H2AL

FULL-SCALE DEMONSTRATION OF REPLICABLE TECHNOLOGIES FOR HYDROGEN COMBUSTION IN HARD TO ABATE INDUSTRIES: THE ALUMINIUM USE-CASE

Project ID	101137610
PRR 2025	Pillar 4 - H_2 End Uses - Stationary Applications
Call Topic	HORIZON-JTI-CLEANH$_2$-2023-04-04
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Clean H_2 JU Max. Contribution	5 993 812.38
Project Period	01-01-2024 - 31-12-2026
Coordinator Beneficiary	UNIVERSITE LIBRE DE BRUXELLES, BE
Beneficiaries	BLUENERGY REVOLUTION SCRL, EKW GESELLSCHAFT MIT BESCHRANKTER HAFTUNG, NIPPON GASES INDUSTRIAL SRL, GHI HORNOS INDUSTRIALES, SL, 2A SPA, GASWARME-INSTITUT ESSEN EV, EUROPEAN ALUMINIUM, FUNDACION TECNALIA RESEARCH and INNOVATION, FRAUNHOFER GESELLSCHAFT ZUR FORDERUNG DER ANGEWANDTEN FORSCHUNG EV

PROJECT AND GENERAL OBJECTIVES

H2AL has the overall objective to develop, validate, implement, and demonstrate at full-scale in real operational conditions a set of technologies, such as an integrated hydrogen burner and support systems, refractory materials, and sensors, within heating furnaces in hard-to-abate industries - aluminium ingot and internal scrap recycling - by retrofitting an existing furnace at the demonstration site (2A facilities). The demonstration will run for more than six months, with at least one trial of 100 hours at 100% H_2 and with a thermal output of at least 2 MWth - ensuring that TRL7 is achieved at the project's end. The impact of H_2 combustion on the refractory materials, overall furnace structure, and product quality (aluminium) will also be investigated, and measures to minimise its effects will be implemented. H2AL will also develop and implement a set of data, documentation and guidelines ensuring that the project outcomes can be replicated in other industrial sites (in other hard-to-abate industries) in a cost-effective, sustainable and safe way.

NON-QUANTITATIVE OBJECTIVES

H2AL aims to develop and demonstrate safe, efficient hydrogen combustion technologies for the aluminium industry, with broader applications in hard-to-abate industrial sectors. Key goals include:

- Understanding hydrogen combustion: Conduct experiments and simulations to study H_2 combustion effects on process efficiency, emissions, and equipment wear.
- Burner development: Design burners compatible with 100% hydrogen and H_2/natural gas blends, achieving low NO_x emissions and high efficiency.
- Furnace retrofit: Equip an industrial furnace with new burners, optimised materials, and sensors for real-time monitoring and performance optimisation.
- Full-scale demonstration: Retrofit and operate a commercial-scale aluminium furnace on 100% hydrogen for at least 100 hours to reach TRL7.
- Safety procedures: Develop standard operating procedures for safe hydrogen integration in industrial settings.
- Impact assessment: Evaluate technical, economic, and environmental impacts of hydrogen substitution in industrial processes.
- Business models: Create viable business models and tools for scaling hydrogen-based heat solutions, promoting wider adoption in industrial decarbonisation.

PROGRESS, MAIN ACHIEVEMENTS AND RESULTS

H2AL has achieved key milestones advancing hydrogen combustion technologies for aluminium production and beyond.

- Completed technology baseline analysis, system requirements, safety assessments, and updated hydrogen standards. Defined key performance indicators and a techno-economic baseline for hydrogen use.
- Developed and validated computational fluid dynamics models; conducted material testing to identify optimal refractory materials under hydrogen combustion conditions.
- Finalised H_2 supply system design via tube trailers, secured safety approvals, and initiated infrastructure preparations including gas regulation panels.
- Carried out a techno-economic analysis, showing external H_2 supply is more viable than on-site production for now. Assessed 2A's relevance as a model for EU foundries.

The project has also established strategic collaborations, enhancing its potential for replication and broader industrial impact. H2AL is on track to deliver cost-effective, safe, and scalable hydrogen solutions for industrial decarbonisation.

Clean Hydrogen Partnership
Co-funded by the European Union

FUTURE STEPS AND PLANS

H2AL will advance by adapting the combustion model to the specific burner geometry, focusing on pure hydrogen combustion. Experimental tests will be conducted at GWI, alongside further optimisation of refractory materials under H_2 and steam-rich atmospheres (up to 1 000°C), including microstructural analysis and the role of barium.

Infrastructure efforts will include:

- Building the pressure-reducing panel.
- Completing technical and safety documentation to obtain final approval from the Turin Fire Brigade.
- Securing the CE mark for the retrofitted furnace.

Strategic tasks ahead:

- Finalising EU aluminium foundry archetypes.
- Identifying replication sectors with similar burner needs.
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PROJECT TARGETS

Target source	Parameter	Target achieved?
Project's own objectives	Roadmap for 100% elimination of fossil fuels combustion in aluminium industry.	
	Enabling the utilisation of H_2-based heat production at 2A foundry and other aluminium and hard-to-abate industries.	
	Insights on process effect of e.g., H_2/O_2 ratio, flame temperature, emissions.	
	Comprehensive evaluation of KPI of H_2 combustion.	
	Technology roadmap for effective integration of 100% H_2 combustion for heat production in the aluminium industry.	
	Technology roadmap and industry best practices to (at least) maintain the quality of the final product (aluminium) in terms of melt quality, porosity, dimensional accuracy, and mechanical properties of the finished products.	
	Full-scale operational demonstration at 2A aluminium foundry, running at least 100h at 100% H_2.	
	Application of H_2 burners with low NO_x emissions (<100mg/kg, e.g.: as low as 20 mg/kg for SNCR enhanced flameless regenerative burners).	
	Better understanding of H_2 utilisation.	
	Systematic analysis and application of safety protocol and risk assessment applied to the use of H_2 in testing and demonstration site.	
	Optimised combustion models to further improve the consortium's simulation tools for H_2 combustion mechanisms.	
	Documented demonstrator at 2A including plant integration processes and procedures.	
	TRL9 roadmap for further industry integration, including business model opportunities for replication in other case scenarios, including GIS information.	
	New burners capable of using 0-100% of H_2/NG mixtures.	