AD ASTRA

HARNESSING DEGRADATION MECHANISMS TO PRESCRIBE ACCELERATED STRESS TESTS FOR THE REALIZATION OF SOC LIFETIME PREDICTION ALGORITHMS

Project ID:	825027
PRD 2023:	Panel 5 – cross-cutting
Call topic:	FCH-04-3-2018: Accelerated stress testing (AST) protocols for solid oxide fuel cells (SOFC)
Project total costs:	EUR 3 008 426
Clean H_2 JU max. contribution:	EUR 3 008 426
Project period:	1.1.2019–31.8.2022
Coordinator:	Agenzia Nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile, Italy
Beneficiaries:	Commissariat à l'énergie atomique et aux énergies alternatives, Danmarks Tekniske Universitet, École Polytechnique Fédérale de Lausanne, Europäisches Institut für Energieforschung EDF KIT EWIV, Institute of Electrochemistry and Energy Systems, SolydEra SpA, Sunfire GmbH, Università degli Studi di Genova, Università degli Studi di Salerno

https://www.ad-astra.eu/

PROJECT AND OBJECTIVES

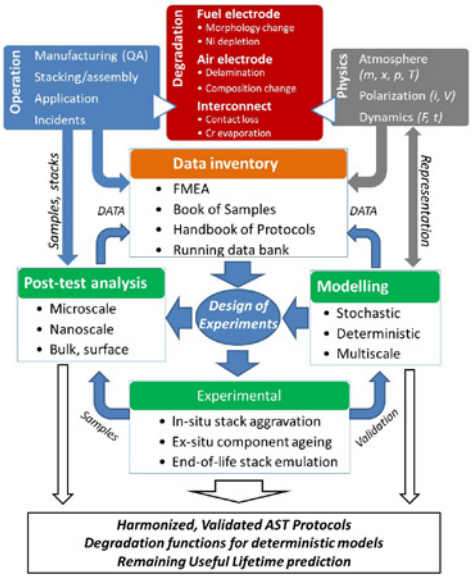
Accelerated stress tests deliberately stress a test material, component or product for a short period to assess the stability of new materials without having to use them in an operational system over a long period. The EU-funded AD ASTRA project aims to define accelerated stress testing protocols deduced from a systematic understanding of degradation mechanisms in aged components of solid oxide cell stacks operating in both fuel cell and electrolysis modes. Benchmarking has been completed, as have the first two campaigns of possible accelerated tests. Validation of the test protocols is the next step.

PROGRESS AND MAIN ACHIEVEMENTS

- Twelve accelerated stress testing (AST) protocols have been developed through three cycles of testing campaign.
- AST protocols have been verified qualitatively, by comparison with analyses of field-tested samples, and quantitatively, using dedicated experiments to estimate degradation rates and accelerating factors.
- AD ASTRA completed the model for transfer functions developed from accelerated stress testing for real-life operation.
- It designed a multiple-model prognosis algorithm for estimating remaining useful life.

FUTURE STEPS AND PLANS

- AD ASTRA will support the development of an international standard for AST protocols and its implementation at the industry level.
- Accelerated stress testing protocols will be validated on solid oxide cell stacks.



QUANTITATIVE TARGETS AND STATUS

Target source	Parameter	Target	Achieved to date by the project	Target achieved?
Project's own objectives	Degradation acceleration	10 ×	More than 10 ×	✓
	Published articles	2 for each of work packages (WPs) 3, 4 and 5	8 for WP3, 4 for WP4, 7 for WP5	✓

Clean Hydrogen Partnership
Co-funded by the European Union

BEST4Hy

SUSTAINABLESOLUTIONSFORRECYCLINGOFEND OF LIFE HYDROGEN TECHNOLOGIES

Project ID:	101007216
PRD 2023:	Panel 5 – cross-cutting
Call topic:	FCH-04-4-2020: Development and validation of existing and novel recycling technologies for key FCH products
Project total costs:	EUR 1 586 015
Clean H_2 JU max. contribution:	EUR 1 586 015
Project period:	1.1.2021–31.12.2023
Coordinator:	Parco Scientifico Tecnologico per l'Ambiente SpA, Italy
Beneficiaries:	Aktsiaselts Elcogen, Commissariat à l'énergie atomique et aux énergies alternatives, EKPO Fuel Cell Technologies GmbH, ElringKlinger AG, Hensel Recycling GmbH, IDO-Lab GmbH, Politecnico di Torino, RINA Consulting SpA, Univerza v Ljubljani

https://best4hy-project.eu/

PROJECT AND OBJECTIVES

The overall objective of BEST4Hy is to identify and develop viable recycling strategies, supported by innovative technologies, that will provide the best solution for material recovery from fuel cell and hydrogen products (i.e. proton-exchange membrane fuel cells (PEMFCs) and solid oxide fuel cells (SOFCs)), and to establish proof of concept for the recovery of iridium and palladium from proton-exchange membrane water electrolysis with novel technologies. Currently, the project is validating four recovery processes at laboratory scale (technology readiness level (TRL) 3) on materials of different ages (PEMFCs and SOFCs). BEST4Hy is performing life cycle analysis / life cycle cost analysis on fuel cell and hydrogen products and end-of-life processes. The regulatory aspects study / policymakers' involvement and the standardisation aspects started in December 2021.

PROGRESS AND MAIN ACHIEVEMENTS

- BEST4Hy achieved Pt recovery via the hydrometallurgical process (listed in the Innovation Radar).
- The project created a novel membrane electrode assembly gaseous-phase dismantling process (listed in the Innovation Radar).
- It achieved Ni-YSZ anode component recovery by HTH and HTM (listed in the Innovation Radar).
- It developed a novel electroleaching and electrolisciviation process for PEMFCs (listed in the Innovation Radar).

FUTURE STEPS AND PLANS

- Scaling up from TRL 3 to TRL 5 will be finalised in 2023.
- The initial results of the life cycle assessment / life cycle costing were expected in early 2023.
- The standardisation and regulations assessment will be performed, supporting the development of a final policy paper and a standardisation roadmap for end-of-life fuel cells.
- A dissemination and exploitation action plan will be created, involving several workshops and events to boost the project's impact and raise market awareness of the technologies.

QUANTITATIVE TARGETS AND STATUS

Target source	Parameter	Unit	Target	Achieved to date by the project	Target achieved?
Project's own objectives	Incoming Pt recovered	%	80	90	✓
	Incoming anode material recovered overall for SOFCs	%	80	> 80	✓
	Incoming Pt recovered	%	90	95	✓
	La and Co recovery	%	> 80	La > 78, Co > 87	✓
	Incoming membrane	%	100	N/A	⚙
	Greenhouse gas emissions in the overall production	%	– 20	N/A	⚙

Clean Hydrogen Partnership
Co-funded by the European Union

eGHOST

ESTABLISHING ECO-DESIGN GUIDELINES FOR HYDROGEN SYSTEMS AND TECHNOLOGIES

Project ID:	101007166
PRD 2023:	Panel 5 – cross-cutting
Call topic:	FCH-04-3-2020: Development of eco-design guidelines for FCH products
Project total costs:	EUR 1 133 541.25
Clean H_2 JU max. contribution:	EUR 998 991.25
Project period:	1.1.2021–31.12.2023
Coordinator:	Fundación IMDEA Energía, Spain
Beneficiaries:	Commissariat à l'énergie atomique et aux énergies alternatives, Fundación para el Desarrollo de las Nuevas Tecnologías del Hidrógeno en Aragón, Symbio France, Institute of Applied Energy, Univerza v Ljubljani

https://eghost.eu/

PROJECT AND OBJECTIVES

eGhost will reach the first milestone in the development of ecodesign criteria in the European hydrogen sector. Two guidelines for specific fuel cell and hydrogen (FCH) products are being prepared, and the lessons learned will be integrated into the eGHOST white book: a reference guidance book for any future ecodesign project on FCH systems. The project addresses the eco(re)design of mature products (proton-exchange membrane fuel cell (PEMFC) stacks) and those emerging with low technology readiness level (TRL) (solid oxide electrolysers) in such a way that sustainable design criteria can be incorporated from the earliest stages of product development.

NON-QUANTITATIVE OBJECTIVES

- eGHOST aims to contribute to FCH systems' sustainability. Ecodesigning products will improve their sustainability performance.
- The project aims to contribute to social acceptance. Sustainable products are better accepted by end users and stakeholders, including civil society.

PROGRESS AND MAIN ACHIEVEMENTS

- The preliminary life cycle sustainability assessment of the PEMFC stack is complete.
- The preliminary life cycle sustainability assessment of the solid oxide electrolysis cell stack is complete.
- The PEMFC stack has been evaluated in accordance with the EU ecodesign directive.
- Product concepts have been designed.

FUTURE STEPS AND PLANS

- Product concepts will be assessed and prioritised as a function of the reduction goals (month 30).
- Methodological and technical ecodesign guidelines for the PEMFC stack will be issued (month 33).
- Methodological and technical ecodesign guidelines for the solid oxide electrolysis cells will be issued (month 33).
- The eGHOST white book will contain the main recommendations for FCH products' eco(re)designing, drawing on the lessons learned (month 36).

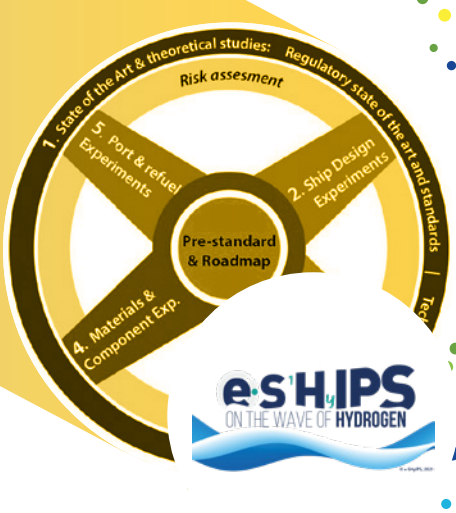
QUANTITATIVE TARGETS AND STATUS

Target source	Parameter	Unit	Achieved to date by the project	Target achieved?
AWP 2020	Cumulative cost reduction	%	3	
	Cumulative environmental reduction	%	10	
	Ecoefficiency improvement	%	10	

Clean Hydrogen Partnership
Co-funded by the European Union

E-SHyIPS

ECOSYSTEMIC KNOWLEDGE IN STANDARDS FOR HYDROGENIMPLEMENTATIONONPASSENGERSHIPS



Project ID:	101007226
PRD 2023:	Panel 5 – cross-cutting
Call topic:	FCH-04-2-2020: PNR on hydrogen-based fuels solutions for passenger ships
Project total costs:	EUR 2 560 000
Clean H_2 JU max. contribution:	EUR 2 500 000
Project period:	1.1.2021–31.12.2024
Coordinator:	Politecnico di Milano, Italy
Beneficiaries:	Agenzia Nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile, Atena Scarl – Distretto Alta Tecnologia Energia Ambiente, Cineca Consorzio Interuniversitario, Danaos Shipping Company Limited, Dimos Andravidas-Kyllinis, DNV Hellas Single Member SA, Ghenova Ingeniería SL, Ingegneria del Fuoco SRL, Levante Ferries Naftiki Etaireia, Oy Woikoski AB, Proton Motor Fuel Cell GmbH, Scheepswerf Damen Gorinchem BV, Teknologian tutkimuskeskus VTT Oy, UNI – Ente Italiano di Normazione, Università degli Studi di Napoli Parthenope

https://e-shyips.com/

PROJECT AND OBJECTIVES

Hydrogen is considered an option for reaching emission reduction targets; however, there is currently no regulatory framework applicable to hydrogen-fuelled ships. e-SHyIPS brings together hydrogen and maritime stakeholders to gather new knowledge based on regulatory framework review and experimental data. The project's approach is vessel independent, and is focused on the risk and safety assessment methodologies. e-SHyIPS will define a pre-standardisation plan for an update – regarding passenger ships using hydrogen-based fuels – to the International Code of Safety for Ships using Gases or other Low-flashpoint Fuels, and a roadmap to boost the hydrogen maritime economy.

NON-QUANTITATIVE OBJECTIVES

- e-SHyIPS aims to define functional scenarios relating to the project concept. In close cooperation with the project's industrial maritime partners, the technical and functional requirements of hydrogen-based-fuels passenger ships will be elicited in operational profile scenarios. Use cases for vessel design will be defined in line with the requirements of industrial maritime partners and the stakeholders.
- The project aims to determine vessel scenario and bunkering functional and technical requirements for the purpose of producing a scenario report. The technical features of hydrogen-based-fuels passenger ships will be described for the associated subsystem (pumps, hoses, etc.). The metrics and safety-related analyses to be conducted will be communicated and specified for the purposes of the risk assessment process. Operational features, such as bunkering procedures and hydrogen fuel conditions, will also be described, defining the limits for the scope of the analysis.
- The results of the analysis of emergency hydrogen discharge or major leaks from the vessel were expected at the end of 2022. The test is focused on piping/venting mast arrangements for emergency hydrogen discharge, and the dispersion of hydrogen outside the ship.
- The guidelines for ship design and operation regarding emergency hydrogen discharge for different types and sizes of vessel and of hydrogen storage were expected to be finalised at the end of 2022.
- The project aims to determine best risk and safety practices for the maritime sector. It will report on technical knowledge gaps and models for risk assessment and risk management of gaseous hydrogen and liquid hydrogen, and hydrogen-based alternative fuels on ships, in 2024.

PROGRESS AND MAIN ACHIEVEMENTS

- The project has developed ecosystemic knowledge of standards for hydrogen implementation for passenger ships.
- Fuel cell stack inclination testing has been completed (listed in the Innovation Radar).
- Fuel cell salt spray testing has been carried out.
- Hazard identification analysis for gas-compressed hydrogen has been undertaken.
- The safety system has been reviewed.
- Hazard identification analysis for liquid hydrogen has been undertaken.
- Explosion risk has been assessed.
- New forcing/damping methods have been tested in OpenFOAM.
- Mesh has been optimised, with a focus on seakeeping.
- The zero hull velocity wave–hull interaction simulation (in LincoSim) has been validated.
- The new LincoSim production web application for external expert users has been tested.

FUTURE STEPS AND PLANS

- e-SHyIPS will continue to develop the hydrodynamic analysis. The LincoSim platform using the updated mesh and wave–hull interaction simulation will be rolled out (expected to be completed in 2023).
- The safety assessment of each vessel design for each scenario is expected to be completed at the end of 2023.
- The technical report on the H_2-based fuel bunkering system's basic design is expected to be completed by the end of 2023.
- The onboard H_2 dispersion and explosion model test will be carried out, with enhanced results expected by the end of 2023.
- Results from the material and component testing and post-mortem analysis are expected at the end of 2023.
- Initial results for the fuel delivery and bunkering solutions for ships were expected at the end of 2022.
- NMA and ISO dissemination of gaps and research considerations is expected to take place at the end of 2023.

QUANTITATIVE TARGETS AND STATUS

Target source	Parameter	Unit	Target	Achieved to date by the project	Target achieved?
Project's own objectives	Performance degradation (potential loss at constant current)	mV		– 10 mV to – 20 mV during U–I curve – 13 mV during continuous operation	⚙
	Constant operation of stack possible	–	Yes	Yes	✓
	To find materials that do not induce additional degradation of the fuel cell compared with baseline	Comparison with reference samples	No additional degradation	Certain ethylene propylene diene monomer materials that may be suitable for the cathode sides have been identified	✓

Clean Hydrogen Partnership
Co-funded by the European Union

HyResponder

EUROPEAN HYDROGEN TRAIN THE TRAINER PROGRAMME FOR RESPONDERS

Project ID:	875089
PRD 2023:	Panel 5 – cross-cutting
Call topic:	FCH-04-1-2019: Training of responders
Project total costs:	EUR 1 000 000
Clean H_2 JU max. contribution:	EUR 1 000 000
Project period:	1.1.2020–31.5.2023
Coordinator:	University of Ulster, United Kingdom
Beneficiaries:	Association Comité National Français du Comité Technique International de prévention et d'extinction de Feu, Ayuntamiento de Zaragoza, Commissariat à l'énergie atomique et aux énergies alternatives, Crisis Simulation Engineering SARL, Deutsches Zentrum für Luft- und Raumfahrt EV, DLR Institut für Vernetzte Energiesysteme EV, Ecole nationale supérieure des officiers de sapeurs-pompiers, Fire Service College Limited, International Fire Academy, Air Liquide SA, Landes-Feuerwehrverband Tirol, Ministry of the Interior of the Czech Republic, Persee, Service Public Fédéral Intérieur, Università degli Studi di Roma la Sapienza, Universitetet i Sørøst-Norge

https://hyresponder.eu/

PROJECT AND OBJECTIVES

The aim of HyResponder is to develop and implement a sustainable trainers' programme on hydrogen safety for responders throughout Europe. The updated operational, virtual reality and educational training reflects state-of-the-art hydrogen safety. The *European Emergency Response Guide* has been revised. Translated materials for responders will be available in eight languages via a purpose-built e-platform. The translated materials will be utilised by trainers to deliver workshops and impact training nationally in 10 European countries, enhancing the reach of the programme.

NON-QUANTITATIVE OBJECTIVES

- HyResponder aimed to embed elements of the training at national level. Each country has a short- to medium-term plan to maximise impact during and beyond HyResponder.
- The project aimed to develop a formal module/certificate. A draft document has been prepared with the key learning outcomes, content, etc., which will be trialled by some partners during national training.
- It aimed to develop training packages at different levels. Stratified educational materials are now available.

PROGRESS AND MAIN ACHIEVEMENTS

Three activities have been evaluated by the Innovation Radar. The translated material is now available:

- e-platform to support training of responders in hydrogen safety (https://innovation-radar.ec.europa.eu/innovation/44458);
- stratified training materials for responders spanning four learning levels (https://innovation-radar.ec.europa.eu/innovation/44457);
- novel training sequences to support online training of responders (https://innovation-radar.ec.europa.eu/innovation/44454).

FUTURE STEPS AND PLANS

- Within HyResponder, trainers from across Europe have undertaken online (June 2021) and operational (June 2022) training.
- The trainers used this training to deliver training in their regions, as part of HyResponder, but also to ensure that a plan is in place beyond the project.
- The consortium is documenting this through a deliverable and through a paper submitted to the *International Journal of Hydrogen Energy*.

QUANTITATIVE TARGETS AND STATUS

Target source	Parameter	Target	Achieved to date by the project	Target achieved?
Project's own objectives	Training events (1 train-the-trainer event, 10 national events)	12	5	⚙
	Threefold training materials (lectures, operational training, virtual reality training)	3	3	✓
	Revised *European Emergency Response Guide*	1	1	✓
	Materials translated into eight languages	8	8 but not all elements	⚙

Clean Hydrogen Partnership
Co-funded by the European Union

HyTunnel-CS

PNR FOR SAFETY OF HYDROGEN DRIVEN VEHICLES AND TRANSPORT THROUGH TUNNELS AND SIMILAR CONFINED SPACES

Project ID:	826193
PRD 2023:	Panel 5 – cross-cutting
Call topic:	FCH-04-1-2018: PNR for safety of hydrogen driven vehicles and transport through tunnels and similar confined spaces
Project total costs:	EUR 2 500 000
Clean H_2 JU max. contribution:	EUR 2 500 000
Project period:	1.3.2019–31.7.2022
Coordinator:	University of Ulster, United Kingdom
Beneficiaries:	Commissariat à l'énergie atomique et aux énergies alternatives, Danmarks Tekniske Universitet, Fundación para el Desarrollo de las Nuevas Tecnologías del Hidrógeno en Aragón, Health and Safety Executive, International Fire Academy, Karlsruher Institut für Technologie, National Center for Scientific Research 'Demokritos', Pro-Science – Gesellschaft für Wissenschaftliche und Technische Dienstleistungen mbH, Service Public Fédéral Intérieur, Stichting Koninklijk Nederlands Normalisatie Instituut, Università degli Studi di Roma la Sapienza, Universitetet i Sørøst-Norge

https://hytunnel.net

PROJECT AND OBJECTIVES

This pre-normative research project aimed to improve the safety of hydrogen-driven vehicles in underground infrastructure. HyTunnel-CS aimed to synthesise analytical, numerical and experimental research to produce recommendations for intervention strategies and tactics for first responders, recommendations for the safer use of hydrogen vehicles in underground transportation systems and recommendations for regulations, codes and standards (RCS). The project also aimed to reduce overconservatism in infrastructure safety design for hydrogen accidents and to reduce the costs of underground systems. The outcomes can be directly implemented in relevant RCS.

NON-QUANTITATIVE OBJECTIVES

The project aimed to ensure that fuel cell electric vehicles entering tunnels are at a level of risk equal to / below that of fossil fuel vehicles. This was addressed by considering tunnel vehicles as a system through experimental, theoretical and numerical studies.

PROGRESS AND MAIN ACHIEVEMENTS

The project achieved all objectives and milestones.

- Work on the state of the art in safety provisions for underground transportation systems and in prioritising accident scenarios was completed in the first reporting period, with all public deliverables being achieved. This work formulated problems and prepared the field for pre-normative research in work package (WP) 2–WP5 (all publicly available on the project website).
- Analytical, numerical and experimental pre-normative research in WP2–WP4 started with the development of detailed research plans, reported in deliverables 2.1, 3.1 and 4.1. The work performed in WP2–WP4 from the beginning of the project to its end was reported in deliverables 2.3, 3.3 and 4.3 (final report on analytical, numerical and experimental studies for each work package). Most analytical and numerical research plans have been completed in a timely manner, sometimes ahead of the schedule (e.g. engineering tools in deliverable 4.2). The experimental studies were affected by the COVID-19 pandemic but mostly recovered during the 5-month extension period. Experimental work at the Health and Safety Executive suffered from off-design test conditions at a large-scale tunnel facility, but was completed in December 2022 (final reports on deliverables 2.3, 3.3 and 4.3 are available on the project website) (relevant Innovation Radar entry: https://www.innoradar.eu/innovation/40447).
- All deliverables in WP5 (first responders' intervention strategies and tactics for hydrogen accidents in underground transportation systems and risk assessment) – deliverables 5.1, 5.2, 5.3 and 5.4 – have been achieved on time and are publicly available on the project website. The stakeholder workshop (milestone 6.2) and the international workshop of emergency services (milestone 5.2 and deliverable 5.2) were changed from face-to-face to online events due to the COVID-19 pandemic (reports on deliverables 5.3 and 5.4 are available on the project website) (relevant Innovation Radar entry: https://www.innoradar.eu/innovation/40450).
- WP6 (synthesis, outreach and dissemination) was responsible for the two principal project outcomes – deliverables 6.9 (recommendations for inherently safer use of hydrogen vehicles in underground traffic systems) and 6.10 (recommendations for RCS). National networks and a stakeholder advisory board were formed and operated within WP6. The board meeting minutes are reported in deliverables 6.2, 6.4, 6.6, 6.7, 6.8 and 6.13. The list of publications was compiled and maintained as part of milestone 6.5 (report 6.9, deliverable 6.10 and the publication list are available on the project website).
- The safety strategies developed in the project, the closed knowledge gaps and the main public outcomes (deliverables 5.4, 6.10 and 10) were presented at the dissemination conference (deliverable 6.12), which was organised as a face-to-face event on 14–15 July 2022 in Brussels (all conference presentations are available on the project website).

FUTURE STEPS AND PLANS

- The project completed its work.
- Final periodic and financial reports were submitted.
- Partners continue to communicate the project results through scientific publications and at the meetings of standardisation organisations.

QUANTITATIVE TARGETS AND STATUS

Target source	Parameter	Target	Achieved to date by the project	Target achieved?
Project's own objectives	D5.4 Harmonised recommendations on response to hydrogen accidents	1	1	✓
	D6.10 Recommendations for RCS	1	1	
	D6.9 Recommendations for inherently safer use of hydrogen vehicles in underground traffic systems	1	1	
	Engineering models and simulations	34	34	
	Two seminars (M6, M30), two workshops (both M15), dissemination conference (M36).	5	5	
AWP 2018	Unique experimental data / experimental data to support development of physical models, simulations and engineering tools	20	20	

Clean Hydrogen Partnership
Co-funded by the European Union

MultHyFuel

MULTI-FUEL HYDROGEN REFUELING STATIONS (HRS): A CO-CREATION STUDY AND EXPERIMENTATIONTOOVERCOMETECHNICALAND ADMINISTRATIVE BARRIERS

Project ID:	101006794
PRD 2023:	Panel 5 – cross-cutting
Call topic:	FCH-04-1-2020: Overcoming technical and administrative barriers to deployment of multi-fuel hydrogen refuelling stations (HRS)
Project total costs:	EUR 2 121 906.25
Clean H_2 JU max. contribution:	EUR 1 997 406.25
Project period:	1.1.2021–31.12.2023
Coordinator:	Hydrogen Europe, Belgium
Beneficiaries:	Engie, Health and Safety Executive, Institut national de l'environnement industriel et des risques, ITM Power (Trading) Limited, Kiwa Nederland BV, Air Liquide SA, Shell Nederland Verkoopmaatschappij BV, Snam SpA, Zentrum für Sonnenenergie- und Wasserstoff-Forschung Baden-Württemberg

https://multhyfuel.eu/

PROJECT AND OBJECTIVES

MultHyFuel's ultimate goal is the amendment of best practice guidelines for the design, construction and development of multifuel refuelling stations. An analysis of the current legal framework regarding permitting requirements throughout Europe has been carried out. A risk assessment analysis and experimental data acquisition on the leakage characteristics and consequences in the station's forecourt will take place shortly.

NON-QUANTITATIVE OBJECTIVES

The project aims to contribute to safety improvement by selecting the critical scenarios identified in a multifuel refuelling station and proceeding to experimental testing of hydrogen leakage and its consequences.

PROGRESS AND MAIN ACHIEVEMENTS

- *Permitting requirements and risk assessment methodologies for HRS in the EU* (first edition) was submitted and presented to the stakeholders, with a summary of the main commonalities and differences found in permitting requirements from 14 European countries.
- Feedback from public authorities was received, as was feedback from experts during the interim review meeting.
- In work package (WP) 3, three case-study models with different configurations were identified and designed, and a preliminary risk assessment was performed on them to identify the most critical scenarios to study in WP2.
- In WP2, *Assessment of dispersion for high pressure H_2* was submitted, with results from computational fluid dynamics modelling simulations performed to evaluate the size of clouds expected considering different scenarios of leakage in H_2 dispensers.

FUTURE STEPS AND PLANS

- MultHyFuel will complete testing on the leakage characteristics of the dispenser. The project was waiting for equipment to be delivered and to acquire the data needed for the correct design of the system – testing was expected to start in January 2023.
- The project will complete testing of leakage consequences (fire and explosion) in the forecourt. Testing was expected to start in January 2023.
- MultHyFuel will organise a workshop with hydrogen refuelling station operators and public authorities. This is to take place once results from the experimental WP 2 are ready, so that they can be presented to the key stakeholders and so that feedback can be acquired.
- The project will perform a risk assessment and amend the best practice guidelines. This will take place once the experimental results have been released.

QUANTITATIVE TARGETS AND STATUS

Target source	Parameter	Unit	Achieved to date by the project	SoA result achieved to date (by others)	Year of SoA target
Project's own objectives	Safety refuelling distance	m	N/A	5–35, depending on the country	2021
	Guidelines for safety barriers	–	N/A	Dependent on the country	N/A
	Number of stakeholders endorsing project's results	number	17	N/A	N/A

Clean Hydrogen Partnership
Co-funded by the European Union

PRHYDE

PROTOCOL FOR HEAVY DUTY HYDROGEN REFUELLING

Project ID:	874997
PRD 2023:	Panel 5 – cross-cutting
Call topic:	FCH-04-2-2019: Refuelling protocols for medium and heavy-duty vehicles
Project total costs:	EUR 3 167 078.16
Clean H_2 JU max. contribution:	EUR 1 494 417.00
Project period:	1.1.2020–30.9.2022
Coordinator:	Ludwig-Bölkow-Systemtechnik GmbH, Germany
Beneficiaries:	Commissariat à l'énergie atomique et aux énergies alternatives, Engie, ITM Power plc, Air Liquide SA, NEL Hydrogen A/S, Nikola Corporation, Shell Deutschland GmbH, Toyota Motor Europe SA, Toyota Motor North America, Zentrum für Brennstoffzellen-Technik GmbH

https://prhyde.eu/

PROJECT AND OBJECTIVES

PRHYDE, running between January 2020 and September 2022, had the aim of developing recommendations for non-proprietary heavy-duty refuelling protocols used for future standardisation activities for trucks and other heavy-duty transport systems applying hydrogen technologies. Based on existing fuelling protocols and the current state of the art for compressed gaseous hydrogen fuelling, different hydrogen fuelling protocol concepts were developed for large tank systems with 35 MPa, 50 MPa and 70 MPa nominal working pressures using simulations, and experimental verification was carried out. A broad industry perspective was captured as a result of a comprehensive stakeholder participation process, with several workshops held throughout the project.

PROGRESS AND MAIN ACHIEVEMENTS

- PRHYDE has formulated four new fuelling protocol concepts for the heavy-duty segment.
- Complementary to the four PRHYDE fuelling concepts, a protocol feature that can apply to all concepts was also developed. This feature, called the SOC taper, can adjust the fuelling speed when the station encounters non-ideal situations such as low storage capacity or high-flow restrictions.
- Numerical approaches (thermodynamic and computational fluid dynamics modelling) and an experimental test campaign at different test sites were conducted to validate the modelling efforts and provide proof of concept that the protocol concepts work as intended.

FUTURE STEPS AND PLANS

The project has been completed.

QUANTITATIVE TARGETS AND STATUS

Target source	Parameter	Target	Achieved to date by the project	Target achieved?
Project's own objectives	Meetings with standards organisation groupings	4	4	✓
	Reports sent to standard-developing organisations	18	21	
	Publicly accessible workshops/webinars	6	6	

Clean Hydrogen Partnership
Co-funded by the European Union

SH2E

SUSTAINABILITY ASSESSMENT OF HARMONISED HYDROGEN ENERGY SYSTEMS: GUIDELINES FOR LIFE CYCLE SUSTAINABILITY ASSESSMENT AND PROSPECTIVE BENCHMARKING

Project ID:	101007163
PRD 2023:	Panel 5 – cross-cutting
Call topic:	FCH-04-5-2020: Guidelines for life cycle sustainability assessment (LCSA) of fuel cell and hydrogen systems
Project total costs:	EUR 2 142 778.75
Clean H_2 JU max. contribution:	EUR 1 997 616.25
Project period:	1.1.2021–30.6.2024
Coordinator:	Fundación IMDEA Energía, Spain
Beneficiaries:	Commissariat à l'énergie atomique et aux énergies alternatives, Forschungszentrum Jülich GmbH, Fundación para el Desarrollo de las Nuevas Tecnologías del Hidrógeno en Aragón, Greendelta GmbH, Symbio, Institute of Applied Energy

https://sh2e.eu/

PROJECT AND OBJECTIVES

The goal of SH2E is to provide a harmonised (i.e. methodologically consistent) multidimensional framework for the life cycle sustainability assessment (LCSA) of fuel cell and hydrogen (FCH) systems. To that end, SH2E will develop and demonstrate specific guidelines for the environmental, economic and social life cycle assessment and benchmarking of FCH systems, while addressing their consistent integration into robust FCH LCSA guidelines. The aim is for these guidelines to be globally accepted as the reference document for LCSA of FCH systems and to set the basis for future standardisation.

NON-QUANTITATIVE OBJECTIVES

- SH2E aims to contribute to FCH systems' sustainability. The development of harmonised guidelines will contribute to assessing the sustainability of FCH systems.
- The project aims to contribute to social acceptance. Better knowledge of FCH systems' social and environmental impacts will contribute to their acceptance.
- It aims to contribute to standardisation. Harmonised guidelines will pave the way for a standard.

PROGRESS AND MAIN ACHIEVEMENTS

- SH2E reviewed the existing guidelines.
- It reviewed case studies and projects.
- Environmental life cycle assessment guidelines were issued.
- Life cycle cost assessment guidelines were issued.

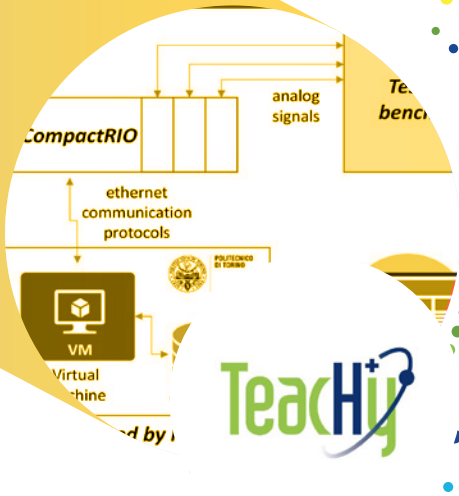
FUTURE STEPS AND PLANS

- Social life cycle assessment guidelines will be issued in mid 2023.
- LCSA guidelines will be issued at the end of 2023.
- The software tool for performing FCH life cycle studies will be issued in month 36.

Clean Hydrogen Partnership
Co-funded by the European Union

TeacHy

TEACHING FUEL CELL AND HYDROGEN SCIENCE AND ENGINEERING ACROSS EUROPE WITHIN HORIZON 2020



Project ID:	779730
PRD 2023:	Panel 5 – cross-cutting
Call topic:	FCH-04-3-2017: European higher training network in fuel cells and hydrogen
Project total costs:	EUR 1 248 528.75
Clean H_2 JU max. contribution:	EUR 1 248 528.75
Project period:	1.11.2017–31.10.2022
Coordinator:	University of Birmingham, United Kingdom
Beneficiaries:	Danmarks Tekniske Universitet, École Polytechnique Fédérale de Lausanne, Institut polytechnique de Grenoble, Karlsruher Institut für Technologie, National Technical University of Ukraine 'Igor Sikorsky Kyiv Polytechnic Institute', Politecnico di Torino, Technische Universiteit Delft, Universitatea Politehnica din București, Université libre de Bruxelles, University of Ulster, Vysoká škola chemicko-technologická v Praze

http://www.teachy.eu/

PROJECT AND OBJECTIVES

The project has developed an MSc programme on fuel cells and hydrogen. The MSc modules are also being offered as part of continuous professional development (CPD). The first run of the MSc programme is coming to a close, with the first student cohort starting their final research projects. Approximately 150 engineers and college teachers have been trained using the CPD modules, with 50 more to be added by the end of the project. The programme is being transferred from the University of Birmingham to Vysoká škola chemicko-technologická v Praze, and the programme started in September 2022.

NON-QUANTITATIVE OBJECTIVES

TeacHy aims to develop an accreditation system for CPD modules, despite the substantial challenges in achieving this.

PROGRESS AND MAIN ACHIEVEMENTS

- The MSc programme was created.
- The CPD modules were created.
- The project ensured the transferability of the learning management system (LMS) content.

FUTURE STEPS AND PLANS

- The project aims to transfer the programme to more universities; it is waiting for the results of the transfer to Vysoká škola chemicko-technologická v Praze.
- TeacHy will develop tools for transfer between different LMSs.
- The project will develop concise CPD programmes.
- It will establish a business entity for post-project activities.

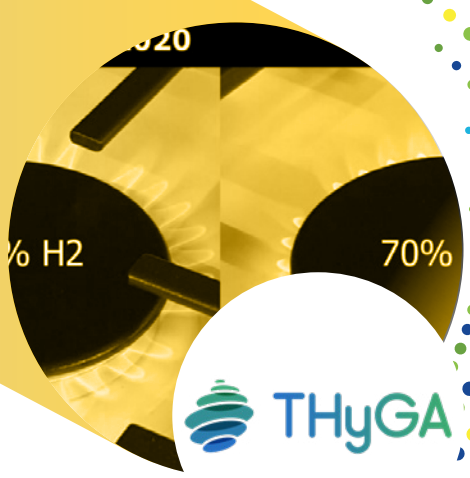
QUANTITATIVE TARGETS AND STATUS

Target source	Parameter	Unit	Target	Achieved by the project	Target achieved?
Project's own objectives	Start of the MSc course	Date	October 2019	October 2021	✓
	Modules established on the LMS	Number of modules	12	15	
	MSc modules used for CPD delivery	Number of modules run	N/A	8	⚙
	Modules translated into various languages	Number of modules	12	6 (partly)	⚙

Clean Hydrogen Partnership
Co-funded by the European Union

THyGA

TESTING HYDROGEN ADMIXTURE FOR GAS APPLICATIONS



Project ID:	874983
PRD 2023:	Panel 5 – cross-cutting
Call topic:	FCH-04-3-2019: Hydrogen admixtures in natural gas domestic and commercial end uses
Project total costs:	EUR 2 468 826.25
Clean H_2 JU max. contribution:	EUR 2 468 826.25
Project period:	1.1.2020–31.3.2023
Coordinator:	Engie, France
Beneficiaries:	BDR Thermea Group BV, Commissariat à l'énergie atomique et aux énergies alternatives, Dansk Gasteknisk Center AS, DVGW Deutscher Verein des Gas- und Wasserfaches – Technisch-Wissenschaftlicher Verein EV, Electrolux Italia SpA, gas.be, Gaswärme-Institut Essen EV, Gerg – le Groupe Européen de Recherches Gazières

https://thyga-project.eu/

PROJECT AND OBJECTIVES

The THyGA project is investigating the amount of hydrogen that can be injected without compromising the safety, emissions and efficiency of existing and new applications. It focuses on the end-user perspective, specifically domestic and commercial gas appliances (space heating, hot water, cooking and catering), which account for > 40 % of the EU's gas consumption. The objectives are to close knowledge gaps on the impact of H_2NG blends, support standardisation activities and identify potential mitigation opportunities.

NON-QUANTITATIVE OBJECTIVES

- THyGA aims to involve external partners in the project. Some laboratories and manufacturers expressed their wish to use the THyGA protocol to create their own tests and contribute to the analysis.
- The project aims to have an international reach. THyGA's test protocol has been requested for use as a test reference by international partners (in Canada, Chile and the United States).

PROGRESS AND MAIN ACHIEVEMENTS

- THyGA tested around 100 appliances, including as part of the preparation of reports for work packages 4 (standardisation) and 5 (mitigation).
- Thirteen public deliverables/newsletters were created and distributed, and five public workshops were organised.

FUTURE STEPS AND PLANS

Results were expected to be disclosed during the final workshop on 24 March 2023. All results will be published on the THyGA website. In addition, the results will be disseminated to the European Committee for Standardization technical committees, with the opportunity for experts to request dedicated meetings and discussions.

QUANTITATIVE TARGETS AND STATUS

Target source	Target	Achieved to date by the project	Target achieved?
Project's own objectives	Understanding the actual theoretical and experimental information on the impact of H_2NG blends on combustion	12 public deliverables and 7 additional deliverables to be published by April 2023	⚙
	Understanding the actual theoretical and experimental information on the impact of H_2NG blends on materials	Theoretical and practical reviews released	✓
	Segmentation of the types of appliances	Segmentation validated with stakeholders (advisory panel group)	✓
	Tests of up to 100 appliances	95 % of tests done	⚙
	Establishing how the existing certification can be modified to allow higher concentrations, including the related additional costs and the required changes to common gas burners	State-of-the-art reports	⚙
	Recommendations for revision of EN for ISO standards, or drafting of new standards based on PNR results and a review of the existing testing methods	Ongoing	⚙

Clean Hydrogen Partnership
Co-funded by the European Union