Ref. Ares(2026)6474626 - 26/06/2026

DELYCIOUS

Clean Hydrogen Partnership

Co-funded by the European Union

D5.2 Development of the condition monitoring scheme

by Air Liquide



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Document control sheet

Project number	101192075		
Project name	**D**iagnostic tools for **EL**ectrol**Y**sers: **C**ost-efficient, **I**nnovative, **O**pen, **U**niversal and **S**afe		
Project acronym	DELYCIOUS		
Call	HORIZON-JTI-CLEANH2-2024		
Topic	HORIZON-JTI-CLEANH2-2024-01-04		
Type of action	HORIZON-JU-RIA (Research and Innovation Action)		
Granting authority	Clean Hydrogen Partnership and European Union		
Start date	01/01/2025	Duration	36 months
Project coordinator	Fraunhofer IWES		

Deliverable ID	**D5.2**
Deliverable Name	**Development of the condition monitoring scheme**
Version	**1**
Type of Deliverable	OTHER
Work Package No	5
Due date	30/06/2026
Actual submission date	26/06/2026

Lead Beneficiary	Air Liquide	
Author(s)	Dominik Schack	
Dissemination level	Public	
	Sensitive	**x**
Reviewed by (WP leader or proxy)	Esaar Naeem Butt (University of Twente)	
Document Approval	Reviewer and WP leaders	

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About DELYCIOUS

As Europe accelerates its transition to clean energy, the Net Zero Industry Act identifies low-carbon hydrogen production as a strategic priority. DELYCIOUS tackles key challenges in water electrolysis technology, focusing on extending electrolyser lifespans and reducing operational costs under variable renewable energy sources. In DELYCIOUS, the development of cost-efficient, innovative, open, universal, and safe diagnostic tools to investigate the chemical and electrochemical properties of electrolysis systems is foreseen. This project combines Raman Spectroscopy (Raman) and Electrochemical Impedance Spectroscopy (EIS), to explore the chemical and electrochemical properties of electrolysis systems. By using both physical and data-driven modeling, it will be possible to identify important degradation parameters. To ensure that the diagnostic tools work effectively in various temperature ranges and across various electrolysis technologies, three technologies namely Alkaline Electrolysis (AEL), Proton Exchange Membrane Electrolysis (PEMEL), and Solid Oxide Electrolysis (SOEL) are addressed in this project, with a demonstration on alkaline electrolysers beyond 100 KW.

Consortium

Fraunhofer IWES

Coordinator

Air Liquide

UNIVERSITY OF TWENTE.

DUMAREY

HORIBA

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stargate hydrogen

SIVONIC

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Publishable Summary

The DELYCIOUS project aims to monitor and assess the degradation of three primary electrolyzer technologies: PEM, AEL, and SOEC. Because internal physical degradation mechanisms cannot be directly observed during operation, an Extended Kalman Filter (EKF) was developed to bridge the gap between a "black box" physical plant model and noisy, real-world pilot plant sensor data.

The EKF handles the non-linear relationship between physical aging parameters and observable Key Performance Indicators (KPIs) such as Voltage, Hydrogen in Oxygen (HTO), and Oxygen in Hydrogen (OTH). It operates in a recursive predict-and-update loop, dynamically weighing physical model predictions against sensor data.

The EKF demonstrated high robustness in simulated environments. It accurately tracked both gradual (linear) wear and catastrophic (rapid step-change) degradation profiles, effectively filtering out introduced sensor noise without lagging. Furthermore, the EKF was applied to a real-world AEL dataset, successfully updating the physical model to track actual KPI fluctuations. The algorithm revealed highly dynamic gas diffusivity parameters in response to noisy crossover data, while the active catalyst surface area remained remarkably stable.

The current implementation serves as a successful Proof of Concept (POC) for using statistical filtering to track electrolyzer health. The immediate next steps involve systematically analyzing the influence of the Kalman tuning parameters (Process Noise and Measurement Noise) and completing the validation across all electrolyzer technologies.

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