AD ASTRA

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

Project ID	825027
PRD 2022 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 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	Sunfire GmbH, SOLIDpower SpA, Europäisches Institut für Energieforschung EDF – KIT EWIV, Institute of Electrochemistry and Energy Systems, Università degli Studi di Salerno, École Polytechnique Fédérale de Lausanne, Università degli Studi di Genova, Danmarks Tekniske Universitet, Commissariat à l'énergie atomique et aux énergies alternatives

https://www.ad-astra.eu

PROJECT AND OBJECTIVES

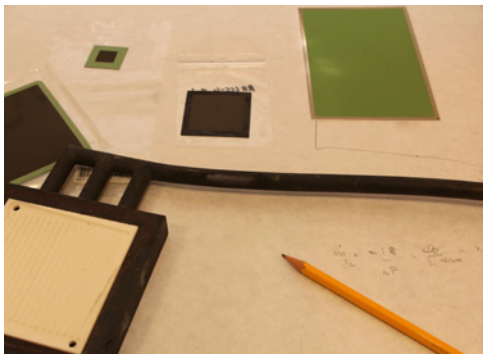
Accelerated stress tests deliberately stress a test material, component or product for a short period to assess the stability of new materials without having to use them in an operational system over a long period. The EU-funded AD ASTRA project aims to define accelerated stress testing protocols deduced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

PROGRESS AND MAIN ACHIEVEMENTS

- Over 200 samples from field and laboratory tests have been delivered and analysed.
- An online database was developed for the storing of all data (sample identity details, test conditions, measurement results) in an indexed archive.
- AD ASTRA completed the model for transfer functions developed from accelerated stress test conditions for real-life operation.

FUTURE STEPS AND PLANS

- AD ASTRA will conclude the validation tests and will adopt the schematic description of validated accelerated test procedures. Tests are ongoing, in collaboration with the Joint Research Centre.
- The models are validated and the transfer functions have been incorporated. Different modelling approaches will be considered.



QUANTITATIVE TARGETS AND STATUS

Target source	Parameter	Target	Achieved to date by the project	Target achieved?
Project's own objectives	Degradation acceleration	10x	4x	⚙
	Published articles	2 for each of work packages (WPs) 2, 3 and 4	11 for WP3, 3 for WP4, 5 for WP5	✓
AWP 2018	Submission of NWIP to IEC for standardisation	1	Technical report provided	⚙

PRD 2022 PANEL
Cross-cutting

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Clean Hydrogen Partnership

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BEST4Hy

SUSTAINABLE SOLUTIONS FOR RECYCLING OF END OF LIFE HYDROGEN TECHNOLOGIES

Project ID	101007216
PRD 2022 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 max. contribution	EUR 1 586 015
Project period	1/1/2021 – 31/12/2023
Coordinator	Parco Scientifico Tecnologico per l'Ambiente – Environment Park Torino SpA, Italy
Beneficiaries	IDO-Lab GmbH, Hensel Recycling GmbH, ElringKlinger AG, Aktsiaselts Elcogen, Univerza v Ljubljani, RINA Consulting SpA, Politecnico di Torino, Commissariat à l'énergie atomique et aux énergies alternatives

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 – proton-exchange membrane fuel cells (PEMFCs) and solid oxide fuel cells (SOFC) – and proof of concept for the recovery of iridium and palladium from proton-exchange membrane water electrolysis with novel technologies. Currently, the project is performing validation of four recovery processes at laboratory scale (TRL3) on materials of different ages (PEMFC and SOFC). 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.
- The project created a novel MEA gaseous-phase dismantling process.
- It achieved Ni-YSZ anode components recovery by HTH and HTM.

FUTURE STEPS AND PLANS

- The TRL 3 processes optimisation is ongoing.
- The project began scaling up the processes to TRL 5 in June 2022, and regulatory and standardisation aspects are ongoing.

QUANTITATIVE TARGETS AND STATUS

Target source	Parameter	Unit	Target	Target achieved?
Project's own objectives	Incoming Pt recovered	%	80	
	Incoming anode material recovered in total for SOFC	%	80	
	Incoming Pt recovered	%	90	
	La and Co recovered	%	> 80	
	Incoming membrane	%	100	
	GHG emission reduction in the overall production	%	– 20	

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eGHOST

ESTABLISHING ECO-DESIGN GUIDELINES FOR HYDROGEN SYSTEMS AND TECHNOLOGIES

Project ID	101007166
PRD 2022 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 max. contribution	EUR 998 991.25
Project period	1/1/2021 – 31/12/2023
Coordinator	Fundación IMDEA Energía, Spain
Beneficiaries	Institute of Applied Energy, Symbio, Fundación para el Desarrollo de las Nuevas Tecnologías del Hidrógeno en Aragón, Univerza v Ljubljani, Commissariat à l'énergie atomique et aux énergies alternatives

https://eghost.eu/

PROJECT AND OBJECTIVES

eGHOST will provide the first milestone in the development of ecodesign criteria in the European hydrogen sector. Two guidelines for specific fuel cells and hydrogen (FCH) products are being prepared, and the lessons learnt will be integrated into the eGHOST white book: a reference guidance book for any future ecodesign project on FCH systems. It addresses the eco(re)design of mature products (proton-exchange membrane fuel cell (PEMFC) stacks) and those emerging with low TRLs (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.

FUTURE STEPS AND PLANS

- Product concepts will be completed in month 24. They 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 learnt (month 36).

QUANTITATIVE TARGETS AND STATUS

Target source	Parameter	Unit	Achieved to date by the project	Target achieved?
AWP 2020	Ecodesign guidelines	number published	2	
	Cumulative cost reduction	%	3	
	Cumulative environmental reduction	%	10	
	Ecoefficiency improvement	%	10	

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E-SHyIPS

ECOSYSTEMIC KNOWLEDGE IN STANDARDS FOR HYDROGEN IMPLEMENTATION ON PASSENGER SHIP

Project ID	101007226
PRD 2022 Panel	5 – Cross-cutting
Call topic	FCH-04-2-2020: PNR on hydrogen-based fuels solutions for passenger ships
Project total costs	EUR 2 500 000
Clean H_2 max. contribution	EUR 2 500 000
Project period	1/1/2021 – 31/12/2024
Coordinator	Politecnico di Milano, Italy
Beneficiaries	IDF – Ingegneria Del Fuoco SRL, Levante Ferries Naftiki Etaireia, Dimos Andravidas-Kyllinis, Atena scarl – Distretto Alta Tecnologia Energia Ambiente, Teknologian tutkimuskeskus VTT Oy, Ghenova Ingeniería SL, UNI – Ente Italiano di Normazione, DNV Hellas Single Member SA, Oy Woikoski AB, Scheepswerf Damen Gorinchem BV, Danaos Shipping Company Limited, Proton Motor Fuel Cell GmbH, Cineca Consorzio Interuniversitario, Università degli Studi di Napoli Parthenope, Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile

https://e-shyips.com/

PROJECT AND OBJECTIVES

Hydrogen is considered an option for reaching emission reduction targets; however, a regulatory framework applicable to hydrogen-fuelled ships is not yet available. e-SHyIPS brings together hydrogen and maritime stakeholders to gather new knowledge based on regulatory framework review and experimental data. The approach is vessel independent, and is focused on the risk and safety assessment methodologies. e-SHyIPS will define a pre-standardisation plan for an International Code of Safety for Ships using Gases or other Low-flashpoint Fuels update for the hydrogen-based-fuels passenger ships and a roadmap to boost the hydrogen maritime economy.

NON-QUANTITATIVE OBJECTIVES

- e-SHyIPS aims to define project concept functional scenarios. 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. The functional and technical requirements are for a scenario report. The technical and functional requirements of hydrogen-based-fuels passenger ships were elicited from operational profile scenarios. The technical features will be described for the associated subsystem (e.g. 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 are 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 vessels and hydrogen storages are expected at the end of 2022.
- The project aims to determine risk and safety best practices for the maritime sector. The project 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.

FUTURE STEPS AND PLANS

- e-SHyIPS will continue to develop the hydrodynamic analysis. Implementation on the LincoSim platform is planned for the end of 2022.
- The preliminary vessel design for each scenario is expected to be completed at the end of 2022.
- The H_2-based fuel propulsion system's basic design technical report is expected to be completed by the end of 2022.
- The on-board H_2 dispersion and explosion model test plan, set-up and initial results are expected to be ready for the end of 2022.
- Interim test results from material and component testing and postmortem analysis are expected at the end of 2022.
- Initial results for the fuel delivery and bunkering solutions for ships are expected at the end of 2022.

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Clean Hydrogen Partnership
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FCHgo

FUEL CELLS HYDROGEN EDUCATIONAL MODEL FOR SCHOOLS

Project ID	826246
PRD 2022 Panel	5 – Cross-cutting
Call topic	FCH-04-4-2018: Strengthening public acceptance and awareness of FCH technologies by educating pupils at schools
Project total costs	EUR 502 498.75
Clean H_2 max. contribution	EUR 502 498.75
Project period	1/1/2019 – 30/6/2021
Coordinator	Università degli Studi di Modena e Reggio Emilia, Italy
Beneficiaries	Steinbeis 2i GmbH, InEuropa SRL, Zürcher Hochschule für Angewandte Wissenschaften, Uniwersytet Mikołaja Kopernika w Toruniu, Libera Università di Bolzano, Danmarks Tekniske Universitet

https://fchgo.eu

PROJECT AND OBJECTIVES

FCHgo aims to explain the functioning and application of fuel cells and hydrogen (FCH) technologies, and to make younger generations aware of these by providing an educational toolkit that takes a narrative approach, with a website as a connecting point for all users. The final version of the FCHgo toolkit (lessons and materials) for pupils aged 8–18 is freely available, having been tested in classrooms and validated. FCHgo ended on 30 June 2021, after the launch of the first edition of the award for the best idea/solution to employ FCH. Despite problems related to the COVID-19 pandemic, both national and international events were successful.

NON-QUANTITATIVE OBJECTIVES

- FCHgo aimed to develop an educational programme delivery model (EPDM).The final version of the EPDM is made up of an educational toolkit, comprising a set of guidelines, lessons, toys, plays and videos to support educational activities in European schools. The EPDM is available in 10 languages.
- The project aimed to launch the FCHgo award, providing the possibility for all European students to propose their best idea for future FCH applications. The first award ceremony was successfully carried out.

PROGRESS AND MAIN ACHIEVEMENTS

- The final version of the FCHgo EPDM is available.
- FCHgo award activities were performed.
- The project hosted the first FCHgo award ceremony.

FUTURE STEPS AND PLANS

The project has finished. Partners are planning to organise a second award, depending on whether the necessary financial support can be found.

QUANTITATIVE TARGETS AND STATUS

Parameter	Unit	Target	Achieved to date by the project	Target achieved?
Number of participants in the FCHgo EPDM validation	participants	N/A	32	⚙
Trained pupils in primary and secondary schools for FCHgo award participation	pupils	200–140 000	457	✓
Trained professionals (teachers) for FCHgo award participation	teachers	N/A	130	⚙

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HYDRAITE

HYDROGEN DELIVERY RISK ASSESSMENT AND IMPURITY TOLERANCE EVALUATION

Project ID	779475
PRD 2022 Panel	5 – Cross-cutting
Call topic	FCH-04-1-2017: Limiting the impact of contaminants originating from the hydrogen supply chain
Project total costs	EUR 3 499 867.50
Clean H_2 max. contribution	EUR 3 499 867.50
Project period	1/1/2018 – 30/9/2021
Coordinator	Teknologian tutkimuskeskus VTT Oy, Finland
Beneficiaries	Sintef AS, Zentrum für Brennstoffzellen-Technik GmbH, PowerCell Sweden AB, Zentrum für Sonnenenergie- und Wasserstoff-Forschung Baden-Württemberg, NPL Management Limited, Stiftelsen Sintef, Commissariat à l'énergie atomique et aux énergies alternatives

https://hydraite.eu/

PROJECT AND OBJECTIVES

The HYDRAITE project aims to solve the issue of hydrogen quality for transportation applications. The effects of contaminants, originating from the hydrogen supply chain, on the fuel cell systems in automotive applications were studied. A hydrogen-refuelling station (HRS) sampling campaign was conducted. In-line monitoring of hydrogen quality at the HRS and a sampling strategy and methodology for new impurities, gases, particles and liquids were evolved. Three European H_2 laboratories were established, capable of measuring all of the contaminants in accordance with International Organization for Standardization (ISO) standard 14687.

NON-QUANTITATIVE OBJECTIVES

- HYDRAITE aims to make recommendations for the revision of ISO standard 14687. Similar measurement set-ups of six partners were undertaken, the methodology was validated and fuel cell measurements were completed with CO, CO_2, sulphur, ionic liquids, freon and toluene.
- The project aims to make recommendations for fuel cell stack contaminant measurements in automotive-type operations. These recommendations have been created.
- It aims to gather technical data on fuel composition from HRSs. Three sampling campaigns have been conducted, with a total of 30 samples collected.
- HYDRAITE aims to perform in-line monitoring of hydrogen fuel quality. The concept for the proton-exchange-membrane-based sensor and HRS online quality monitoring were established.
- The project aims for three European laboratories to measure the ISO-defined contaminants. Three project laboratories are using analytical methods compliant with ISO standard 14687.

PROGRESS AND MAIN ACHIEVEMENTS

- The project set up three European hydrogen-quality laboratories capable of full analysis in accordance with European Standard EN 17124.
- Three HRS sampling campaigns were completed, collecting public data from a total of 30 samples from Germany, Norway and Sweden.
- HYDRAITE validated the methodology for studying the effect of impurities on fuel cell stacks.

FUTURE STEPS AND PLANS

The project has finished.

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Clean Hydrogen Partnership

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HyResponder

EUROPEAN HYDROGEN TRAIN THE TRAINER PROGRAMME FOR RESPONDERS

Project ID	875089
PRD 2022 Panel	5 – Cross-cutting
Call topic	FCH-04-1-2019: Training of Responders
Project total costs	EUR 1 000 000
Clean H_2 max. contribution	EUR 1 000 000
Project period	1/1/2020 – 31/12/2022
Coordinator	University of Ulster, United Kingdom
Beneficiaries	Fire Service College Limited, International Fire Academy, Ministry of the Interior of the Czech Republic, Universitetet i Sørøst-Norge, Landes-Feuerwehrverband Tirol, Persee, Crisis Simulation Engineering SARL, École nationale supérieure des officiers de sapeurs-pompiers, Service Public Fédéral Intérieur, Ayuntamiento de Zaragoza, Association Comité National Francais du CTIF (Comité Technique International de prévention et d'extinction de Feu), DLR-Institut für Vernetzte Energiesysteme EV, L'Air Liquide SA, Deutsches Zentrum für Luft- und Raumfahrt EV, Università degli Studi di Roma la Sapienza, Commissariat à l'énergie atomique et aux énergies alternatives

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. 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 the 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

- A beta version of the HyResponder e-platform with stratified training materials and tools is available online.
- Responder trainers from 10 partner countries have been trained in hydrogen safety.
- Novel online training sequences were developed to support the remote training of responders.

FUTURE STEPS AND PLANS

- HyResponder will deliver regional workshops. Countries' schedules have been revised, with the exception of that of Austria, to allow for in-person training in ENSOSP in June 2022. Online training has been piloted in Austria. As of June 2022, nine regional workshops are still to be held. These will be completed by April 2023.
- The project will complete translation of training materials. This is partially complete; it is expected to be completed by the end of April 2022.
- HyResponder will demonstrate the project's impact nationally. Each partner has a plan to ensure that the HyResponder training has an impact within and beyond HyResponder. The project consortium will document this.

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; 10 national)	11	2	⚙
	Threefold training materials (lectures, operational, virtual reality)	3	3	✓
	Revised *European Emergency Response Guide*	1	1	✓
	e-platform for responders	1	1	✓
	Materials translated into eight languages	8	1	⚙

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Clean Hydrogen Partnership

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HyTunnel-CS

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

Project ID	826193
PRD 2022 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 max. contribution	EUR 2 500 000
Project period	1/3/2019 – 31/7/2022
Coordinator	University of Ulster, United Kingdom
Beneficiaries	International Fire Academy, Universitetet i Sørøst-Norge, Service Public Federal Interieur, Pro-Science – Gesellschaft für wissenschaftliche und technische Dienstleistungen mbH, Karlsruher Institut für Technologie, Fundación para el Desarrollo de las Nuevas Tecnologías del Hidrógeno en Aragón, Health and Safety Executive (HSE), Stichting Koninklijk Nederlands Normalisatie Instituut, National Centre of Scientific Research 'Demokritos', Università degli Studi di Roma la Sapienza, Danmarks Tekniske Universitet, Commissariat à l'énergie atomique et aux énergies alternatives (CEA)

https://hytunnel.net

PROJECT AND OBJECTIVES

This pre-normative research project aims to improve the safety of hydrogen-driven vehicles in underground infrastructure. The project aims 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). HyTunnel-CS aims to reduce over-conservatism 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 aims to ensure that fuel cell electric vehicles entering tunnels are at a level of risk equal to / below that of fossil fuel vehicles. This is being addressed by considering tunnel vehicles as a system through experimental, theoretical and numerical studies.

PROGRESS AND MAIN ACHIEVEMENTS

- The analytical, numerical, small- to medium-scale experimental research programme is being carried out as planned.
- The large-scale experimental programme in a real tunnel (CEA) was completed. The large-scale experimental programme at the HSE is ongoing.
- Two out of three key public deliverables are complete. The remaining key public deliverable is under development.

FUTURE STEPS AND PLANS

- HyTunnel-CS will undertake an analytical and numerical campaign. This will involve the finalisation of the remaining analytical studies, and the validation of computational fluid dynamics simulations against large-scale experimental programme results. The work is in its final stage – the remaining modelling campaign is to be finished after completion of the HSE large-scale experimental programme (June 2022).
- The project will undertake an experimental campaign, fulfilling the experimental programme on hydrogen releases, fires and deflagrations. The large-scale experimental programme has been delayed; it is expected to be completed in June 2022.
- It will undertake a communication campaign. The results will be communicated at the dissemination conference, rescheduled for July 2022.
- HyTunnel-CS will make recommendations for the inherently safer use of hydrogen vehicles, for RCS and for response to hydrogen accidents. The recommendations for RCS have been provided, together with the recommendations for response to hydrogen accidents. The recommendations for the inherently safer use of hydrogen vehicles have been rescheduled.

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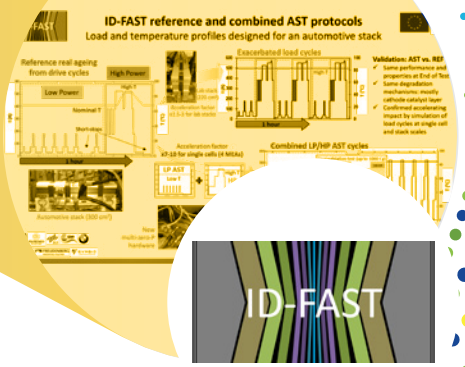
ID-FAST

INVESTIGATIONS ON DEGRADATION MECHANISMS AND DEFINITION OF PROTOCOLS FOR PEM FUEL CELLS ACCELERATED STRESS TESTING



Project ID	779565
PRD 2022 Panel	5 – Cross-cutting
Call topic	FCH-04-5-2017: definition of accelerated stress testing (AST) protocols deduced from understanding of degradation mechanisms of aged stack components in fuel cell systems
Project total costs	EUR 2 748 195
Clean H_2 max. contribution	EUR 2 748 195
Project period	1/1/2018 – 31/12/2021
Coordinator	Commissariat à l'énergie atomique et aux énergies alternatives, France
Beneficiaries	Symbio, Freudenberg Performance Materials SE & Co KG, Freudenberg Technology Innovation SE & Co. KG, Bayerische Motoren Werke Aktiengesellschaft, Zentrum für Sonnenenergie- und Wasserstoff-Forschung Baden-Württemberg, Politecnico di Milano, Deutsches Zentrum für Luft- und Raumfahrt EV, Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung EV

https://www.id-fast.eu/index.php?id=1

PROJECT AND OBJECTIVES

ID-FAST targets the deployment of proton-exchange membrane fuel cells (PEMFC) thanks to specific accelerated stress tests (ASTs) and the link to real durability. The core focus is understanding degradation and the validation of new ASTs relating to in situ, ex situ and modelling data. Postmortem analyses after ageing and modelling are providing insights on the mechanisms involved. Experiments on and simulations of stressors allow ID-FAST to propose accelerating protocols applied in single cells. Combined AST protocols were developed and validated in single cells and stacks with regard to their relevance and their capability to reduce testing time compared with that of real ageing.

NON-QUANTITATIVE OBJECTIVES

- ID-FAST aimed to identify real ageing mechanisms and the impact of conditions. The mechanisms identified include local issues from postmortem analyses of stack components aged in real ageing profiles.
- The project aimed to develop models and couple mechanisms for ASTs' simulation. It aimed to perform new simulations of AST cycles for single cells or stacks, with models including catalyst degradation.
- It aimed to develop and validate specific and combined AST protocols. Two types of operando AST with combined cycles based on low-power/high-power periods of real drive cycles were validated.
- ID-FAST aimed to propose transfer functions relating accelerated degradation to real degradation. The assessment of acceleration factors gave values from 2 to 10, depending on the ASTs. The transfer function was determined as a 1 : 1 ratio for reference cycles and new combined low-power/high-power AST cycles.
- The project aimed to support standardisation efforts of fuel cell testing related to ASTs. A public report with recommendations and contributions to Ad Hoc Group 11 of the International Electrotechnical Commission Technical Committee 105 was started in 2019, dedicated to ASTs for fuel cells, in collaboration with the solid oxide fuel cell project AD ASTRA.

PROGRESS AND MAIN ACHIEVEMENTS

- ID-FAST identified the main stressors and acceleration mechanisms for membrane electrode assembly (MEA) components using specific ageing tests in cells or stacks and postmortem analyses.
- The project simulated AST cycles, including catalyst degradation.
- It defined the operando combined AST with low-power/high-power periods based on ID-FAST drive cycles.

FUTURE STEPS AND PLANS

The project has finished.

QUANTITATIVE TARGETS AND STATUS

Target source	Parameter	Target	Target achieved?	SoA result achieved to date (by others)	Year of SoA target
Project's own objectives	Reduction of the gap in degradation understanding	Improvement	✓	Analyses of MEAs' degradation mechanisms (exp. and model)	2020
	Acceleration factor	2–10	✓	N/A (limited SoA on combined AST representative of the real world)	N/A
	ASTs	New (different combined protocols)	✓	Single-mechanisms AST available for catalyst-coated membrane components	2018

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MultHyFuel

MULTI-FUEL HYDROGEN REFUELING STATIONS (HRS): A CO-CREATION STUDY AND EXPERIMENTATION TO OVERCOME TECHNICAL AND ADMINISTRATIVE BARRIERS

Project ID	101006794
PRD 2022 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 max. contribution	EUR 1 997 406.25
Project period	1/1/2021 – 31/12/2023
Coordinator	Hydrogen Europe, Belgium
Beneficiaries	Shell Nederland Verkoopmaatschappij BV, Snam SpA, Kiwa Nederland BV, ITM Power (Trading) Limited, Health and Safety Executive, Zentrum für Sonnenenergie- und Wasserstoff-Forschung Baden-Württemberg, Institut national de l'environnement industriel et des risques, ENGIE, L'Air Liquide SA

https://multhyfuel.eu/

PROJECT AND OBJECTIVES

MultHyFuel's ultimate goal is the amendment of best-practice guidelines for the design, construction and development of multi-fuel-refuelling stations. An analysis of the current legal framework regarding permitting requirements throughout Europe was previously carried out. A risk assessment analysis and the 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 multi-fuel-refuelling station and proceeding to experimental testing of hydrogen leakage and its consequences.

FUTURE STEPS AND PLANS

- MultHyFuel will complete testing on the leakage characteristics of the dispenser. The project is waiting for equipment to be delivered and to acquire the data needed for the correct design of the system – testing is expected to start before summer 2022.
- The project will complete testing of leakage consequences (fire and explosion) in the forecourt. It is waiting for equipment to be delivered and for the forecourt replica design to be finalised – testing is expected to start before summer 2022.
- MultHyFuel will organise a workshop with hydrogen-refuelling station operators and public authorities. This is to take place once results from the experimental work package 2 are ready, so they can be presented to the important stakeholders and so that feedback can be acquired.
- The project will perform a risk assessment and an amendment of the best-practice guidelines. These are to take place once the experimental results have been released.

QUANTITATIVE TARGETS AND STATUS

Target source	Parameter	Unit	Target achieved?	SoA result achieved to date (by others)
Project's own objectives	Safety distance	m		5–35, depending on the country
	Number of authorities represented at the workshops	number		N/A

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Cross-cutting

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PRESLHY

PRE-NORMATIVE RESEARCH FOR SAFE USE OF LIQUID HYDROGEN

Project ID	779613
PRD 2022 Panel	5 – Cross-cutting
Call topic	FCH-04-4-2017: PNR for a safe use of liquid hydrogen
Project total costs	EUR 1 905 862.50
Clean H_2 max. contribution	EUR 1 724 277
Project period	1/1/2018 – 31/5/2021
Coordinator	Karlsruher Institut für Technologie, Germany
Beneficiaries	International Association for Hydrogen Safety, Pro-Science – Gesellschaft für wissenschaftliche und technische Dienstleistungen mbH, Health and Safety Executive, University of Ulster, Institut national de l'environnement industriel et des risques, L'Air Liquide SA, University of Warwick, National Centre of Scientific Research 'Demokritos'

http://www.preslhy.eu/

PROJECT AND OBJECTIVES

In the PRESLHY project, the project consortium conducted pre-normative research on the safe use of cryogenic/liquid hydrogen in non-industrial settings. The work programme consisted of a preparatory phase, a main phase for executing a concise experimental programme and a final phase for the exploitation of the experimental outcomes. The results are currently being used to update International Organization for Standardization standard ISO/TR 15916 with regard to cryogenic aspects under subtask 2 of Working Group 29.

NON-QUANTITATIVE OBJECTIVES

PRESLHY aims to make recommendations for a non-proprietary heavy-duty refuelling protocol to be used for future standardisation activities for heavy-duty hydrogen refuelling. Refuelling concepts have been developed and are being validated by experimental and simulation tests for 35, 50 and 70 MPa hydrogen refuelling. The risk assessment has been performed. The results are to be disseminated to several stakeholders.

PROGRESS AND MAIN ACHIEVEMENTS

- The project has supported the review of ISO/TR 15916 on the safe use of LH_2 in non-industrial settings.
- PRESLHY has produced a handbook chapter on the safety of LH_2.

FUTURE STEPS AND PLANS

- The project will finalise the experimental and simulations work on the fuelling protocol by mid 2022.
- Dissemination workshops were planned for April and May 2022 to present intermediate results. The final dissemination is planned for after the project's end (September 2022).
- PRESLHY will finalise the refuelling protocol concept and carry out final dissemination by September 2022.

QUANTITATIVE TARGETS AND STATUS

Target source	Parameter	Target	Achieved to date by the project	Target achieved?
Support for RCS development	Number of reports sent to SDOs	1	4	✓
	Number of workshops with SDOs invited	1	4	
	Consortium partners involved in SDOs	1	5	
	Review of standard initiated	1	1	

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PRHYDE

PROTOCOL FOR HEAVY DUTY HYDROGEN REFUELLING

Project ID	874997
PRD 2022 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 max. contribution	EUR 1 494 417.00
Project period	1/1/2020 – 31/12/2021
Coordinator	Ludwig-Bölkow-Systemtechnik GmbH, Germany
Beneficiaries	Toyota Motor North America, Nikola Corporation, Shell Deutschland Oil GmbH, ITM Power (Trading) Limited, Zentrum für Brennstoffzellen-Technik GmbH, Nel Hydrogen AS, Toyota Motor Europe NV, ENGIE, L'Air Liquide SA, Commissariat à l'énergie atomique et aux énergies alternatives

https://prhyde.eu/

PROJECT AND OBJECTIVES

The PRHYDE project is aiming to develop recommendations for a non-proprietary heavy-duty refuelling protocol 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 methods for compressed (gaseous) hydrogen fuelling, different hydrogen fuelling concepts are to be developed for large tank systems with 35, 50 and 70 MPa nominal working pressures using simulations and experimental verification.

PROGRESS AND MAIN ACHIEVEMENTS

- PRHYDE ran webinars.
- The project has published several deliverables to date.
- It conducted a survey of interested stakeholders outside the project consortium.

QUANTITATIVE TARGETS AND STATUS

Parameter	Target	Achieved to date by the project	Target achieved?
Meetings with standards organisation groupings	4	3	
Reports sent to standards-developing organisations	18	10	
Publicly accessible workshops/webinars	6	4	

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SH2E

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

Project ID	101007163
PRD 2022 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 max. contribution	EUR 1 997 616.25
Project period	1/1/2021 – 30/6/2024
Coordinator	Fundación IMDEA Energia, Spain
Beneficiaries	The Institute of Applied Energy, Symbio, Fundación para el Desarrollo de las Nuevas Tecnologías del Hidrógeno en Aragón, GreenDelta GmbH, Forschungszentrum Jülich GmbH, Commissariat à l'énergie atomique et aux énergies alternatives

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 cells and hydrogen (FCH) systems. To that end, SH2E will develop and demonstrate specific guidelines for the environmental, economic and social life cycle assessments 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's 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.
- The project reviewed case studies and projects.

FUTURE STEPS AND PLANS

- Environmental LCA guidelines will be issued in mid 2022.
- Life cycle cost assessment guidelines will be issued in month 24 (at the end of 2022).
- 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 LC studies will be issued in month 36.

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TeacHy

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

Project ID	779730
PRD 2022 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 max. contribution	EUR 1 248 528.75
Project period	1/11/2017 – 31/10/2022
Coordinator	University of Birmingham, United Kingdom
Beneficiaries	Karlsruher Institut für Technologie, National Technical University of Ukraine 'Igor Sikorsky Kyiv Polytechnic Institute', Universitatea Politehnica Din București, Vysoká škola chemicko-technologická v Praze (VSCHT), Institut polytechnique de Grenoble, University of Ulster, École Polytechnique Fédérale de Lausanne, Technische Universiteit Delft, Politecnico di Torino, Université Libre de Bruxelles, Danmarks Tekniske Universitet

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). Currently, 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 VSCHT in Prague, with the programme expected to start there in September 2022.

NON-QUANTITATIVE OBJECTIVES

TeacHy aimed 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 VSCHT.
- 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

Parameter	Unit	Target	Achieved by the project	Target achieved?
Start of the MSc course	date	October 2019	October 2021	✓
Minimum of 12 modules established on LMS	number of modules	12	15	
Used the MSc modules for CPD delivery	modules run	N/A	8	⚙
Modules translated into various languages	number of modules	12	6 (partly)	⚙

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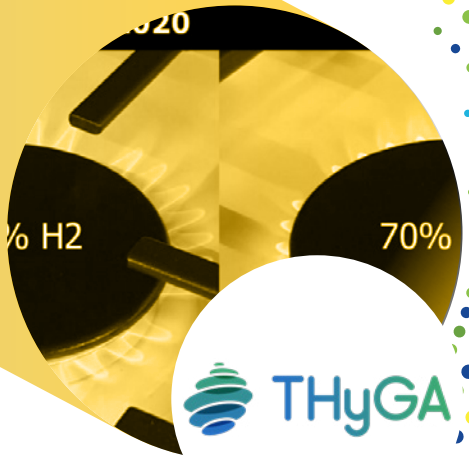
THyGA

TESTING HYDROGEN ADMIXTURE FOR GAS APPLICATIONS



Project ID	874983
PRD 2022 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 max. contribution	EUR 2 468 826.25
Project period	1/1/2020 – 31/12/2022
Coordinator	ENGIE, France
Beneficiaries	Dansk Gasteknisk Center AS, BDR Thermea Group BV, Gerg-Le Groupe Europeen de Recherches Gazières, Gas.Be, Gaswärme-Institut Essen EV, DVGW Deutscher Verein des Gas- und Wasserfaches EV – Technisch-wissenschaftlicher Verein, Electrolux Italia SpA, Commissariat à l'énergie atomique et aux énergies alternatives

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 by international partners (in Canada, Chile and the United States) to be used as a test reference.

PROGRESS AND MAIN ACHIEVEMENTS

- THyGA has completed tests of around 40 appliances.

FUTURE STEPS AND PLANS

- The project will complete the test campaign. To date, around 40 % of the test objectives have been achieved; the goal is to conduct 100 tests by September 2022.
- THyGA will gain the support of the stakeholders regarding standardisation. THyGA has already had many exchanges with technical committees, and plans to develop a common work programme to support the standardisation and certification of H_2NG for appliances.
- The project will develop approaches aiming to identify the technical possibilities of mitigation to improve the rate of H_2 with which appliances can deal (in terms of safety, efficiency, power, etc.).

QUANTITATIVE TARGETS AND STATUS

Target source	Target	Achieved to date by the project
Project's own objectives	Understanding the actual theoretical and experimental information on the impact of H_2NG blends on combustion	Five public deliverables
	Understanding the actual theoretical and experimental information on the impact of H_2NG blends on materials	Bibliography review and preparation of test rig
	Segmentation of the types of appliances	Segmentation validated with stakeholders (advisory panel group)
	Tests of up to 100 appliances	40 % of tests complete
	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

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