	RUBY PROJECT Robust and reliable general management tool for performance and dUraBility improvement of fuel cell stationarY units
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Deliverable No.:	D8.10
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Due date (in months):	M28
Lead beneficiary:	P01 - UNISA
Type:	Websites, patents filing, etc.
Dissemination level:	Public
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Version	Date	Comments
v1	06/07/2022	Opening of the Deliverable
<u>v2</u>	04/03/2023	Deliverable approved and closed



Abstract

The Deliverable D8.10 Workshop No.1 intends to present the activities held during the first project workshop along with the impact metrics.

This deliverable is part of WP8 which is the main interface between the project and the outside world, academics, and industrials playing a role in the value network underpinning the scientific breakthrough in stationary fuel cells systems.



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1. Workshop description

On July 5th 2022, as an official side event of the 15th European SOFC & SOE Forum held in Lucerne, the AD ASTRA & RUBY jointly organized workshop was held, bringing together projects partners, researchers and industries representatives to present and discuss the achievements of both projects regarding the main topics.

Title: FROM BASIC TO APPLIED RESEARCH TOWARDS DURABLE AND RELIABLE FUEL CELLS. Workshop jointly organized by H2020 Projects AD ASTRA and RUBY

Subtitle: Focus on accelerated stress tests, degradation phenomena, fault modelling, advanced monitoring, diagnostics, prognostics and control of SOC and PEMFC

Date: 5 July 2022

Location: Lucerne (CH)

The workshop gathered scientists and engineers from EU research and industry communities active on the broad area of Fuel Cell lifetime enhancement and advanced management. The speakers described the achievements on stress tests analysis and degradation of high temperature Solid Oxide Cells together with the work undergoing in the field of monitoring, diagnostics, prognostics and control of both SOFCs and PEMFCs.

The partners of the projects RUBY and AD ASTRA (<https://www.ad-astra.eu>) shared the results of their efforts, connecting degradation phenomena, fault root causes and mathematical framework that serves for improved stack and balance of plant management. The event addressed in a holistic framework the main topics that can lead to more performing stacks and competitive Fuel Cell Systems. A comprehensive overview and the potential of the projects' outcomes were offered to the interested stakeholders and users from academia, industry and research. Emphasis was given to methodological approaches that can help achieving reliable performance of both stacks and BoP components, providing a comprehensive vision on the improvement of efficiency, performance, reliability, lifetime and maintenance of SOFC and PEMFC.

A talk from the affine project REACTT, presented as a special guest, was also given to encompass the preliminary achievements dealing with advanced diagnostics and control towards increased lifetime of solid oxide cells.

Contributions from the AD ASTRA project addressed the building of Accelerated Stress Test protocols for quantitative identification and prediction of critical degradation mechanisms, correlating them with overall performance variables in Solid Oxide Fuel Cell/Electrolyser and stack components. The experimental data have been exploited to build models to predict Remaining Useful Life based on operating profile in real-time. Final protocols will address realistic failure modes of critical SOC components (fuel electrode, oxygen electrode and interconnect) in two application profiles, namely: power-to-X and CHP.

Presentations from the RUBY project highlighted the aim of developing, integrating, engineering and testing a comprehensive and generalized Monitoring, Diagnostic, Prognostic and Control (MDPC) tool capable of improving efficiency, reliability and durability of SOFC and PEMFC systems for stationary applications. The tool relies on advanced techniques such as Electrochemical Impedance Spectroscopy and dedicated hardware and will be embedded in backup and μ -CHP Fuel Cell Systems for on-line validation in relevant operational environment.

The intertwined connection between the understanding and prediction of SOC component and stack degradation with its effective management during on-field application of real modules strongly emerged as the main outcome of this workshop jointly organized by the AD ASTRA and RUBY projects.



As the former depicted and highlighted the complexity of the physicochemical mechanisms and its attempt to exploit their understanding for artificially accelerate them, the latter stressed out the impact that such complex phenomena have in the real life application, where the monitoring, fault detection and proper automatized intervention for degradation mitigation is undoubtedly one of the key factors for achieving a full market penetration of these hydrogen electrochemical conversion technologies.

The main topic discussed are:

- Accelerated stress test protocols for SOC
- Prediction of degradation mechanisms for SOFC/SOEC stack components
- Prediction of SOFC/SOEC Remaining Useful Life in real-time
- Robust diagnosis of PEMFC via Artificial Intelligence and EIS
- Data-driven and model-based diagnosis of SOFC cells and stacks
- Data-driven and model-based diagnosis of PEMFC & SOFC BoP
- Validation of performance of RUBY-tool for SOFC μ -CHP
- Real Time Optimization control of Fuel Cell Systems
- Degradation-aware energy management of Fuel Cells-based VPPs
- Hardware for on-field EIS: state of the art, solutions and issues

2. Organization

The AD ASTRA & RUBY jointly organized workshop was held On July 5th 2022, as an official side event of the 15th European SOFC & SOE Forum 2022, held in Lucerne on 5-8 July 2022. During the event coffee and lunch were offered to all guests.

The agenda of the workshop is presented hereafter:

9:00-9:05	Welcome	D. Pumiglia (ENEA) - C. Pianese (UNISA)
9:05-9:15	Improving FCs performance from basic phenomena to management	S. J. McPhail - C. Pianese (UNISA)- D. Pumiglia (ENEA)
9:15-9:25	Description of project AD ASTRA	D. Pumiglia (ENEA)
9:25-9:35	Description of project RUBY	P. Polverino (UNISA)
9:35-9:55	How cells and metal interconnects respond to operating parameters up to 40 kh	P. Piccardo (UNIGE)
9:55-10:15	Degradation assessment in solid oxide cell operated in electrolysis mode	A. Leon (EIFER)
10:15-10:25	Q&A	
10:25-10:40	Coffee break & networking	
10:40-11:00	Online total harmonic distortion analysis for rSOC diagnostic: Illustration for reactants depletion	H. Moussaou (EPFL)
11:00-11:20	AST: The effect of pressure on the interconnect ageing	R. Spotorno (UNIGE)
11:20-11:40	SOFC degradation studies through a multiscale modelling approach	F. Bianchi (UNIGE)
11:40-12:00	Development of mathematical transfer functions for AST design	P. Polverino (UNISA)
12:00-12:20	Modeling the impact of electrode degradations on the SOC response	E. Da Silva (CEA)
12:20-12:30	Q&A	
12:30-13:30	Lunch at the Canteen of the University of Lucerne	
13:30-13:50	Robust diagnosis of PEMFC based on Artificial Intelligence and EIS	D. Chanal (UBFC)
13:50-14:10	Data-driven and model-based diagnosis of SOFC cells and stacks	D. Juricic (IJS)
14:10-14:30	Data-driven and model-based diagnosis of PEMFC & SOFC	A. Pandolfi (UNISA)



	Balance of Plants	
14:30-14:50	Validation of performance of RUBY-tool for SOFC μ -CHP	A. Nieminen (VTT)
14:50-15:00	Q&A	
15:00-15:20	Coffee break & networking	
15:20-15:40	Enforcing optimal operation of Fuel Cell systems despite degradation via real-time optimization	T. De Avila Ferreira (HES-SO)
15:40-16:00	Degradation-aware energy management of fuel cell-based VPPs	M. Sorrentino (UNISA)
16:00-16:20	EU project REACTT-Advanced Field Diagnostics of SOEC & rSOC	D. Juricic (IJS)
16:20-16:40	Hardware for on-field EIS: state of the art, solutions and issues	G. Spagnuolo (UNISA)
16:40-16:50	Q&A	
16:50-17:00	Feedback from Q&A sessions, discussion – Closure	D. Pumiglia (ENEA) - C. Pianese (UNISA)

The affiliation of the speakers is the following:

- CEA, French Alternative Energies and Atomic Energy Commission (F);
- EIFER, European Institute for Energy Research (D);
- ENEA, Italian National Agency for New Technologies, Energy and Sustainable Economic Development (I);
- EPFL, Swiss Federal Institute of Technology (CH);
- IJS, Jožef Stefan Institute (SI);
- HES-SO, University of Applied Sciences and Arts Western Switzerland (CH);
- UBFC, University of Bourgogne Franche-Comté (F);
- UNIGE, University of Genova (I);
- UNISA, University of Salerno (I);
- VTT, technical Research Centre of Finland (FI).

The agenda and the workshop brochure are available here: <https://www.rubyproject.eu/wp-content/uploads/2023/01/RUBY-AdAstraJointWorkshop2022.pdf>

Moreover a dedicated communication was published by the Commission at the webpage: https://www.clean-hydrogen.europa.eu/media/events/joint-workshop-organized-h2020-projects-ad-astra-and-ruby-basic-applied-research-towards-durable-and-2022-07-05_en



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Joint Workshop organized by H2020 Projects AD ASTRA and RUBY - From basic to applied research towards durable and reliable fuel cells

TRAINING AND WORKSHOPS

Joint Workshop organized by H2020 Projects AD ASTRA and RUBY - From basic to applied research towards durable and reliable fuel cells

The workshop will gather scientists and engineers from EU research and industry communities active on the broad area of Fuel Cell lifetime enhancement and advanced management. The speakers will describe the achievements on stress tests analysis and degradation of high temperature Solid Oxide Cells together with the work undergoing in the field of monitoring, diagnostics, prognostics and control of both SOFCs and PEMFCs.

hydrogen

5 July 2022, 09:00 CEST - 5 July 2022, 17:00 CEST

Switzerland

The partners of the projects [AD ASTRA](#) and [RUBY](#) will share the results of their efforts, connecting degradation phenomena, fault root

Figure 1 Clean Hydrogen Partnership communication

A dedicated page on the project website was created to collect all the information and to register: <https://www.rubyproject.eu/dissemination/workshop1>. All the presentations have been disclosed at the same webpage for a direct download.

Moreover, the presentations from the workshop are also publicly available at the AD ASTRA project website <https://www.ad-astra.eu>. A link to the recorded videos of the presentations is also provided in the same webpage.



WORKSHOP

FROM BASIC TO APPLIED RESEARCH TOWARDS DURABLE AND RELIABLE FUEL CELLS

Focus on accelerated stress tests, degradation phenomena, fault modelling, advanced monitoring, diagnostics, prognostics and control of SOC and PEMFC

Workshop jointly organized by H2020 Projects AD ASTRA and RUBY

5 July 2022 – Lucerne (CH)

KKL – European Fuel Cell Forum 2022

[DOWNLOAD PRESENTATIONS](#)

Figure 2 RUBY website communication

3. Metrics

The confirmed attendants to the workshop were 30, as indicated in the original participant list with related signatures stored by the Project Coordinator.

A group photo of part of the attendants and presenting authors is reported below, taken at the end of the workshop.



The participants are affiliated at 16 different reaserch centers, univerities and corporates from 9 worldwide Countries, as described in the following graphs:

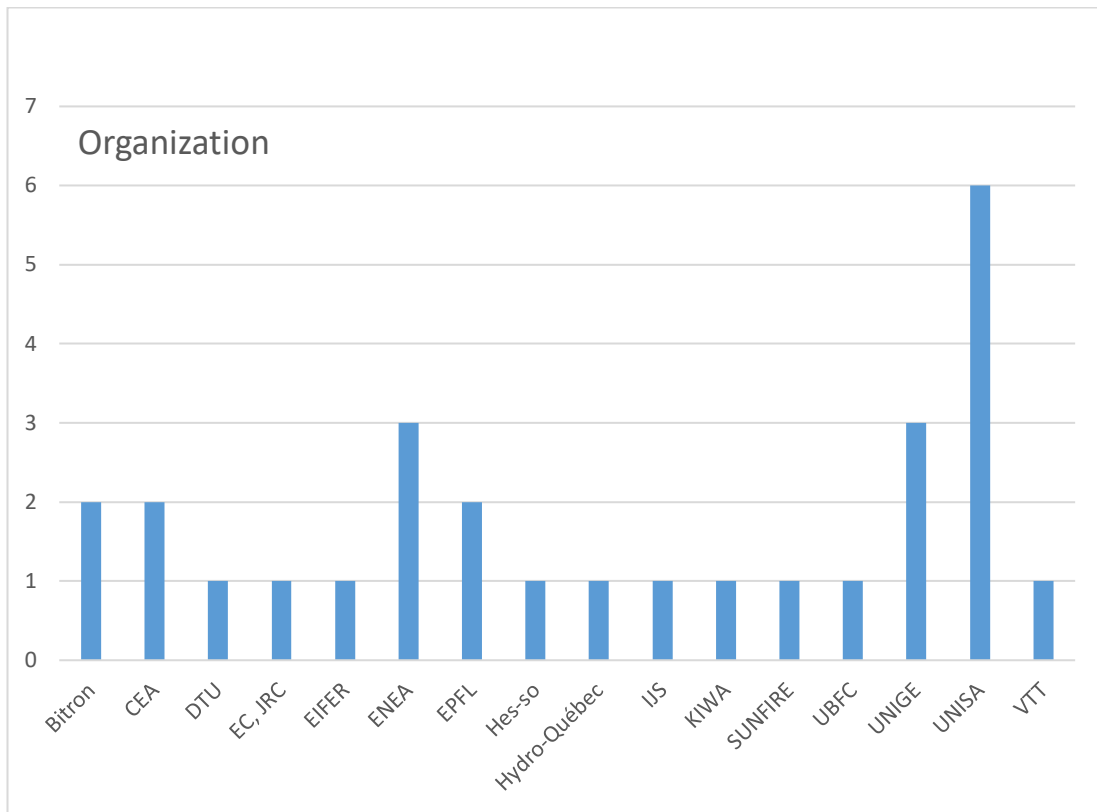


Figure 3 Attendees affiliations

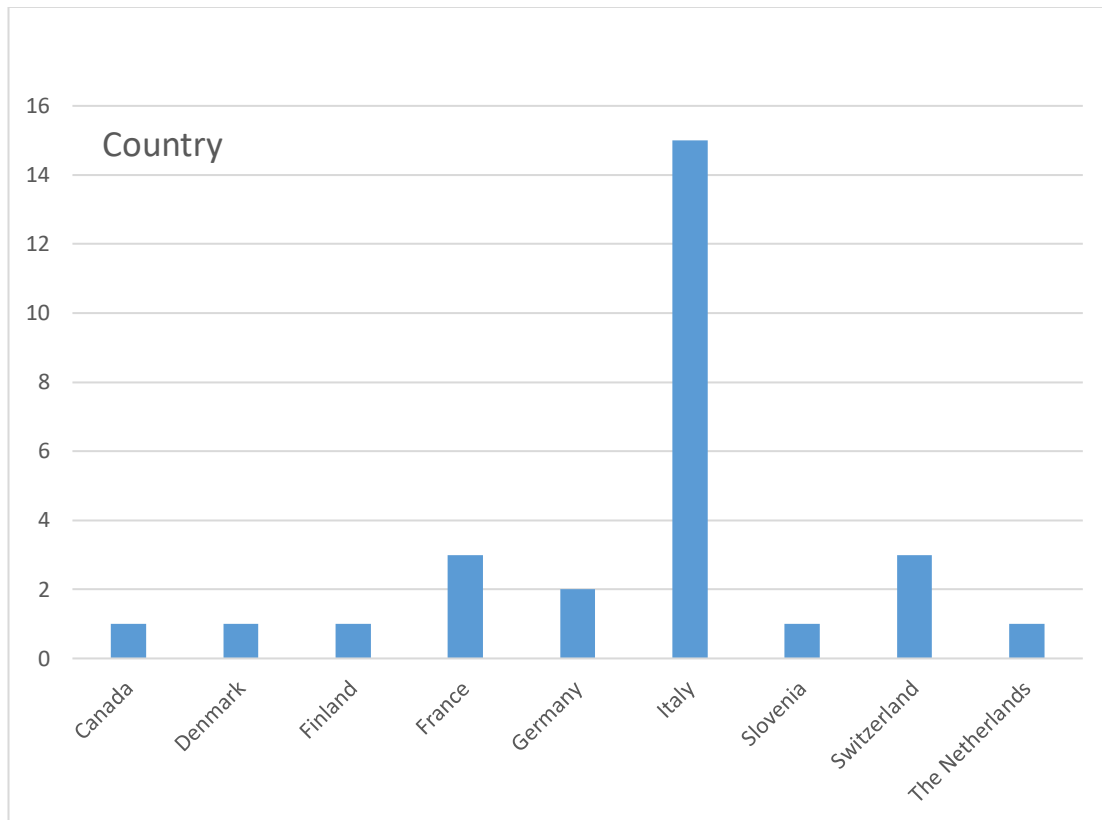


Figure 4 Attendees Affiliation Countries



The workshop info were spread in the Fuel Cells community thanks to the RUBY newsletter #2. Some impact metrics are reported hereafter:

766 Recipients

Audience: Pianese audience

Delivered: Tue, Jun 7, 2022 12:52 pm

Subject: RUBY project Newsletter #2 - Special Issue Workshop

[View email](#) · [Download](#) · [Print](#) · [Share](#)

133 Opened	14 Clicked	84 Bounced	4 Unsubscribed
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Successful deliveries	682 89.0%	Clicks per unique opens	10.5%
Total opens	217	Total clicks	40
Last opened	9/20/22 11:35AM	Last clicked	7/20/22 7:00AM
Forwarded	0	Abuse reports	0

Figure 5 Newsletter communication impact