Enhancing Electrolyzer Durability Through a Multiscale Strategy: The ELECTROLIFE Approach

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Politecnico di Torino

Enhance durability of electrolyser technologies

ELECTROLIFE

Webinar: Advancing Online Diagnostics and Building Durable Electrolysis Systems for Europe's Hydrogen Future

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Outline

- About ELECTROLIFE
- Objectives and Concept
- Partners
- Approach
- Results

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ELECTROLIFE

- Electrolife: **Enhance knowledge on comprehensive electrolyser technology degradation through modelling, testing, and lifetime prediction, toward industrial implementation.**
- ELECTROLIFE aims to advance the understanding of electrolyzer degradation mechanisms and improve cell performance to boost efficiency, reduce critical material use, and extend system lifetime.
- How?
  - Through a combination of experimental testing, multiphysics modelling, and prototyping, the project supports the industrial implementation of durable, scalable, and recyclable green hydrogen technologies.
- Ultimately, ELECTROLIFE seeks to accelerate the decarbonization of European industry by overcoming current limitations in electrolysis technologies.

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ELECTROLIFE

Acronym: ELECTROLIFE

Duration: 60 months

Start date: 01 January 2024

End date: 31 December 2028

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Approach

The ELECTROLIFE concept and architecture is unique because focus its research activities on all **the 5 today classified electrolysis technologies**, in order to approach with the same structured methodology all the paths to understanding and modeling the degradation mechanisms of different electrochemical systems, to develop and assess improved electrochemical cells and stacks (especially under dynamic use and operational stress) and to validate technologies and diagnostic tools (SoH).

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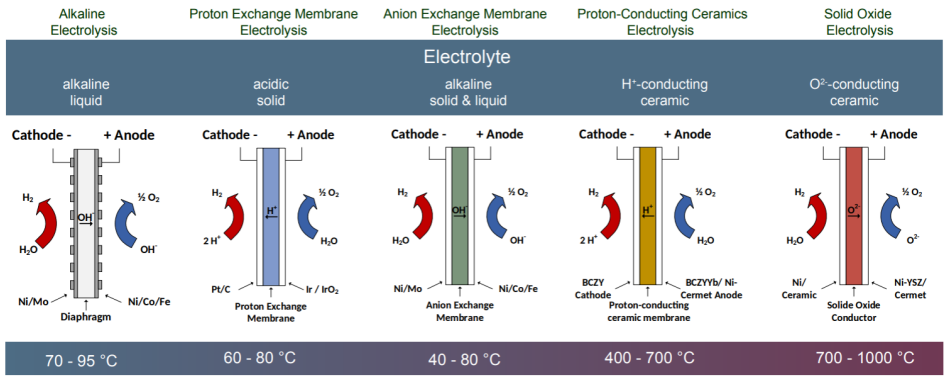

Figure. Overview of the five electrolysis technologies studied in ELECTROLIFE

Keystones

The ELECTROLIFE concept consist of 8 keystones (KS):

KS1: Identification and comprehension of degradation phenomena that affect the 5 (AEL, AEMEL, PEMEL, SOEL, and PCCEL) technologies involved
KS2: Development of degradation and lifetime prediction models
KS3: Development of testing procedures for degradation assessment
KS4: Development of ad-hoc testing and diagnostic tools
KS5: Technologies development and optimization
KS6: Execution of test campaigns on the 5 electrolysis technologies
KS7: Validation of the degradation models and diagnostic tools
KS8: Guidelines for next generation robust stacks, diagnostic tools and optimized strategies of operation, for electrolysers lifetime extension

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ELECTROLIFE in figures

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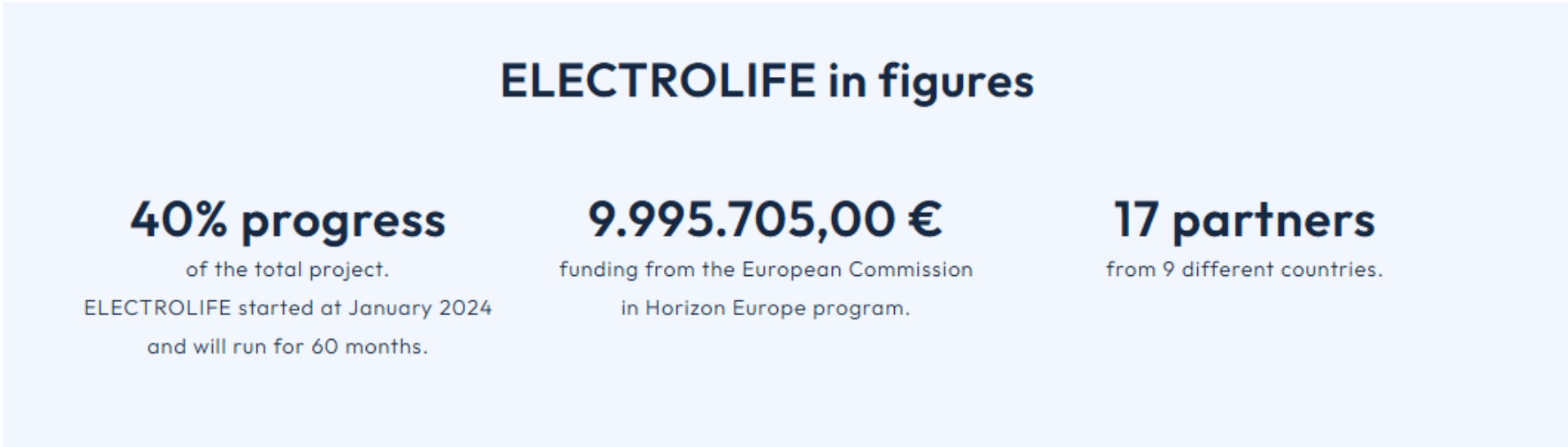

https://electrolife-project.eu/
https://cordis.europa.eu/project/id/101137802

Duration: 60 months
Start date: 01 January 2024
End date: 31 December 2028
Total budget: €9.995.705,00

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ELECTROLIFE Partners

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Politecnico di Torino

UNIRESEARCH

enel Green Power

FAU Friedrich-Alexander-Universität Technische Fakultät

TU Graz

KERIONICS

AAU ENERGY

AALBORG UNIVERSITY

JÜLICH Forschungszentrum

Université de Lille

stargate hydrogen

Pietro Fiorentini

HYTER NEW ENERGY ROUTES

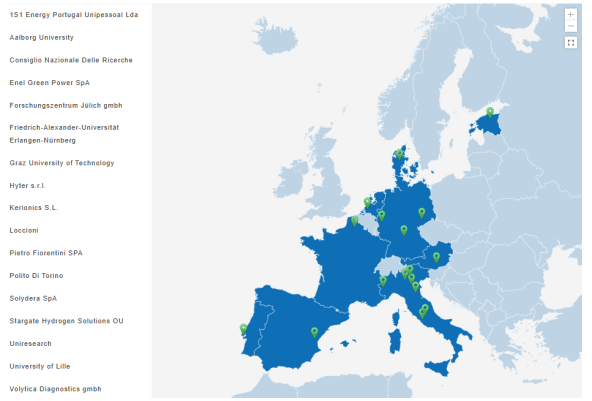
Consiglio Nazionale delle Ricerche

1s1 Energy

LOCCIONI

volytica diagnostics

SolydEra



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General assemblies and partners

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Third General Assembly (#GA03) of ELECTROLIFE in Erlangen, Germany

Second General Assembly (#GA02) of ELECTROLIFE in Ancona, Italy

Four General Assembly (#GA04) of ELECTROLIFE in Tallin, Estonia

Kick-off meeting (#GA01) of ELECTROLIFE in Torino, Italy

Typical meetings: big crowd, bigger ideas

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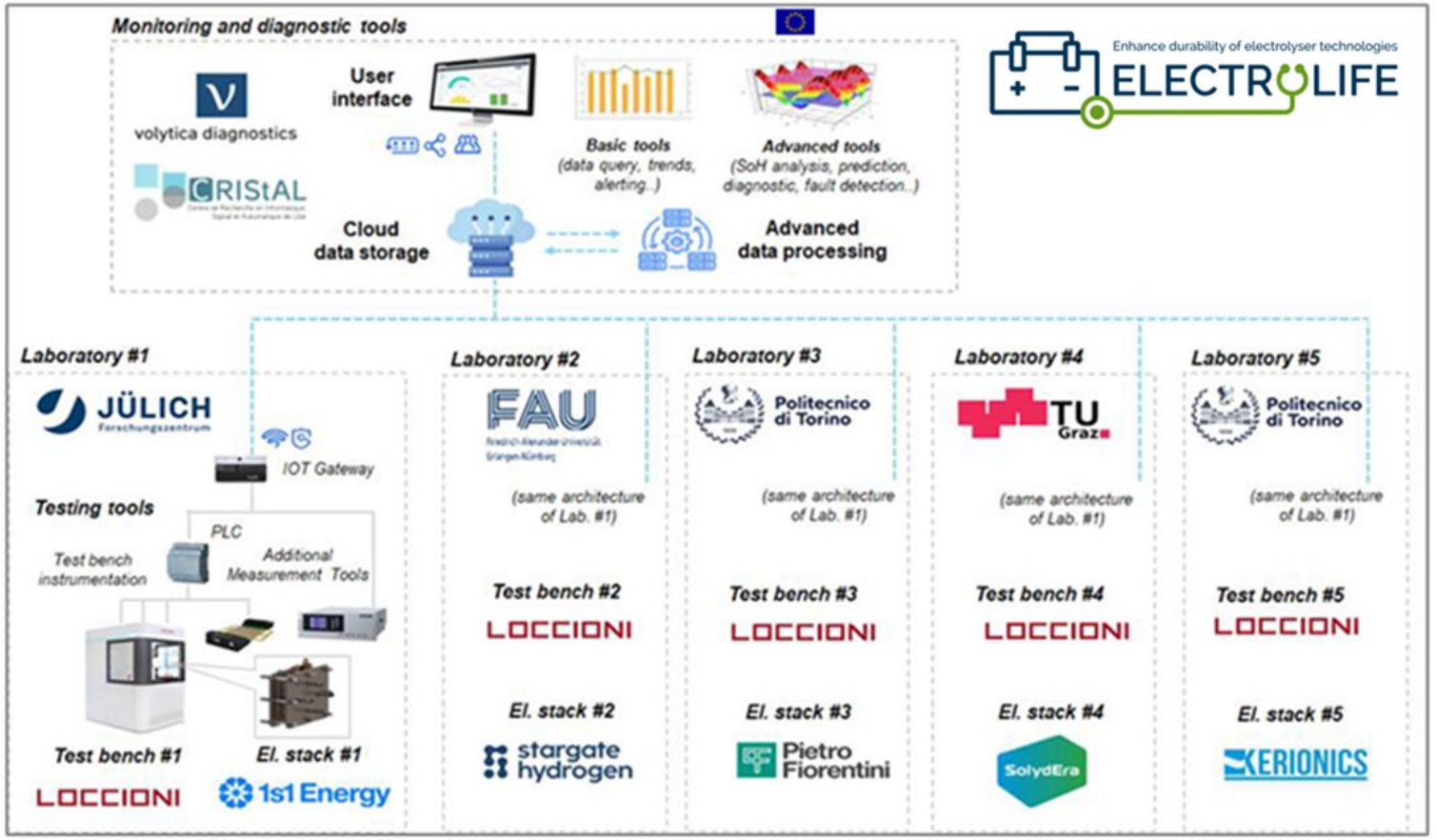
Overall Approach and Key Activities



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Key Activities

Testing of <u>all</u> Electrolyzer Types

- Testing of AEL, AEMEL, PEMEL, SOEL, and PCCEL at the stack level (**<u>TRL 5</u>**).

Durability Testing:

- Conducting durability tests for 10,000 hours.
- Applying RES profiles to assess durability.

Degradation Modeling:

- Developing and validating degradation models at both single-cell and stack levels.

Economic Evaluation:

- Evaluating the Levelized Cost of Hydrogen (LCOH) for specific scenarios.

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Results: Degradation factors, degradation mechanisms and degradation effects

HORIZON EUROPE PROGRAMME
TOPIC HORIZON-JTI-CLEANH2-2023-1
GA No. **101137802**

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Enhance knowledge on comprehensive electrolysers technologies degradation through modeling, testing and lifetime prevision, toward industrial implementation

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Deliverable report

D2.1 – Degradation phenomena compendium

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Summary

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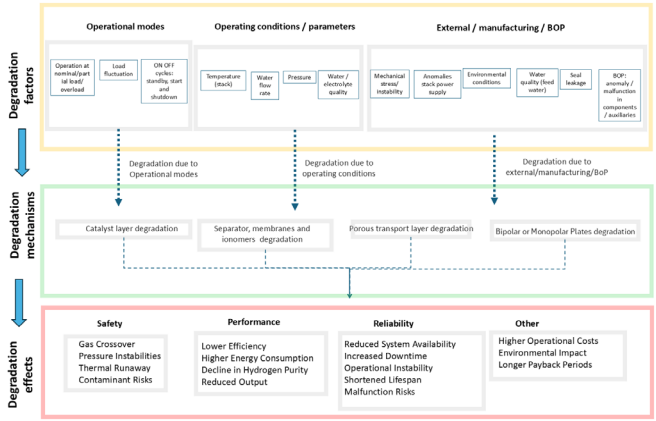

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https://electrolife-project.eu/wp-content/uploads/sites/24/2025/02/ELECTROLIFE_D2.1-Degradation-phenomena-compendium_PUB_final.pdf

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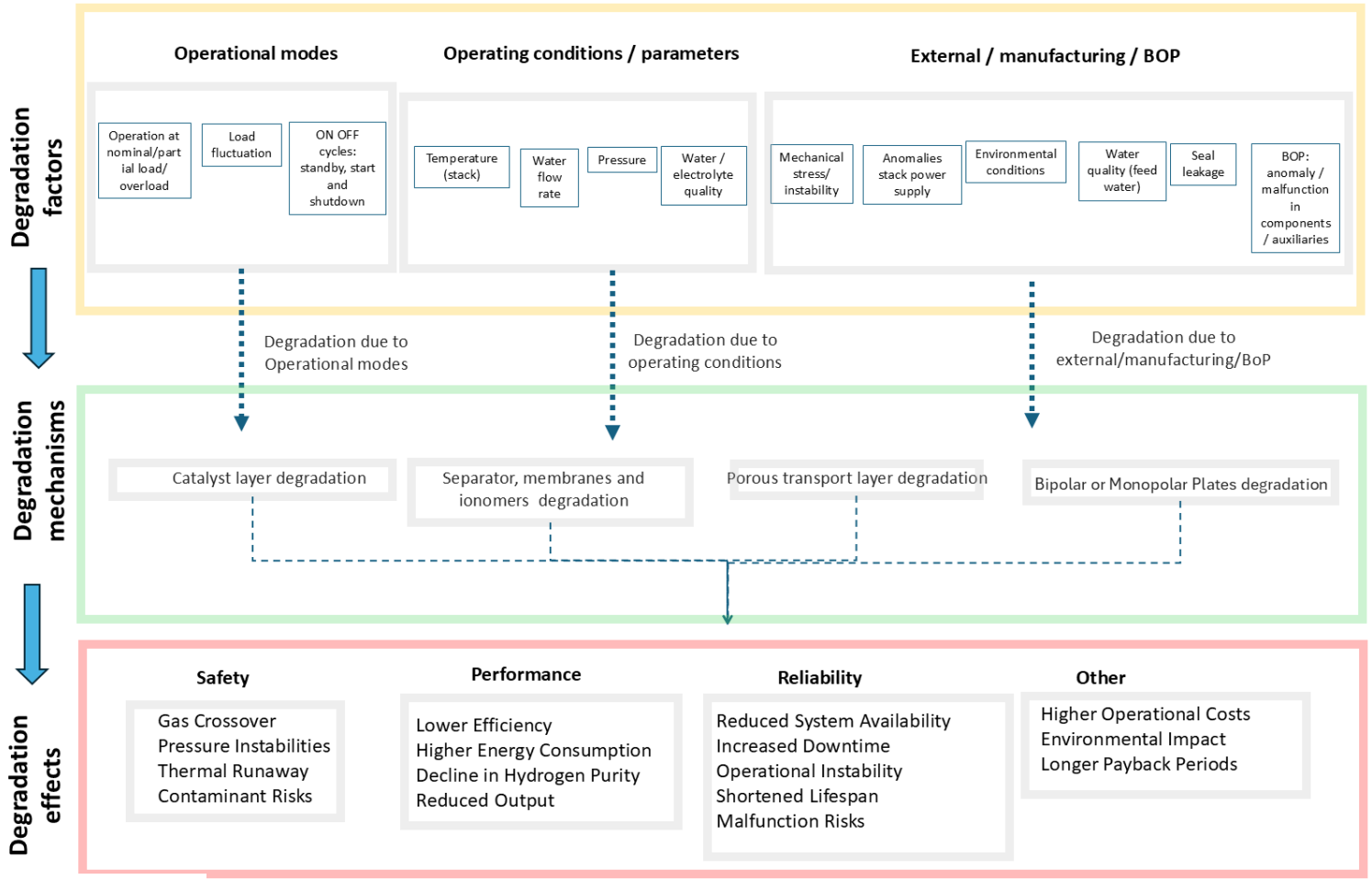
Results: Degradation factors, degradation mechanisms and degradation effects



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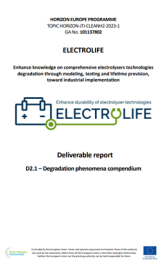
Electrolyser operational modes and various degradation factors (e.g., operating conditions, manufacturing, BoP) trigger specific degradation mechanisms—chemical or physical—based on their frequency and intensity. These mechanisms lead to performance loss, safety issues, and reduced reliability.
Figure illustrates the degradation process in three layers:
Top (yellow): Main degradation factors, including operational, environmental, and manufacturing-related stressors.
Middle (green): Resulting degradation mechanisms affecting key components (e.g., membranes, catalysts, BPPs).
Bottom (red): Effects on system-level performance, safety, and economic viability.

The figure highlights how factors lead to mechanisms, which in turn cause measurable degradation effects.



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Results: Harmonised protocols for LTEL

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GA No. **101137802**

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- Deliverable report

D4.1 – Specification, terminology and Harmonised protocols for LTEL

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Reviewed by JRC

JRC
EUROPEAN COMMISSION

Content

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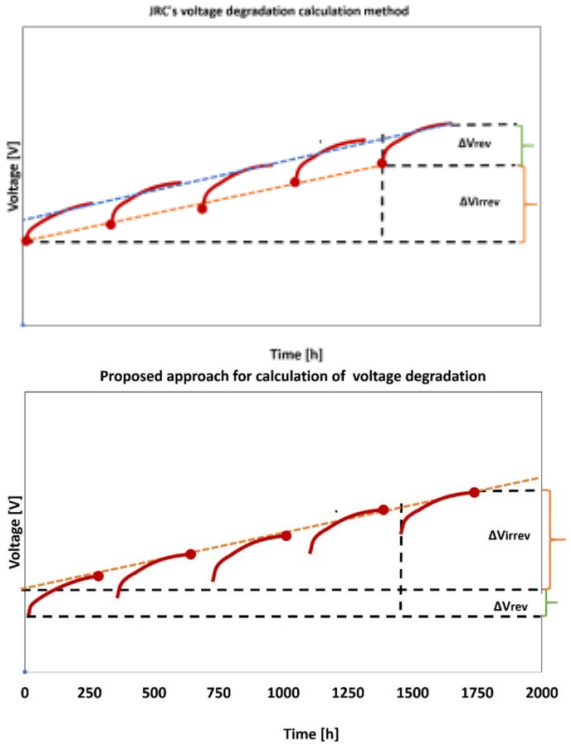

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Results: Specifications of the testing tools

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Test bench Provider	PEM	AEL	AEMEL	SOEL	PCCEL
	LOCCIONI	LOCCIONI	LOCCIONI	LOCCIONI	LOCCIONI
Laboratory	JÜLICH	FAU	Politecnico di Torino	TU Graz	Politecnico di Torino
Stack manufacturer	1s1 Energy	stargate hydrogen	Pietro Fiorentini	SolydEra	KERIONICS

Figure 1. ELECTROLIFE partners directly involved in stack testing

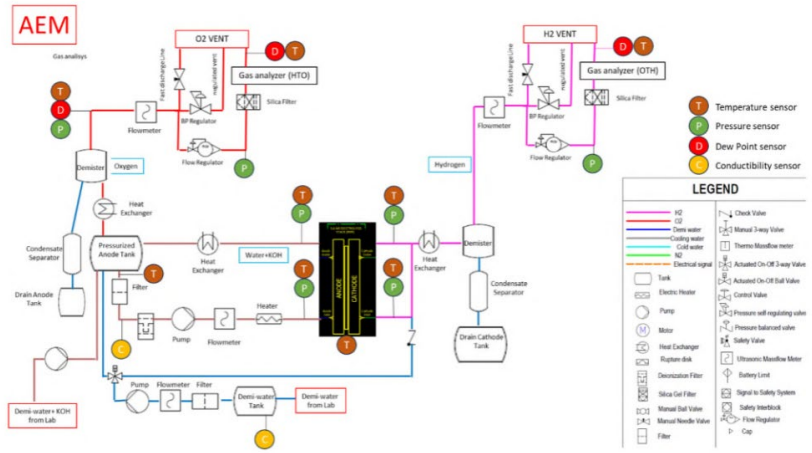

Figure 10: Process Flow Diagram of AEMEL test bench

Detail engineering of stacks and test bench:

Specifications and requirements of the stacks to be tested were discussed between three actors (Test bench Provider, Laboratories and stack manufacturer):

- **Test Bench provider (Loccioni)**
- **Stack manufacturers (1s1, Stargate, PF/Hyter, Solydera, Kerionics**)
- **RTOs owners of labs (Polito, FAU, GRAZ, Julich)**
  - PEMEL, AEL, AEMEL, SOEL and PCCEL
  - Stack specifications, requirements for stack manufacturers; Requirements For Laboratories and Rtos; Specifications of Testing Tools.

Test bench design & construction (*indicative):

- Example of PI&D for AEMEL

[a] EU harmonised protocols for testing of low temperature water electrolysis. https://op.europa.eu/en/publication-detail/-/publication/bbbeba00-ee82-11eb-a71c-01aa75ed71a1

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Results: Test benches manufacturing

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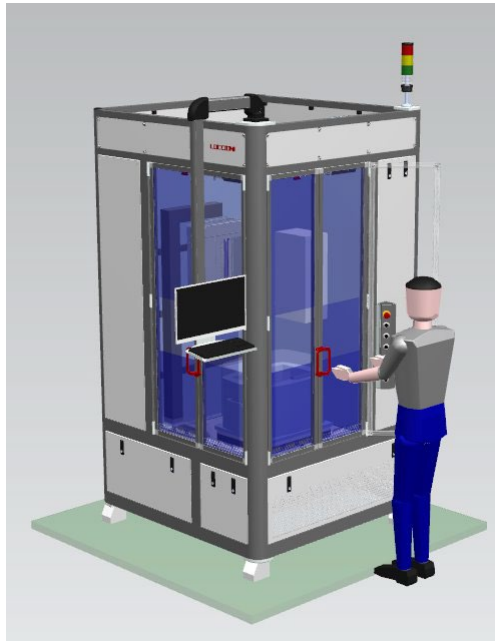
Frame of first two test benches (AEM, AEL) assembled



LOCCIONI

*Courtesy image: Loccioni

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Thanks for the Attention

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