

- **Demonstrate, in-field**, the high power-to-power (P2P) **round-trip efficiency** of this technology (as compared to other H<sub>2</sub> based solutions) and its flexibility and durability in **dynamic operation** (power transient and switch between electrolysis and fuel cell mode)
- Smart Energy Hub installed In SLS Actiparc in France



- Application and market area targeted: ecobuildings/ecodistricts with maximised renewable energies autoconsumption





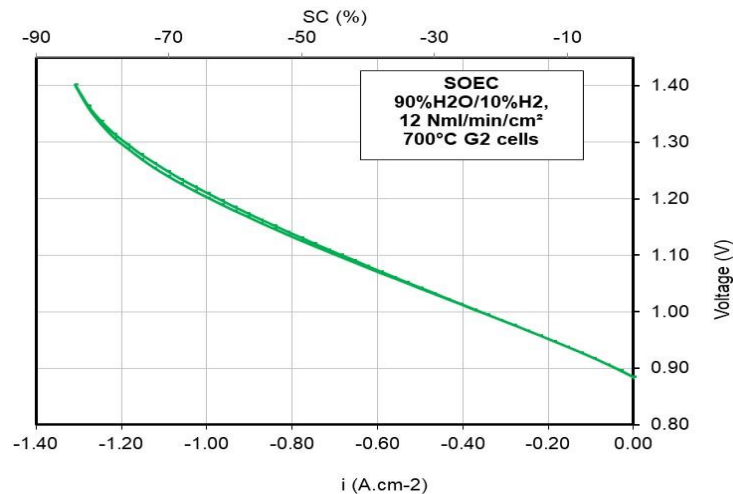
# Project Progress/Actions - Cells and stack performances

## Achievement to-date

- 1.0 A/cm<sup>2</sup> in SOEC  
at 1.3 V (U<sub>TN</sub>),  
0.5 A/cm<sup>2</sup> at 0.8V in  
SOFC  
FU = 50-60%

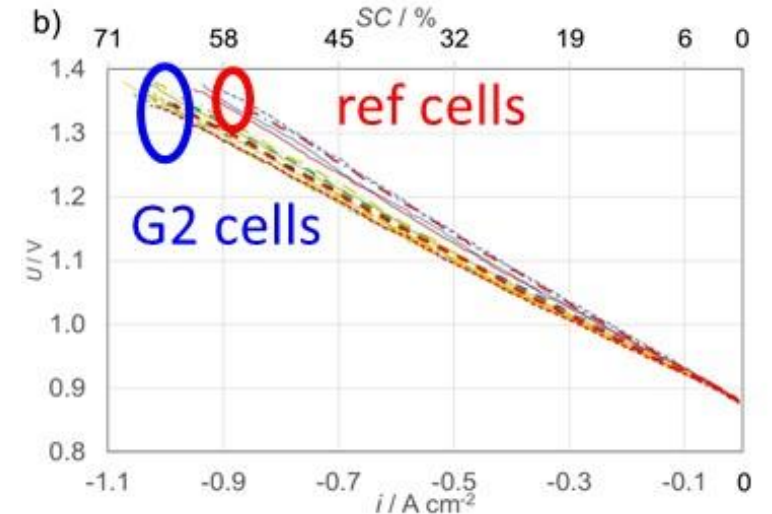
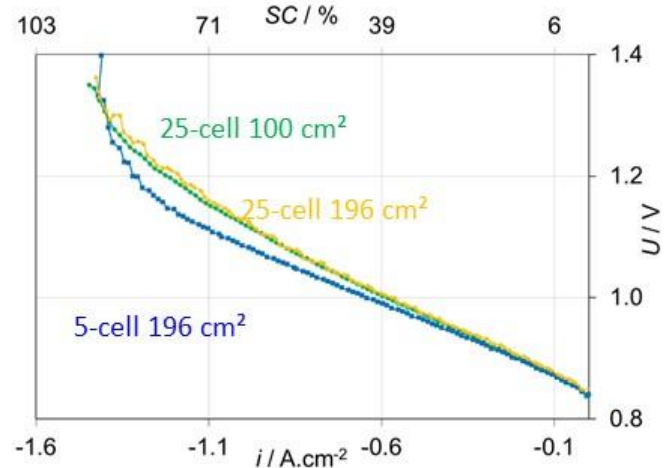
G. Cubizolles, et al., *ECS Trans.*,  
103 (1) 351-361 (2021)

- 1.2 A/cm<sup>2</sup> in SOEC  
at 1.3 V (TNV),  
0.6 A/cm<sup>2</sup> in SOFC  
at 0.8V  
FU = 85%



Targets reached with G2 cells (electrode supported cells) developed in the project

Successful upscaling of cells up to 200 cm<sup>2</sup>  
Successful integration of cells into stacks



Manufacturing of 16 stacks for the Smart Energy Hub with low scattering

# Project Progress/Actions - Cell and stack durability

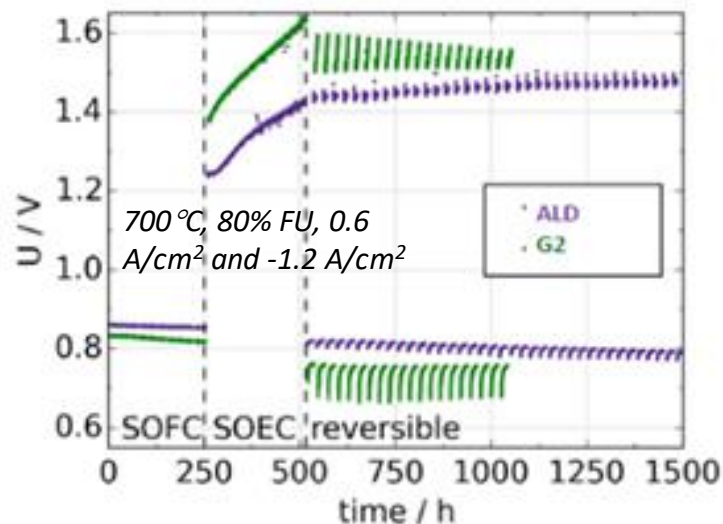
A. Hauch et al., 14th European SOFC&SOE Forum 20-23  
October 2020, Luzern B0903 (2020)

A. Ploner et al, ECS Transactions, 91 (1) 2517-2526 (2019)

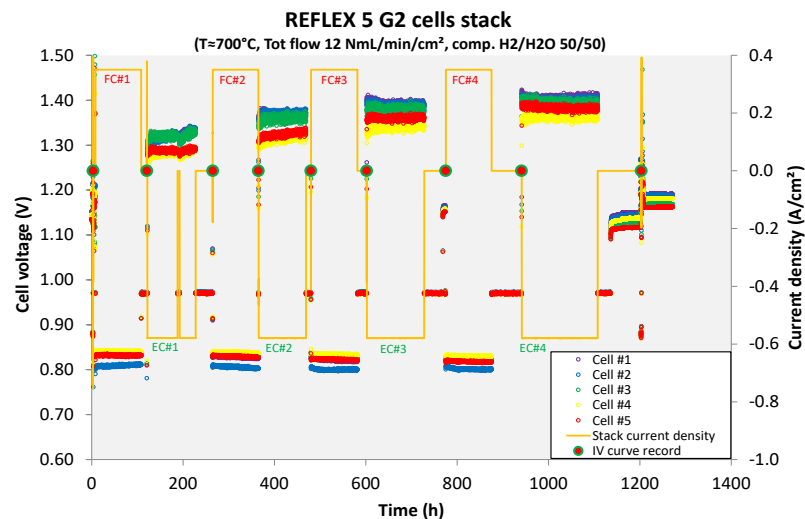
## Achievement to-date

Degradation  
above 5%/1000h  
(severe  
conditions)

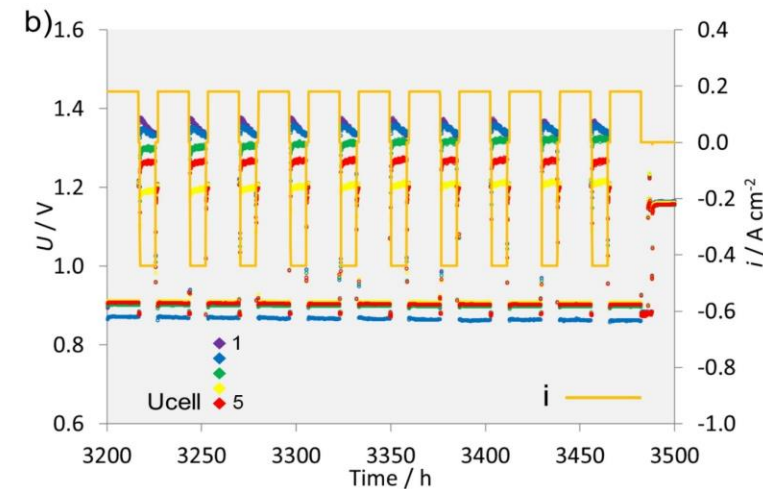
Degradation  
< 2%/1000h



Target reached with G2 cells  
developed in the project in rSOC  
Degradation still high in SOEC in  
those severe conditions



Degradation rates in stack decreasing down to almost zero after 600h  
Thermal effects visible on daily cycles in electrolysis mode



# Project Progress/Actions - Smart Energy Hub Operation

## Achievement to-date

Power (%)	SOEC	SOFC-H2	SOFC-CH4
P min	58	23	13
P med	80	66	75
P max	100	100	100

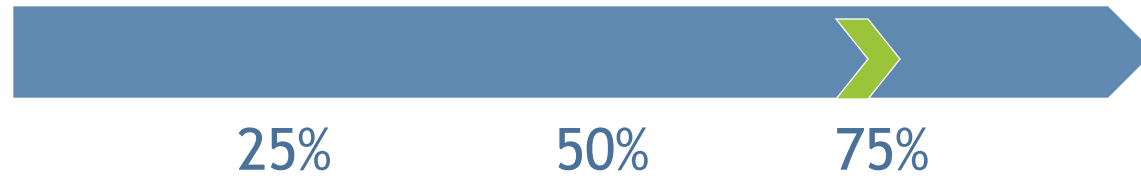
Large power modulation validated at stack level in 3 modes:

SOFC: 13-100% in CH4, 23-100% in H2

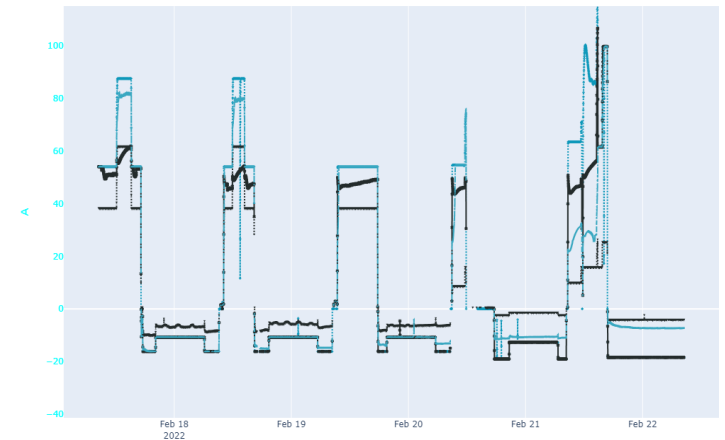
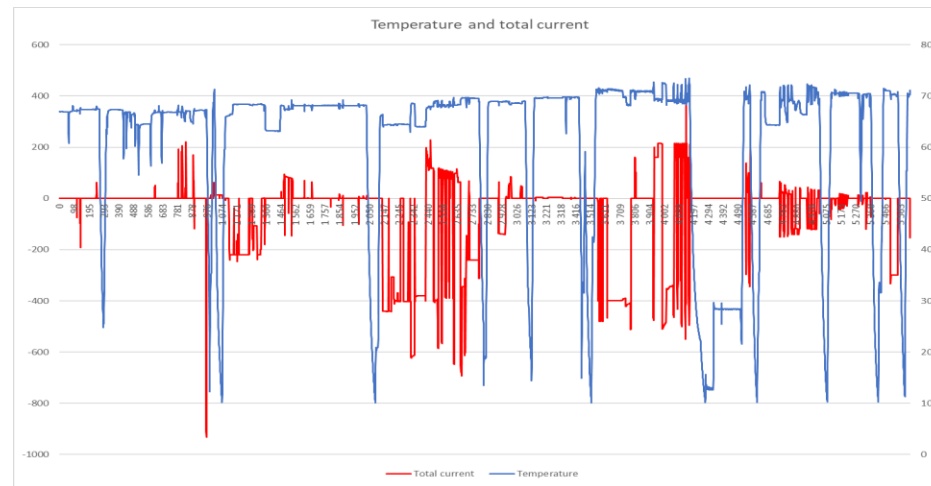
SOEC: 58-100% in SOEC

Setpoints used for system

No multistack module operation



power modulation:  
50-100% SOFC  
70-100% SOEC



> 5600 hours of operation gathering all testing campaigns on one module

more than 3300 h in SOEC or SOFC mode

135 SOEC/SOFC cycles

# Risks, Challenges and Lessons Learned

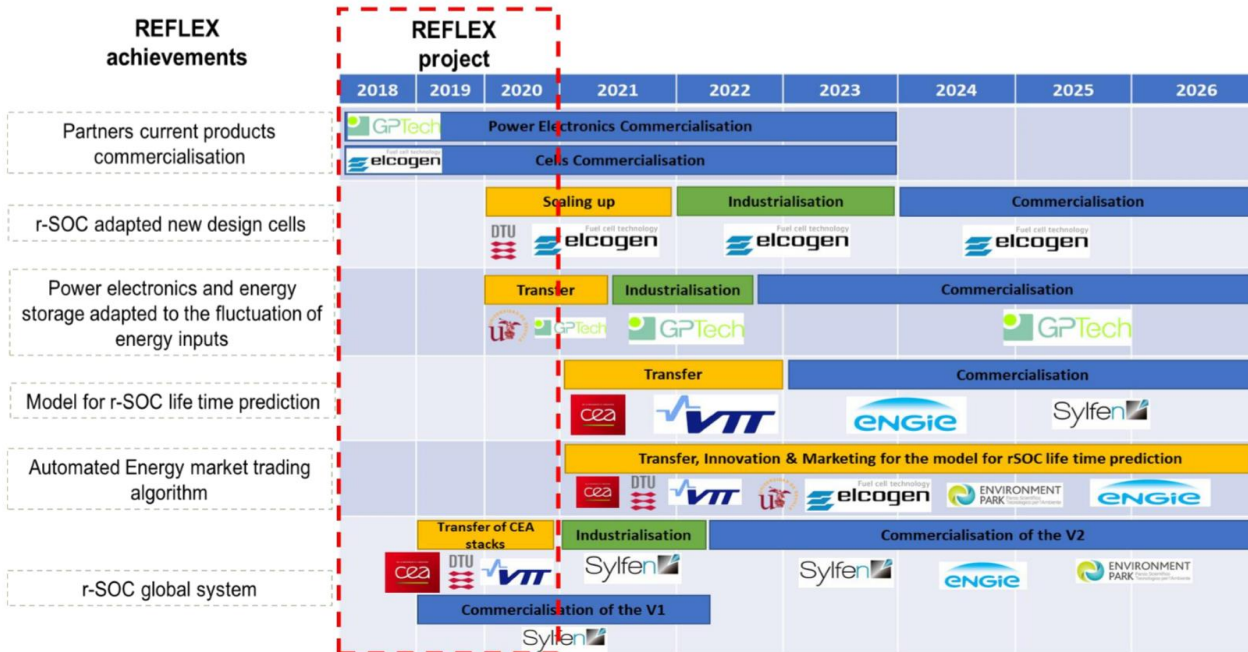
		Measures taken
<b>Risks</b>	Delay in some tasks, mainly cells/stacks testing, stack manufacturing and system design and manufacturing	Parallelisation of some stacks, rescheduling of overall project planning with extension Start of the test with one module
	Regulatory issues with integration in the demo site	Anticipation of preliminary works for installation, including permitting and risk analysis Change of demonstration site
<b>Challenges</b>	Thermal management with switching between SOFC and SOEC and with power modulations	Extensive modelling tasks supporting system design with several options investigated
	Higher costs than planned	Decrease of the number of modules Change of demonstration site



# Exploitation Plan/Expected Impact

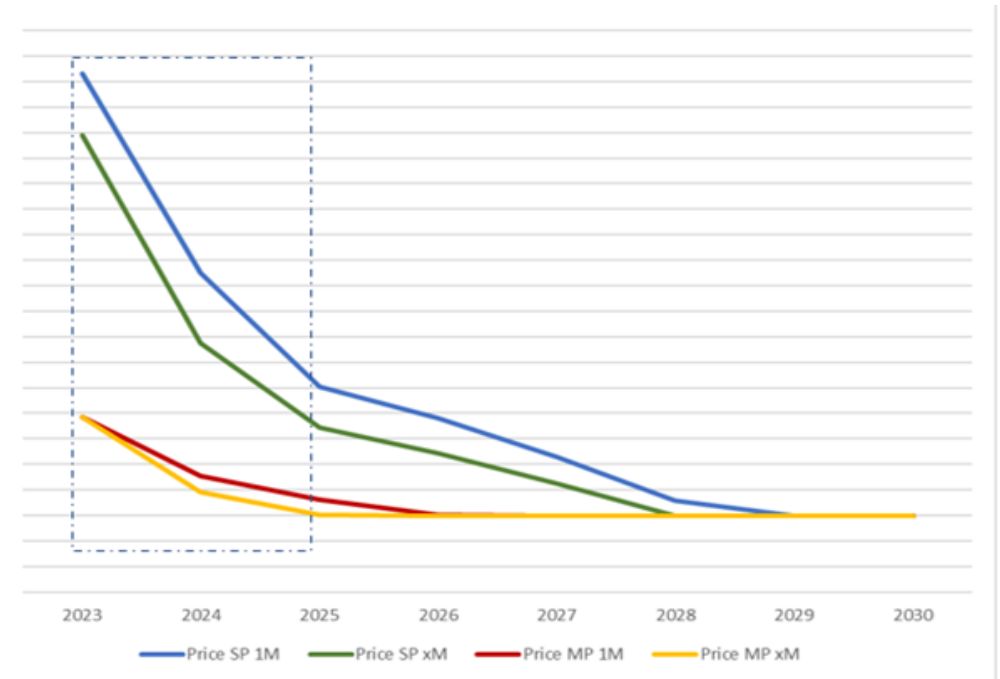
## Exploitation

Projects partners on the whole value chain: each having its own stone



## Impact

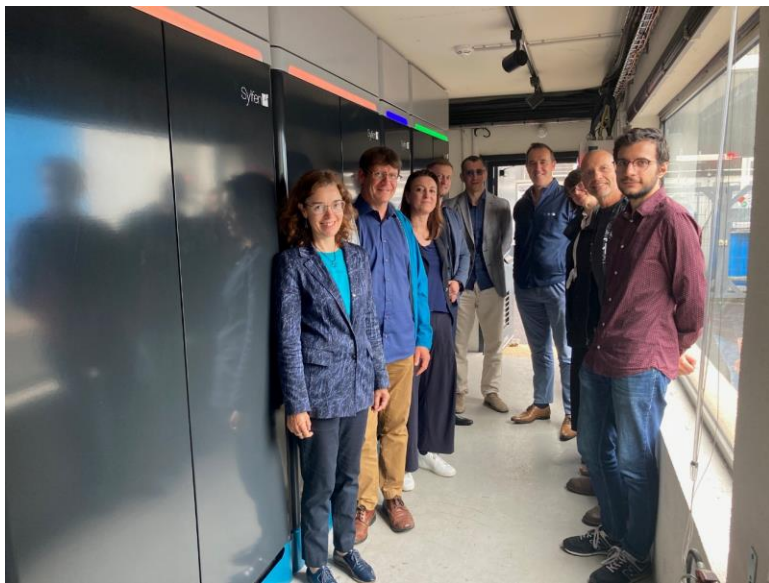
- Most promising markets identified: Before 2025, technology competitive in Germany and Italy, for offices and shopping centers, compared to battery or no PV cases
- Product price decrease forecast over the years



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# Communication activities

- 13 conferences
- 15 publications
- > 10000 visitors on website
- Large dissemination to general public
- International advisory board
- Final event



**2023**

13 JUL  
Video of site preparation and Smart Energy Hub integration for in-field test at...

07 JUL  
REFLEX results included in a presentation given by CEA at SOFC-XVIII conference

11 MAY  
REFLEX project presented at the HYVOLUTION Fair

**REFLEX**  
Reversible solid oxide Electrolyzer and Fuel cell for optimized Local Energy mix

**Closing event**

REFLEX project invites you to its closing event on 30 June 2023 in SLS Actiparc at Le Cheylas, France, to visit the Smart Energy Hub developed and installed in the frame of the project

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No779577. This Joint Undertaking receives support from the European Union's Horizon 2020 Research and innovation program, Hydrogen Europe and Hydrogen Europe Research





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