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FUNDACIÓN PARA EL DESARROLLO DE LAS NUEVAS TECNOLOGÍAS DEL HIDRÓGENO EN ARAGÓN

Elyntegration project overview

Vanesa Gil

EU Workshop – Electrolysis: features, capabilities and projections

23 May 2019, Huesca, Spain

Grid Integrated Multi Megawatt High Pressure Alkaline Electrolysers for Energy Applications: ELYntegration

elyntegration

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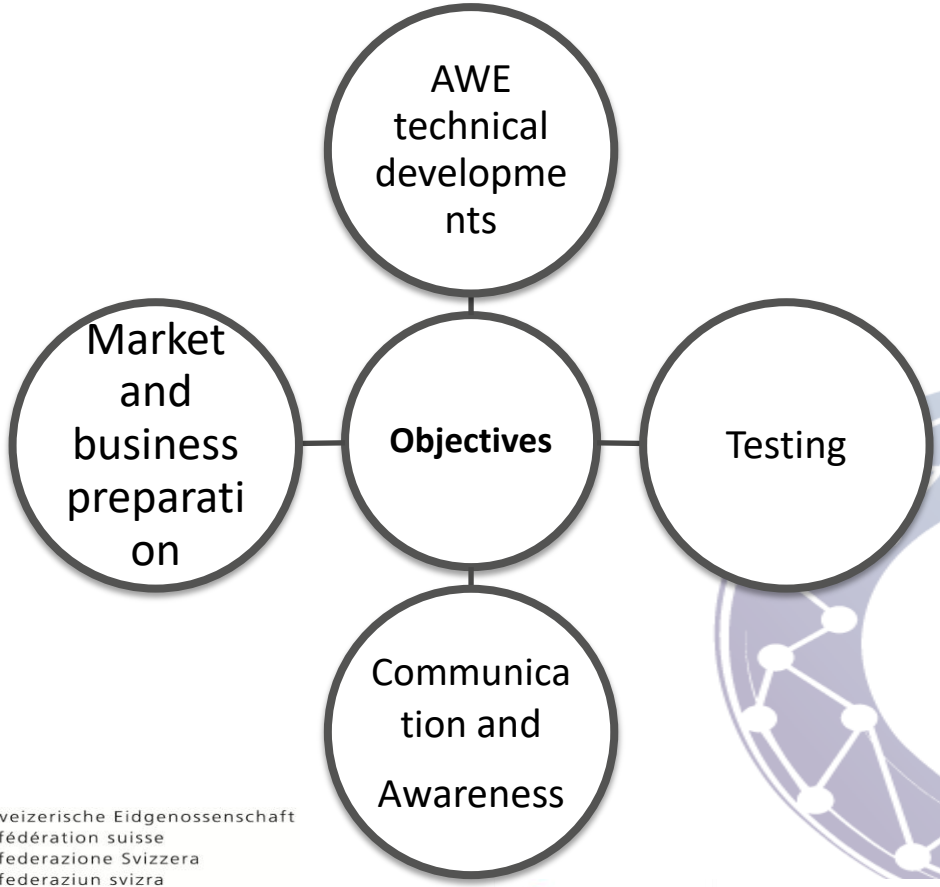
The Consortium

- FHA (Coordinator, ES)
- IHT (CH)
- VITO (BE)
- Fraunhofer-IFAM (DE)
- Inycom (ES)
- IAEW-RWTH Aachen (DE)

ELYntegration – project overview

- Duration: September 2015 – May 2019
- The strategic goal of ELYntegration is the design and engineering of a:
  - robust, flexible and cost competitive
  - Multi Megawatt alkaline water electrolyser
  - capable of producing - with a single stack - up to 4.5 ton H_2/day for energy applications.

Overview


AWE technical developments
Market and business preparation
Objectives
Testing
Communication and Awareness

Alkaline Water Electrolysis

- **Cell design and improvements at stack level**

→high performance in a broad range of the electrolyser load

  - Material development (electrodes , membranes)
  - Topology and assembly of the final stack solutions

- **Definition and design of an optimized balance of plant (BoP) for the dynamic operation**
  - Analysis of the BoP components and streams which could derive in lower costs of the system
  - Participation of industrial and technological partners
- **Advanced communication and control system**
  - Requirements of end-users
  - Enhance the flexibility of the electrolyser providing grid services

Testing

- Tested step by step and continuously during the project:
  - from ex-situ characterization at laboratory level
  - to in-situ testing at different scales (micro pilot to industrial size)
- The most promising results obtained in the project have been included in a final validation electrolyser working in an operational environment.

Highlights – Novel separator membranes

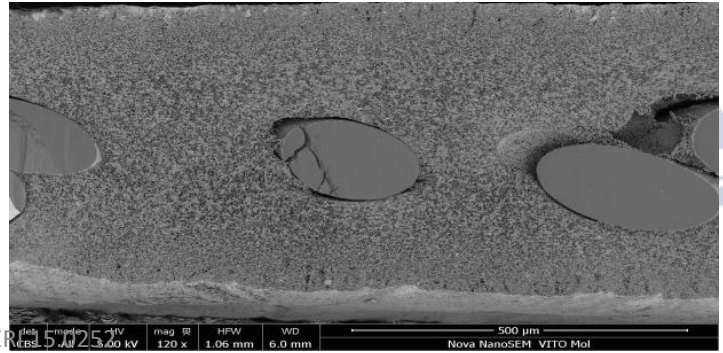
- Highly porous, compressible separator **membrane**
  - low ionic resistance
  - gas tightness thanks to compression in the electrochemical cell

Separator in un-compressed form

Separator compressed in the cell to ~80% of its original thickness

Cross-section of a compressible separator

- Mixed matrix (organic-inorganic) composite membrane
- Textile reinforcement
- Pore template (60 nm/3000 nm primary grain size)

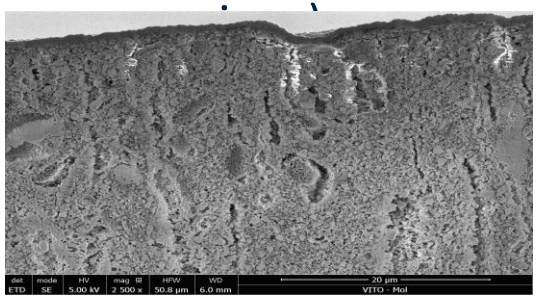


Advanced stack:
new separator membranes, 10 kW power

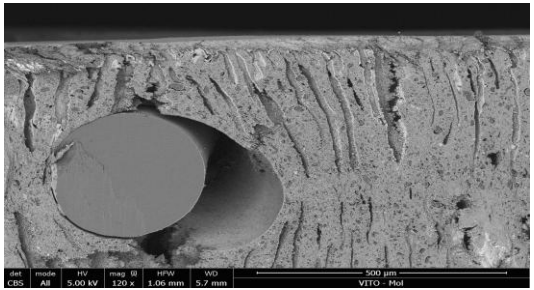
In total:

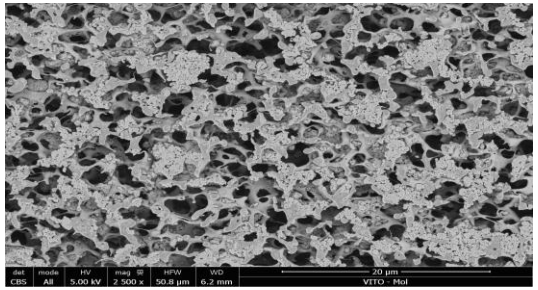
Eight different membranes have been developed and tested **at micropilot scale:**

- 60 nm template particles; 750 µm, 1000 µm and 1250 µm.
- 3000 nm template particles; 750 µm (2 versions), 1000 µm 1250 µm (2



60 nm template





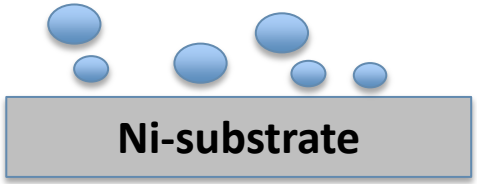
3000 nm template

Two tested at pilot scale

One tested at industrial scale

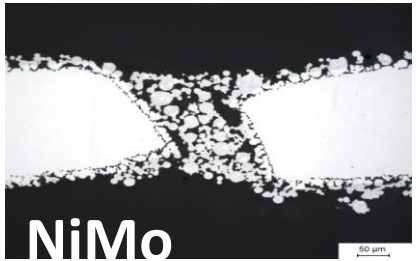
Highlights – Novel electrodes

- An innovative powder metallurgical (PM) route was used to coat a porous substrate (mesh and foam) with an electrochemically active catalyst material (Mo, NiMo and Raney-Ni).



1. Powder deposition

2. ΔT

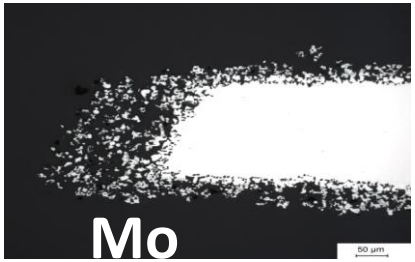


- The production was process was tested on industrial scale and a protocoll for safe handling was developed.
- The highest activity for the HER was obeserved for Raney-Ni electrodes (η_{300} (5 h) < 100 mV). The catalyst was very stabel attached to the substrate even after the AST tests.

→ PM route is suitable for the pproduction of hihgly efficient electrodes for GW electrolysis market.

In total:

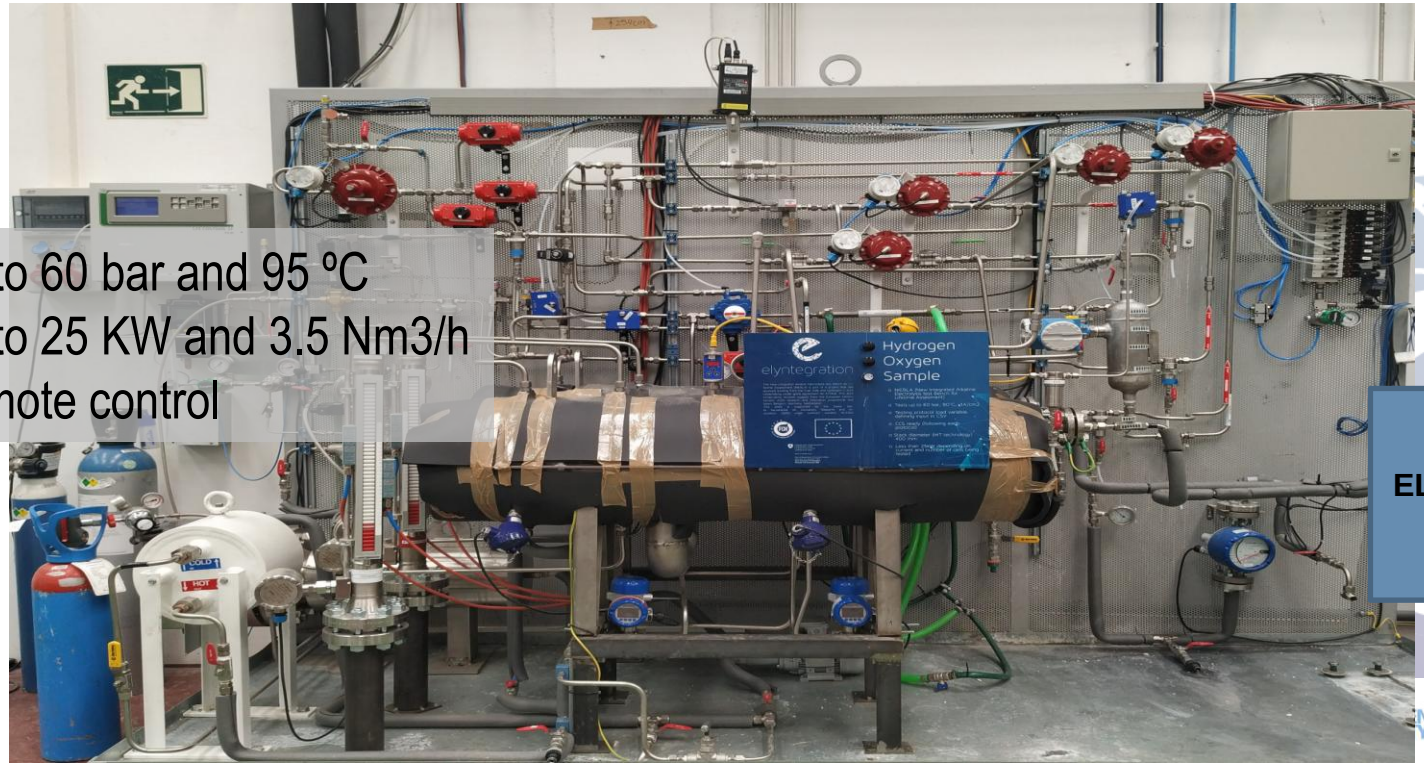
Three different kinds of **electrodes** have been developed at IFAM (Mo, NiMo and Raney-Ni) using a powder metallurgical route.



4 sets of electrode (Ni-, Mo-, NiMo- and Raney-Ni coated) tested **at micropilot scale**

2 sets of electrodes (NiMo and Raney-Ni)tested **at pilot scale**

Test benches commisioned at FHA - pilot scale



- ✓ Up to 60 bar and 95 ºC
- ✓ Up to 25 KW and 3.5 Nm3/h
- ✓ Remote control

STACK ELECTROLYSER (10 kW)

Testing at pilot scale

- Stack performance (characterization)
- Accelerated stress tests protocols

→ lifetime assessment under high dynamic loads

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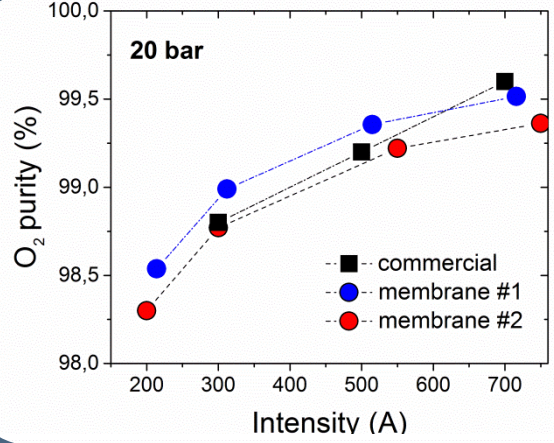
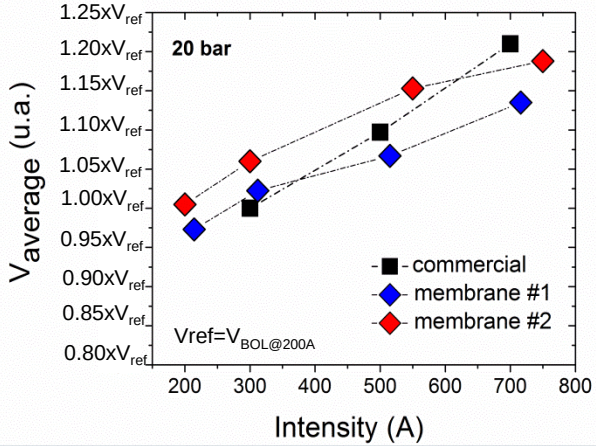
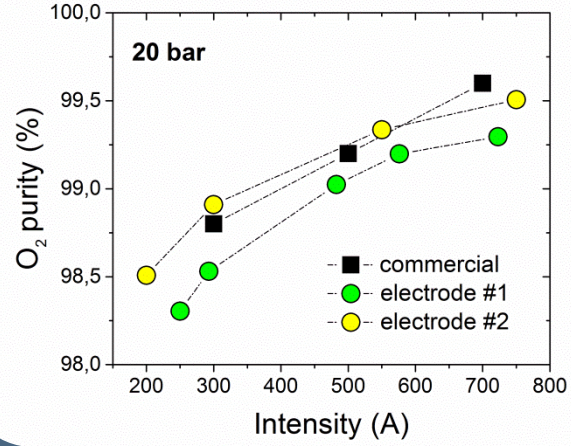
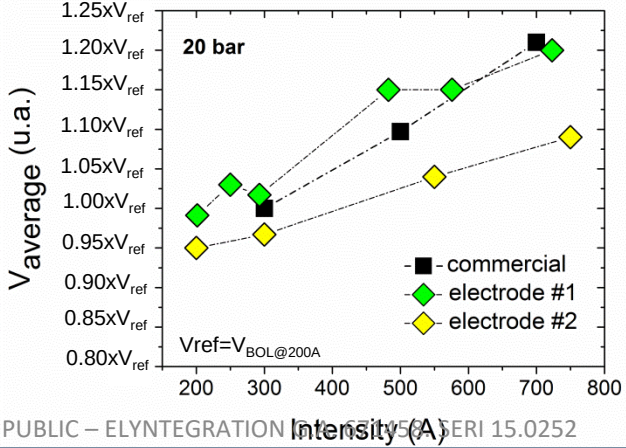
Stack performance





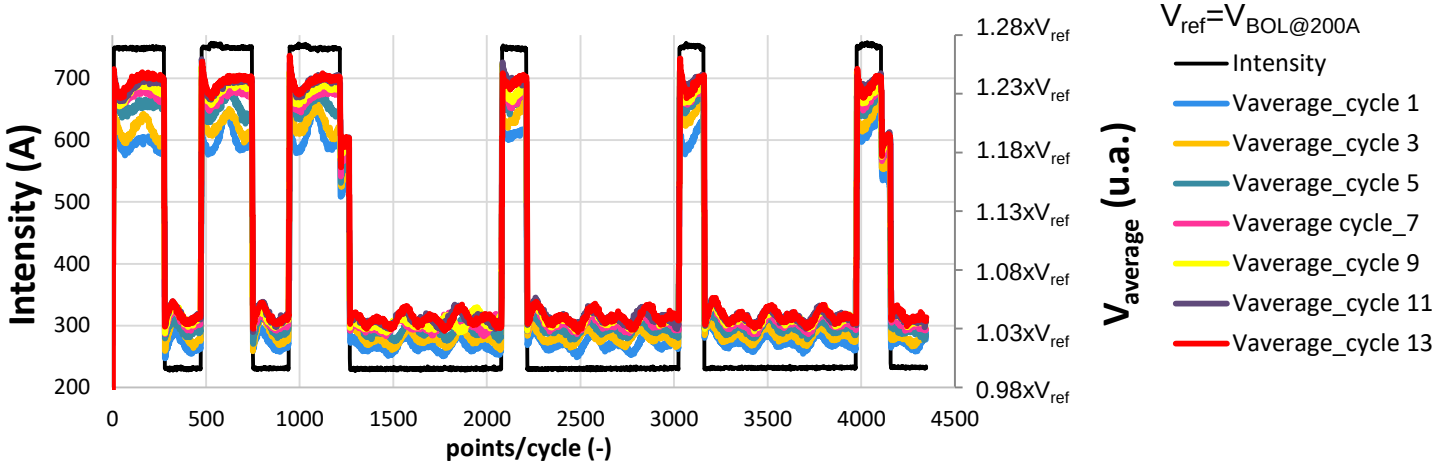
Novel membranes

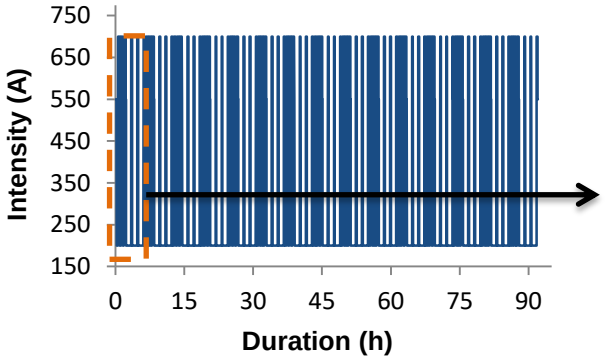




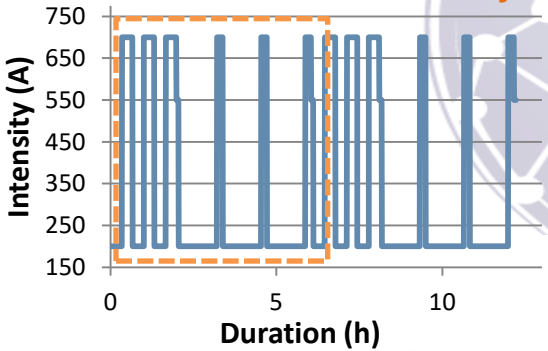
Novel electrodes

AST profile – stack membrane #1



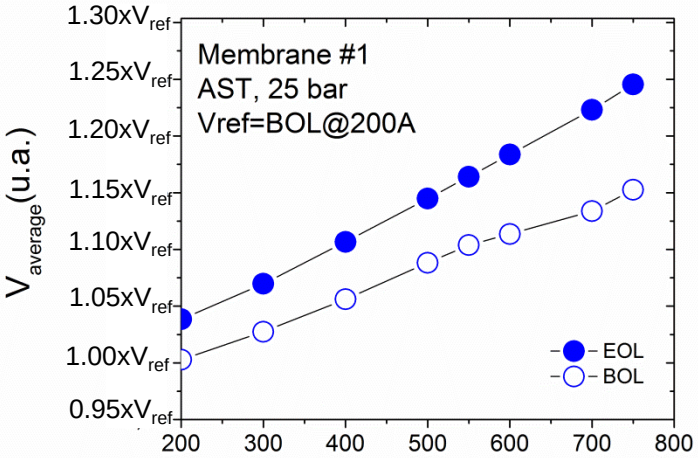


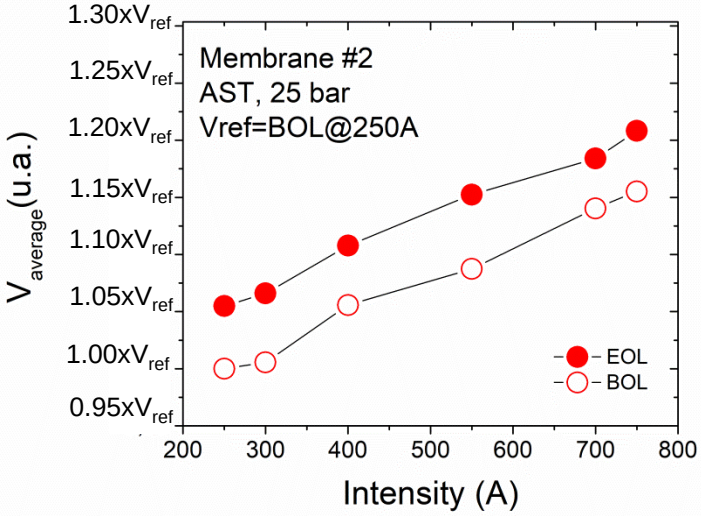
Accelerated load cycle

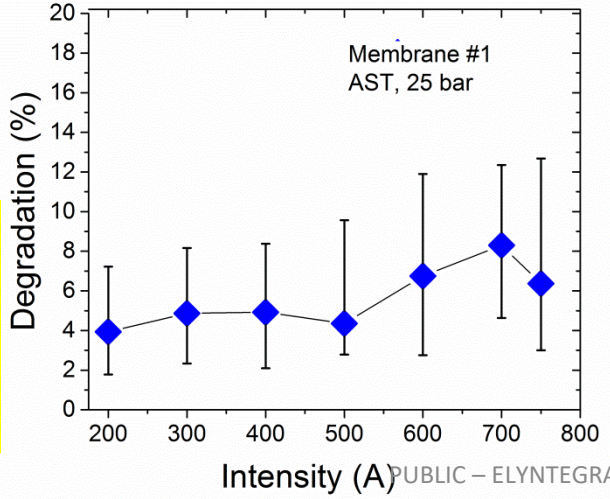


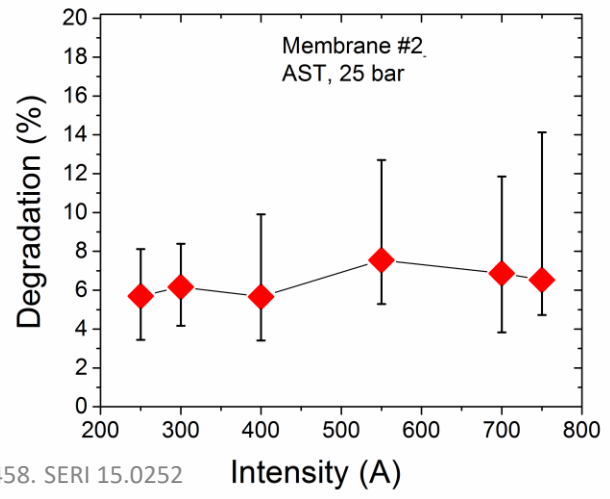
AST novel membranes

2 months providing grid services (Finish aFRR)



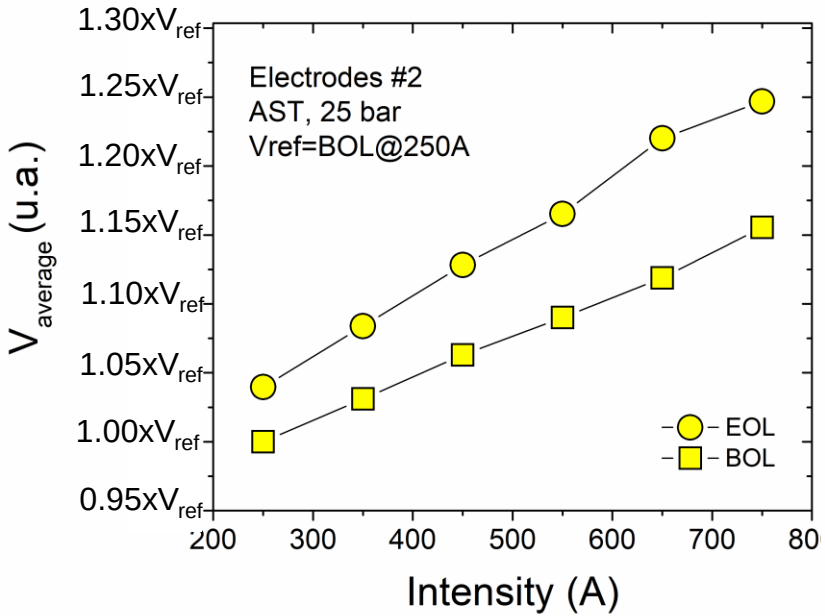


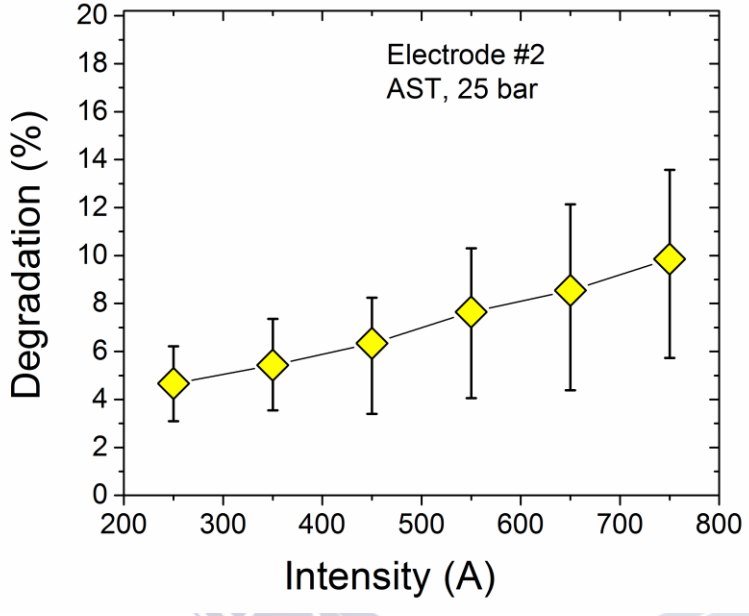




Novel electrodes

AST novel electrodes





2 months providing grid services (Finish aFRR)

Test benches upgraded at FHA

- industrial scale: up to 250 KW, 30 bar, 95 ºC

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Highlights – Demo testing at industrial size

- Stack 4. New topology

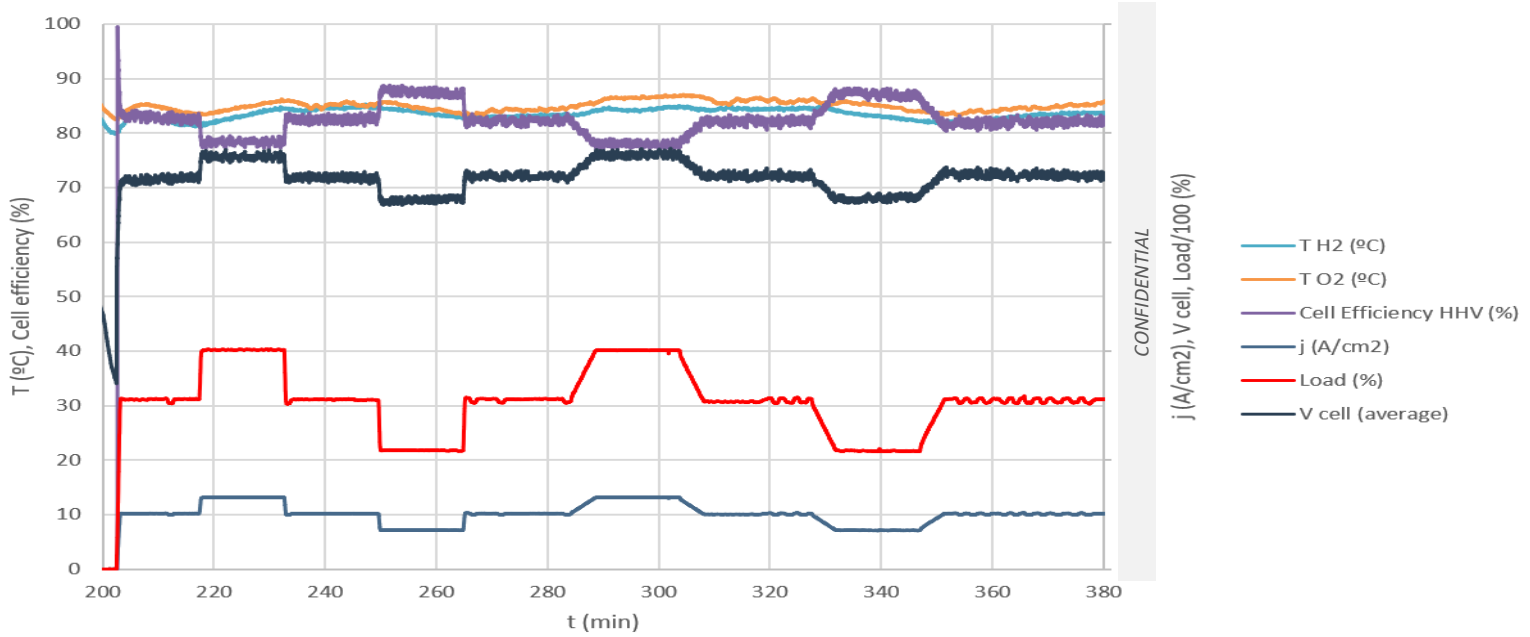
(high dynamic power profile and grid services provision)

- Stack 3. State-of-the-art stack stak (grid services provision)
- Stack 2. Novel membranes

(high dynamic power profile and grid services provision)

- Stack 1. Commercial stack (C&CS validation)

Stack performance – high dynamic power profile



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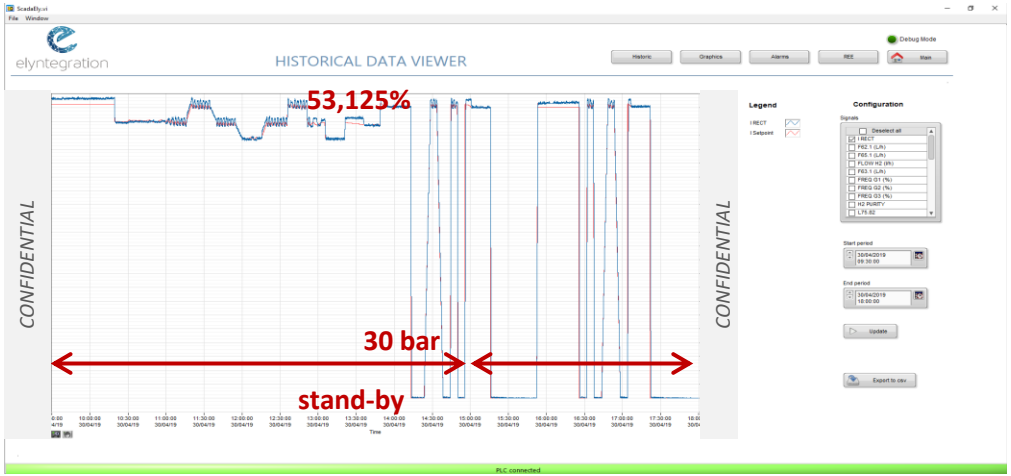
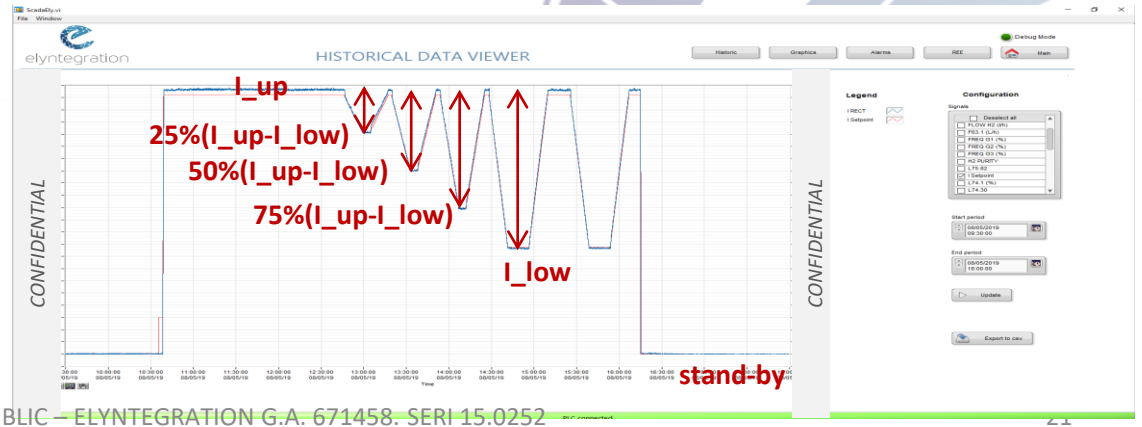
Grid services provision



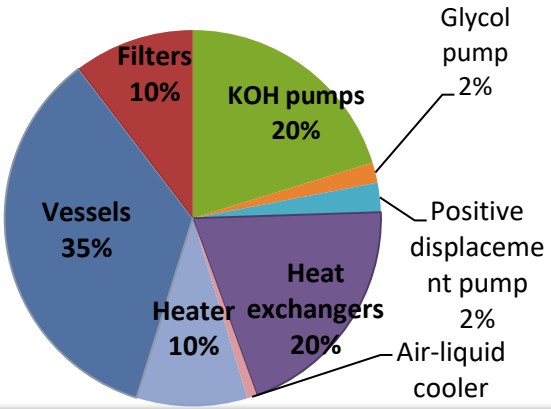


Modelling and BOP cost optimization

- Once validated and demonstrated at prototype level, the advanced constructive features have been integrated in the design of a multi-MW single stack alkaline electrolyser.
- BOP cost and manufacturing optimization has been assessed

Highlights – Cost optimization

6/10th upscaling method



Cost in range [~80,000…~300.000€]
20% error considered

- **"Duplicated" sizing strategy (based on simulations)**
  - 1 additional Heat exchanger
  - 1 additional KOH pump
  - Validation: Grid services & Qualygrids protocols
- **Carbon steel + epoxy resin coating in vessels**
- **Better efficiencies with nanostructured electrodes and electrochemical compressors**
- **FHA experience to reduce instrumentation**
- **Containerization and transport**
- **External processes:** Waste heat (2MWh) Oxygen gas (36 tpd)
  - High valorisation potential

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Market and business preparation

- Feasibility study and market potential assessment
  - determine the best possible markets, sectors and countries for the final product
- The market study has been focus on the national policies towards **renewable energy and energy storage**, with special attention to electricity prices in the power market and the provision of grid services to minimize the cost of the hydrogen production.
- **Exploitation strategy and business plan**: After the results of the demonstration activities, the conclusions of the market study and the analysis of different business cases have been studied

Highlights – Business models

- identified business models in power systems
  - spot market participation and provision of positive control reserve most promising
  - provision of grid services with potential, however subjected to significant short and medium term uncertainty
- main drivers for profitable electrolyser operation
  - hydrogen demand sectors with high hydrogen prices (e.g. mobility)
  - high shares of renewable energies within power system
  - high prices for CO_2 emission certificates
  - potential exemptions from specific end-user price component (network charges, taxes, levies)

Communication and Awareness

- Activities complementary to the exploitation strategy and business plan.
- Targets: policy makers, local authorities, technology providers, general public.
- The final goal is to develop awareness of the services and technology to be demonstrated in the project at each level, including energy transition problematic, grid flexibility and environmental aspects.
- Channels: website, leaflets, participation in specialized conferences and fairs.
- Public deliverables are also published and available in the project's webpage.

Highlights - Communication

- World Hydrogen Technologies Convention, WHTC:

2 oral contributions (June 2019, Tokyo)

- World Hydrogen Energy Conference, WHEC:

Keynote lecture (June 2018, Rio Janeiro) and oral contribution (June 2016, Zaragoza)

- European Hydrogen Energy Conference, EHEC:

1 oral contribution (March 2018, Málaga)

- International Conference on Electrolysis (ICE2017), Iberconnapice (2016, 2017) Hannover Fair (2016,2017, 2018, 2019)
- Publications: 3 scientific open access papers published + 4 on-going

Acknowledgement

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Thank you for your attention

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