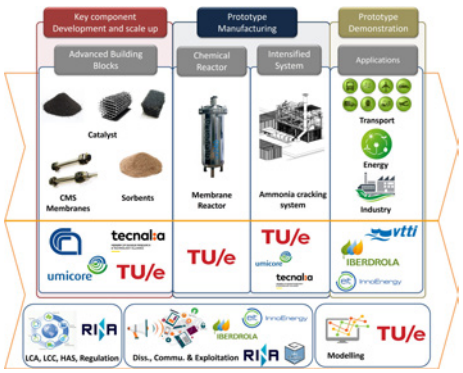
ANDREAH

AMMONIA BASED MEMBRANE REACTOR FOR GREEN HYDROGEN PRODUCTION

Project ID	101112118
PRR 2026	Pillar 2 - H_2 Storage and Distribution
Call Topic	HORIZON-JTI-CLEANH$_2$-2022-02-04
Project Total Costs	2 980 361.25
Clean H_2 JU Max. Contribution	2 980 361.25
Project Period	01-07-2023 - 30-06-2027
Coordinator Beneficiary	FUNDACION TECNALIA RESEARCH and INNOVATION, ES
Beneficiaries	TECHNISCHE UNIVERSITEIT EINDHOVEN, KIC INNOENERGY SE, UMICORE AG and CO KG, EURO TANK TERMINAL B.V., RINA CONSULTING S.P.A, VTTI TERMINAL SUPPORT SERVICES BV, IBERDROLA CLIENTES SOCIEDAD ANONIMA,1 CUBE BV, UMICORE DENMARK APS, CONSIGLIO NAZIONALE DELLE RICERCHE, VTTI BV

https://www.andreahproject.eu/



PROJECT AND GENERAL OBJECTIVES

The ANDREAH HORIZON EUROPE project aims to effect a quantum leap in the development of advanced ammonia decomposition technologies to produce ultra-pure hydrogen (>99.998%) by developing an innovative system based on a catalytic membrane reactor for the cracking of Ammonia. The system will be based on the design, construction, and testing of an advanced ammonia cracker for ultra-pure hydrogen production (10 kg H_2/day) using a catalytic membrane reactor to intensify hydrogen production by integrating cracking and purification. The advanced cracker will include:

- An innovative, environmentally friendly structured catalyst with fewer critical materials, capable of operating at much lower temperatures than the state-of-the-art process.
- Innovative membranes for selective separation of hydrogen during the production process.

ANDREAH will also be involved in developing novel sorbents for polishing the hydrogen recovered by the membranes. In addition, the design and optimisation of all subcomponents for the balance of plant will be included, with particular attention to optimising thermal integration.

NON-QUANTITATIVE OBJECTIVES

- Designing and setting up a broad and complete network of value chains with world-class universities, research centres and industrial partners to develop the key building blocks for ammonia cracking.
- Developing a full life-cycle assessment, life-cycle costing and health and safety analysis of ANDREAH.
- Developing a set of flexible, cost-effective and environmentally friendly technologies that can be easily tailored for the decomposition of ammonia into green hydrogen for different applications, such as energy and transport.
- Paving the way for the future exploitation of ANDREAH's key results by laying the foundations for new business opportunities in developing advanced catalysts and membranes. These will be integrated into membrane reactors to significantly intensify processes, enabling distributed hydrogen generation from ammonia as a long-term storage medium.
- Promoting the dissemination and communication of ANDREAH's results and expanding its impact.

PROGRESS, MAIN ACHIEVEMENTS AND RESULTS

- Market and stakeholder analysis;
- Preliminary business model development;
- Characterisation tables for Key Exploitable Results (KERs);
- Identification and analysis of current regulations, including mapping of applicable international and European standards;
- Catalyst kinetic modelling and membrane modelling;
- Development of first- and second-generation catalysts: a 1 wt% Ru-based catalyst exhibited performance above the project target;
- Development of second-generation structured catalysts based on 3D-printed gyroid TPMS supports for integration into a single-tube membrane reactor;
- Successful scale-up of the 1 wt% Ru-based catalyst, with studies initiated on dip-coating gyroid POCS substrates to enable integration of structured catalysts and membranes;
- Development of second-generation carbon membranes selective to H_2 in H_2, N_2 and NH_3 mixtures;

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- Development of first-generation carbon membranes selective to H_2 in H_2, N_2 and NH_3 mixtures;
- Development of sorbent materials for the removal of residual ammonia from hydrogen streams exiting membrane reactors;
- Preliminary drafting of the system P&ID;
- Refined life cycle assessment (LCA), life cycle costing (LCC), and social LCA (S-LCA) analyses;
- Comprehensive health, safety, and environmental (HSE) studies on ammonia and hydrogen;
- Initiation of techno-economic assessment of ammonia-derived hydrogen recovery, focusing on reaction unit modelling;
- Update of the Dissemination, Exploitation and Communication Plan (mid-2025)

FUTURE STEPS AND PLANS

- Consolidation of the business model;
- Finalisation of the collection of Exploitation Roadmaps;
- Drafting of the regulatory baseline document and an initial regulatory white paper;
- Completion of the ammonia cracking system model;
- Preparation and delivery of membranes, catalysts, and sorbents for the prototype;
- Development of third-generation structured catalysts and membranes;
- Design and manufacturing of the membrane reactor system;
- Reporting on the ANDREAH health and safety requirements;
- Review of the dissemination, exploitation, and communication plan.

PROJECT TARGETS

Target source	Parameter	Unit	Target	Target achieved?	SoA result achieved to date (by others)	Year for reported SoA result
Project's own objectives	OPEX of the ammonia cracking system	k€/year	209.5		282.42	2020
	Decentralised cost of H_2 production	€/kg	4.27		5.51	2020
	CAPEX of the ammonia cracking system	k€	211.74		384.72	2020
	Amount of Ru in the catalyst for low-temperature (< 500 °C) cracking	wt%	<1		2 - 8	2021
	Amount of Pd per membrane	g	<0.1		2.6	2023

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CANDHY

COMPATIBILITY ASSESSMENT OF NON-STEEL METALLIC DISTRIBUTION GAS GRID MATERIALS WITH HYDROGEN

Project ID	101111893
PRR 2026	Pillar 2 - H_2 Storage and Distribution
Call Topic	HORIZON-JTI-CLEANH$_2$-2022-02-01
Project Total Costs	2 607 481.25
Clean H_2 JU Max. Contribution	2 607 481.00
Project Period	01-09-2023 - 31-08-2026
Coordinator Beneficiary	FUNDACIÓN PARA EL DESARROLLO DE LAS NUEVAS TECNOLOGÍAS DEL HIDRÓGENO EN ARAGÓN, ES
Beneficiaries	FUNDACIÓN TECNALIA RESEARCH and INNOVATION, NATRAN, REDEXIS GAS SERVICIOS SL, GERG LE GROUPE EUROPÉEN DE RECHERCHES GAZIERES, REDEXIS SA, RINA CONSULTING - CENTRO SVILUPPO MATERIALI SPA, SUMNISTROS INDUSTRIALES DIVERSOS SA, UNIVERSITÀ DEGLI STUDI DI BERGAMO

http://candhy.eu/

PROJECT AND GENERAL OBJECTIVES

- Performing a comprehensive review of the state of the art in European gas distribution grids, standards and testing codes for material compatibility with hydrogen, and hydrogen embrittlement mechanisms. The collected information will support the development of testing protocols to determine the properties of material classes studied in CANDHy under relevant operating conditions.
- Designing, developing and performing an experimental campaign to test the most relevant non-steel metallic materials found in CANDHy under different hydrogen levels to assess their tolerance towards this gas at operating conditions applicable for the distribution grid.
- Documenting and analysing the effect of hydrogen gas on the non-steel metallic materials tested in the aforementioned experimental campaign.
- Developing models for the prediction of hydrogen embrittlement mechanisms.
- Proposing guidelines, procedures and areas of development to support future standardisation of the testing and qualification of materials in the distribution network in the presence of hydrogen and natural gas blends.
- Developing a technical database on the hydrogen compatibility of metals as a tool to aid in the selection of materials for use in hydrogen gas distribution.

PROGRESS, MAIN ACHIEVEMENTS AND RESULTS

- A thorough review of the state of the art of grid materials was performed by creating a questionnaire and distributing it among DSOs and gas associations to collect relevant data (i.e. type of materials, year of installation, pipeline length, etc.). All the data collected were reviewed, and the conclusions were consolidated.
- A review of the state of the art of relevant standards useful for studying embrittlement phenomena in non-steel metallic materials was performed.
- A literature review on hydrogen dissociation, solubility, and diffusion in non-steel metallic materials was performed.
- The information extracted from the different reviews enabled the selection of the most representative materials for the experimental campaign. It supported the design of the experimental matrix, which is currently underway. The experimental test matrix, together with the main characteristics of the selected materials and specimen geometries, was compiled.



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- Testing platforms were adapted to the new operating conditions (pressure level of 16 bar) and to accommodate new types of non-steel metallic components. A Round Robin Test (RRT) involving four independent testing platforms was conducted, and the results are currently being processed. Complementary tests are being initiated in the testing laboratories.
- Machining of samples for the second campaign of CANDHy is in progress. A first version of a semi-empirical model to predict hydrogen embrittlement in non-steel metallic materials has been developed; validation will be performed using results from the second campaign.
- A database for non-steel metallic materials has been created and is being populated with data collected during the RRT. An exploitation plan for the project is under development, and the Horizon Booster platform is being used to define business plans for each Key Exploitable Result (KER).

FUTURE STEPS AND PLANS

- Finalise the analysis of results from the Round Robin Test (RRT).
- Perform complementary tests on non-steel metallic materials to further analyse the impact of hydrogen on their mechanical stability.
- Validate the semi-empirical model using empirical testing results gathered during the individual testing campaign.
- Populate the database on gas grid metallic materials behaviour with data generated in the project and make it accessible via the CANDHy webpage.
- Finalise the exploitation plan for the project.
- Propose novel harmonisation guidelines for measuring the mechanical and chemical impact of hydrogen on grid components, based on the results of the CANDHy experimental campaigns.

PROJECT TARGETS

Target source	Parameter	Unit	Target	Achieved to date by the project	Target achieved?
Project's own objectives	Inventory of distribution grid materials	Km	Collect as much information as possible from European DSOs	2 471 198.91	✓
	Review of SoA standards related to hydrogen embrittlement tests	Number of standards	Review as many as possible	9	
	Database with compatible non-steel metallic materials	Number	1	-	⚙
	Study the impact of hydrogen on non-steel metallic materials	Number of materials analysed	at least 5		
	Semi-empirical model	Number	1		
	Harmonised guidelines	Number	Propose harmonised guidelines for future standardisation		

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COSMHYC DEMO

COMBINED SOLUTION OF METAL HYDRIDE AND MECHANICAL COMPRESSORS: DEMONSTRATION IN THE HYSOPARC GREEN H_2 MOBILITY PROJECT

Project ID	101007173
PRR 2026	Pillar 2 - H_2 Storage and Distribution
Call Topic	FCH-01-8-2020
Project Total Costs	3 773 858.75
Clean H_2 JU Max. Contribution	2 999 637.13
Project Period	01-01-2021 - 30-09-2025
Coordinator Beneficiary	EIFER EUROPAISCHES INSTITUT FÜR ENERGIEFORSCHUNG EDF KIT EWIV, DE
Beneficiaries	Cavendish Hydrogen A/S, COMMUNAUTÉ DE COMMUNES TOURAINE VALÉE DE L'INDRE, MAHYTEC SARL, STEINBEIS INNOVATION GGMBH, EIFHYTEC

https://cosmhyc.eu/

PROJECT AND GENERAL OBJECTIVES

To meet the demands of a growing hydrogen economy, new technologies for hydrogen refuelling infrastructure, including hydrogen compression, are necessary. In COSMHYC DEMO, the innovative COSMHYC compression solution, which combines a metal hydride and mechanical compressor, is ready for commercial deployment. At the test site in France, a public hydrogen refuelling station (HRS) has been installed to serve a variety of vehicles (e.g., vehicle fleets and garbage trucks). The hybrid compressor will supply hydrogen at both 350 bar and 700 bar.

NON-QUANTITATIVE OBJECTIVES

- Integrating the new compressor into a local ecosystem with existing hydrogen mobility activities and demonstration projects will accelerate the deployment of hydrogen mobility. The project has also helped increase public acceptance of hydrogen mobility.
- The project also aimed to include a smart gas hub to enable switching between storage, the hydrogen refuelling station (HRS), and the filling centre. A new gas panel has been designed to enable smart switching among the trailer filling centre, on-site hydrogen storage, and the HRS.

PROGRESS, MAIN ACHIEVEMENTS AND RESULTS

The main achievement is the installation of the new hydrogen refuelling station (HRS) at the demonstration site and the start of refuelling operations, mainly with the garbage truck from the HECTOR Interreg NWE project. Other main progress and achievements include:

- The new membrane mechanical compressor (MC) as well as the innovative metal hydride compressor (MHC) were designed, manufactured, and installed at the new HRS site.
- The metal hydride compositions for all compression stages were selected without the use of rare earth materials. These hydrides were produced in large quantities (approximately 1 000 kg per compression stage), and the compression reactors were manufactured and certified, including a newly developed heat exchanger specifically designed for the project.
- The filling centre gas panel was completed, including associated safety studies. The refuelling demonstration site at CCTVI will also be equipped with green hydrogen production, funded under the "Hy Touraine" initiative. The COSMHYC DEMO metal hydride compressor and filling centre gas panel will also be used to compress hydrogen produced at HYSOPARC.
- The commissioning of the MHC was completed, enabling the extension of the test phase to include both the MHC and the integrated COSMHYC hydride compression solution under real-life operating conditions.
- The official inauguration event of the HRS and all related components was held in May 2025, gathering local stakeholders, the general public, and EU officials at the demonstration site.
- The testing phase at the HRS demonstration site in Sorigny (France), including all elements such as the newly commissioned metal hydride compressor, was completed in September 2025, allowing for the collection of extensive operational data before the MHC was safely decommissioned.
- The data collected throughout the testing activities were subjected to comprehensive analysis to evaluate the performance of both the MHC and the integrated COSMHYC compression system.
- Technical, economic, and environmental aspects were assessed through techno-economic analysis (TEA), life cycle assessment

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- (LCA), and detailed evaluation of technical performance data.
- The main results were presented to an expert audience during a final webinar held after the official end of the project

PROJECT TARGETS

Target source	Parameter	Unit	Target	Target achieved?
Project's own objectives	Refuelling protocol	-	SAE J2601 (light duty vehicles)|SAE J2601-2 (heavy duty vehicles)	✓
	Noise	dBA	60	

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DELHYVEHR

DELIVERY OF LIQUID HYDROGEN FOR VARIOUS ENVIRONMENT AT HIGH RATE

Project ID	101137743
PRR 2025	Pillar 2 - H_2 Storage and Distribution
Call Topic	HORIZON-JTI-CLEANH$_2$-2023-02-05
Project Total Costs	5 064 971.25
Clean H_2 JU Max. Contribution	3 711 901.13
Project Period	01-01-2024 - 31-12-2026
Coordinator Beneficiary	ENGIE, FR
Beneficiaries	TRELLEBORG CLERMONT FERRAND SAS, Fives Cryomec AG, CESAME-EXADEBIT SA, TRELLEBORG SEALING SOLUTIONS UK LIMITED, DEKRA SERVICES SA, ASOCIATIA ENERGY POLICY GROUP, EUROPEAN RESEARCH INSTITUTE FOR GAS AND ENERGY INNOVATION, BENKEI, ARIANEGROUP SAS, ABSOLUT SYSTEM SAS, ELENGY SA, UNIVERSITY OF ULSTER

https://delhyvehr.eu/

PROJECT AND GENERAL OBJECTIVES

The European Research Project DeLHyVEHR, coordinated by ENGIE, will develop a liquid hydrogen (LH_2) high-rate bunkering station with a refuelling flow rate > 5 TPH and zero boil-off losses, dedicated to maritime, aviation and railroad applications. The project is expected to achieve its demonstration by 2027. Alongside market maturity, the cost of distribution is expected to be halved by 2030.

DeLHyVEHR will drive the maturation of each of the main systems constituting the large-scale refuelling station, with a specific focus on pumping (AlfaLaval), metering (CESAME), loading (TRELLEBORG), and boil-off gas (BOG) management systems (ABSOLUT), to the full demonstration (ARIANE). Throughout the project, H_2 safety management activities (ULSTER UNI) will support the maturation plan and derisk design and operation. Tech, eco, and environmental studies (EPG) will allow assessment and replication of the demonstration's performance.

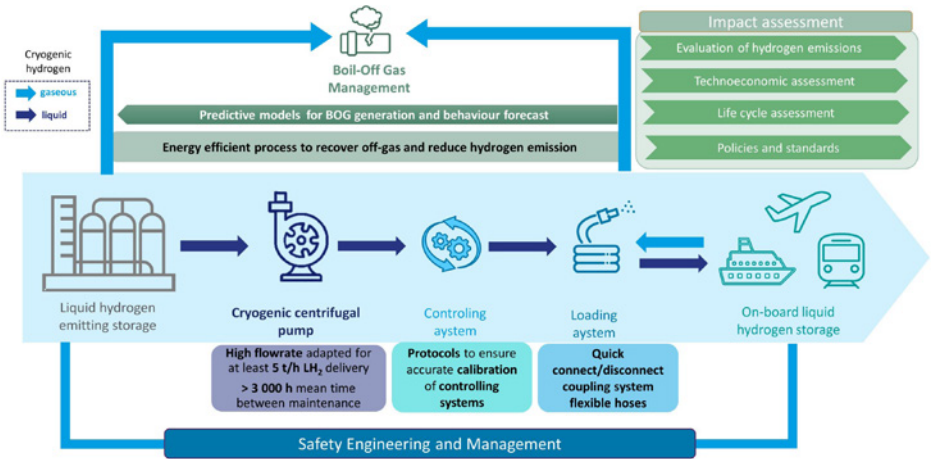
NON-QUANTITATIVE OBJECTIVES

- Facilitate the industrialisation of high-rate refuelling stations for aviation, maritime, and rail applications.
- Reduce helium consumption—which could become a showstopper in liquid hydrogen development—by using gaseous nitrogen for sanitation.
- Provide harmonised guidelines and recommendations for the deployment of bunkering stations.
- Decarbonise heavy-duty vehicle transport and dedicated infrastructure to achieve a hydrogen-related carbon footprint in line with the second edition of the Renewable Energy Directive (below 3.38 kg CO_2/kg H_2).

PROGRESS, MAIN ACHIEVEMENTS AND RESULTS

During this first period, two main tasks were undertaken: laying the groundwork for a generic liquid hydrogen refuelling station (LHRS) and developing the test bench and its components. A comprehensive assumption book was prepared and presented at the project kick-off meeting, providing a framework for partners' activities and highlighting interdependencies. Accordingly, all work packages initiated their activities.

Work focused on the design and integration of the test bench and the development of concepts and datasets for a generic LHRS, cov



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ering design, economics, regulatory context, and safe operation.

- Cryogenic pump: Minimum requirements were defined, and subsystem design and supplier quotations were completed. An improved design exceeding performance expectations was delivered, and prototype manufacturing and integration into the test bench were initiated.
- Loading line systems: Coupling designs integrating quick connect, disconnect, and breakaway functions are being finalised. Flexible hoses were tested, and flowmeters selected following benchmarking. The calibration system (RDCL) was upgraded and manufactured.
- Boil-off gas (BOG) management: Preliminary simulations provided an initial BOG inventory, enabling selection of suitable management strategies. The system for the test bench was defined and its performance assessed.
- Functional analysis and integration: The station architecture and test bench design were defined and validated. Component procurement is ongoing, and planning and budgeting for prototyping and demonstration phases are being refined.
- Preliminary cost assessment: A cost study for maritime and aviation use cases was completed, including operational expenses, LCOH contributions, and market analysis of LHRS development in Europe and globally. Policy analysis led to initial recommendations for LH_2 deployment.
- Safety studies: Hazard identification and CFD simulations were performed, supporting safety engineering and the development of a multiphase LH_2 fuelling model. Regulations, codes, and standards were reviewed to identify gaps.

FUTURE STEPS AND PLANS

- Define the high-level requirements for each application based on a functional design analysis, with support from end-users represented on the advisory board.
- Through modelling, design, manufacturing, and functional testing, the project will increase the technological maturity of each key component of the refuelling line within a dedicated development track.
- These developments will feed into the integrated system design and associated protocol specifications.
- The resulting components will be assembled into a demonstration unit at ArianeGroup SAS's European facility in Vernon, France.

PROJECT TARGETS

Target source	Parameter	Unit	Target	Target achieved?
Project's own objectives	LH_2 flowmeter calibration uncertainty on the mass flow rate	%weight	0.6	
	Delivered liquid hydrogen flow rate	kg/h	5 000	
	Cryogenic pump design hydraulic efficiency	%	60	
	Endurance test duration on the demonstrator	hours	10	
	Gas for the connection/disconnection inserting operation	-	GN_2	
	Number of connection-disconnection tests	Number	20	
	BOG recovery rate achievable	%	80	

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EUH$_2$STARS

EUROPEAN UNDERGROUND H$_2$ STORAGE REFERENCE SYSTEM

Project ID	101137798
PRR 2026	Pillar 2 - H$_2$ Storage and Distribution
Call Topic	HORIZON-JTI-CLEANH$_2$-2023-02-01
Project Total Costs	27 228 904.25
Clean H$_2$ JU Max. Contribution	19 655 460.13
Project Period	01-01-2024 - 30-09-2029
Coordinator Beneficiary	RAG AUSTRIA AG, AT
Beneficiaries	LINZ STROM GAS WARME GMBH FUR ENERGIEDIENSTLEISTUNGEN UND TELEKOMMUNIKATION, AXIOM POLSKA SP ZOO, NEDERLANDSE ORGANISATIE VOOR TOEGEPAST NATUURWETENSCHAPPELIJK ONDERZOEK TNO, EBN BV ENERGIE BEHEER NEDERLAND BV, AXIOM ANGEWANDTE PROZESSTECHNIK GES.M.B.H., MONTANUNIVERSITAET LEOBEN, MAGYAR FOLDGAZTAROLO ZARTKORUEN MUKODO RESZVENYTARSASAG, AGGM AUSTRIAN GAS GRID MANAGEMENT AG, TRINITY ENERGY STORAGE SL, SHELL GLOBAL SOLUTIONS INTERNATIONAL BV, ENERGIEINSTITUT AN DER JOHANNES KEPLER UNIVERSITAT LINZ VEREIN

http://euh2stars.eu

PROJECT AND GENERAL OBJECTIVES

The EUH$_2$STARS project (European Underground Hydrogen STorAge Reference System) is an industry-driven flagship initiative funded by the Clean Hydrogen Partnership (CHP) under the motto *"Paving the way towards the future of European underground hydrogen storage"*.

The project brings together gas storage operators, technology providers, utilities, research organisations, and public bodies to demonstrate competitive, fully qualified underground hydrogen storage (UHS) in depleted porous natural gas reservoirs at TRL 8 by the end of the decade.

Building on a pilot facility previously developed to TRL 6 within the Underground Sun Storage 2030 project, EUH$_2$STARS uses RAG Austria AG's existing UHS facility as a demonstrator. The operational experience gained from this facility, combined with the consortium's research expertise, will support the development of common guidelines and recommendations for the deployment of UHS across Europe.

The project also addresses the conversion of existing underground natural gas reservoirs into hydrogen storage facilities and their integration into the future European hydrogen infrastructure. Demonstration and replication activities are being carried out through sites located in Austria, Hungary, the Netherlands, and Spain.

NON-QUANTITATIVE OBJECTIVES

- Demonstrate the storage of pure hydrogen in depleted porous reservoirs through four seasonal storage cycles at the RAG demonstrator and two cycles at the HGS replicator site, showcasing different market-driven operating scenarios.
- Develop and integrate an advanced hydrogen purification system into the withdrawal process to demonstrate effective impurity removal and achieve standardised hydrogen purity levels under real operating conditions.
- Obtain relevant green hydrogen certification for the power-to-hydrogen electrolysis system and actively participate in green hydrogen certificate trading schemes.
- Develop guidelines addressing environmental, safety, legal, regulatory, societal, and market aspects to support the successful deployment of underground hydrogen storage (UHS) facilities across Europe.
- Implement a comprehensive stakeholder engagement strategy, including an external expert advisory board, to maximise transparency, visibility, public acceptance, and exploitation of project results.
- Establish a generic HSEQ (Health, Safety, Environment and Quality) framework, including monitoring plans and risk management measures, to ensure operation at ALARP (As Low As Reasonably Practicable) risk levels.
- Define transformation pathways for scaling up demonstrator results to commercial UHS facilities through subsurface design, surface engineering concepts, and CAPEX assessments.
- Provide best-practice examples for integrating UHS facilities into regional, national, and European energy infrastructures and markets, including links to the European Hydrogen Backbone.
- Demonstrate the conversion and integration of existing underground natural gas storage assets into future hydrogen storage infrastructure in Austria, Hungary, the Netherlands, and Spain.

PROGRESS, MAIN ACHIEVEMENTS AND RESULTS

Key achievements included the definition of the Societal Embeddedness Level (SEL) methodology and implementation guidelines, the development of a Measurement, Monitoring and Verification (MMV) plan for the Rubensdorf

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underground hydrogen storage (UHS) demonstrator facility, and the initiation of UHS scale-up studies.

The project also developed its communication, dissemination, and stakeholder engagement framework, including stakeholder mapping, surveys, and engagement activities. In addition, an assessment of hydrogen value chain programmes, structures, and related European initiatives was completed.

Project management activities established the project's data management framework and communication tools, including the project website and supporting dissemination materials.

In 2025, the consortium continued to progress in accordance with the Grant Agreement. Communication, dissemination, exploitation, and stakeholder engagement activities gained momentum as additional project results became available. Following the finalisation of the Rubensdorf operations plan, RAG's 100% hydrogen underground storage demonstration facility commenced the first of four seasonal storage cycles under the EUH$_2$STARS project, marking a major step towards demonstrating underground hydrogen storage at scale.

FUTURE STEPS AND PLANS

In June 2025, the consortium met in the Netherlands, enabling in-person exchanges among partners on key technical, operational, and strategic topics.

Throughout 2025, the project progressed in line with the consortium plan across all work packages. Communication, dissemination, exploitation, and stakeholder engagement activities continued to expand as new results became available, and project visibility increased.

Following the finalisation of the Rubensdorf operations plan, RAG's 100% hydrogen underground storage demonstration facility commenced the first of four seasonal storage cycles under the EUH$_2$STARS project. This marked a major milestone towards demonstrating underground hydrogen storage in depleted porous natural gas reservoirs and advancing the technology towards commercial deployment.

PROJECT TARGETS

Target source	Parameter	Unit	Target	Target achieved?
Project's own objectives	Hydrogen purification is achieved at the exit of the hydrogen purification unit	%	98 - Grade A according to ISO 14 687	
	Hydrogen Recovery Factor	%	95	

FRHYGE

FULL QUALIFICATION IN FRANCE OF LARGE-SCALE HYDROGEN UNDERGROUND STORAGE AND REPLICATION FROM GERMANY TO ALL EUROPEAN COUNTRIES

Project ID	101137892
PRR 2026	Pillar 2 - H_2 Storage and Distribution
Call Topic	HORIZON-JTI-CLEANH$_2$-2023-02-01
Project Total Costs	27 240 481.25
Clean H_2 JU Max. Contribution	19 994 886.40
Project Period	01-03-2024 - 28-02-2029
Coordinator Beneficiary	STORENGY SAS, FR
Beneficiaries	INSTITUT NATIONAL DE L ENVIRONNEMENT INDUSTRIEL ET DES RISQUES - INERIS, AXENS SA, ENAGAS TRANSPORTE SA, ECOLE NATIONALE SUPERIEURE DES MINES DE PARIS, NATRAN, ARTELYS, GEOSTOCK SAS, ESK GMBH, ECO MED, GEOMETHANE, STORENGY DEUTSCHLAND GMBH, GASNETZ HAMBURG GMBH, STORENGY FRANCE, ARTELYS BELGIUM, STORENGY DEUTSCHLAND BETRIEB GMBH, IFP Energies Nouvelles, ASSOCIATION POUR LA RECHERCHE ET LE DEVELOPPEMENT DES METHODES ET PROCESSUS INDUSTRIELS, CAPENERGIES ASSOCIATION

https://frhyge-project.eu

PROJECT AND GENERAL OBJECTIVES

FrHyGe aims to demonstrate and qualify the injection and withdrawal of hydrogen at an existing commercial natural gas storage site in France, addressing one of the key barriers to the large-scale deployment of hydrogen as an energy carrier: the availability of cost-effective, technically viable hydrogen storage solutions.

The project seeks to support the integration of renewable energy sources and the development of a future European hydrogen market by demonstrating underground hydrogen storage in salt caverns and facilitating its replication across Europe.

The main objectives of FrHyGe are:

- Develop and implement conversion processes for transforming existing natural gas or brine caverns into hydrogen storage facilities.
- Demonstrate hydrogen storage and cycling capabilities in a cavern with a potential storage capacity of 3 000 tonnes of hydrogen, including up to 100 charge and discharge cycles ranging from one hour to one week.
- Assess local hydrogen value chains and evaluate the techno-economic impacts of underground hydrogen storage, supporting future deployment along the European Hydrogen Backbone.
- Evaluate the safety, environmental, and operational risks associated with cyclic hydrogen storage in salt caverns and provide recommendations for regulatory, safety, and standardisation frameworks in Europe.
- Develop conversion and scale-up strategies to accelerate the replication of underground hydrogen storage projects across Europe.

By enabling the conversion and development of hydrogen storage caverns, FrHyGe aims to unlock a potential storage capacity of 38 000 tonnes of hydrogen by 2030 and up to 1.5 million tonnes by 2050, while targeting capital expenditure below €10/kg of hydrogen stored.

NON-QUANTITATIVE OBJECTIVES

- Propose a conceptual design for the demonstrator.

Carry out all required studies and laboratory tests (kinetics of hydrogen solubility in cavern brine, hydrogen permeation in salt during cycling, etc.).

- Develop geomechanics and thermodynamic predictive models for hydrogen storage in largely brine-filled salt caverns.
- Provide guidance on mechanical integrity testing and tightness testing of hydrogen caverns, assess the impact of gas quality requirements on the deployment of salt cavern and porous media storage, and outline technical options for evolutive salt cavern completions with subsurface safety equipment. This guidance will enable industrial-scale replication (3 000-ton hydrogen storage potential) of findings obtained at demonstration scale and through technical and scientific studies.
- Deliver an off-grid layout connecting two neighbouring caverns, including engineering and demonstrator design.
- Provide a cost-benefit-analysis for the hydrogen storage projects GeoH$_2$ and SaltHy.

Provide a market uptake plan for the GeoH$_2$ and SaltHy hydrogen storage projects.

Estimate the development costs for site-specific underground storage at the European scale.

- Provide a comprehensive risk assessment and deliver a safety plan for the demonstrator. Test the administrative permitting procedure for the demonstrator.

Assess the environmental impacts of salt-cavern hydrogen storage, including greenhouse gas emissions.

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- Issue the project communication plan and carry out all communication actions.

Coordinate logistics and communication for events such as workshops and congresses.

Support for scientific publications and conference participation.

- Prepare a summary of the results in "Horizon, the EU research and Innovation Magazine".

PROGRESS, MAIN ACHIEVEMENTS AND RESULTS

- Project kick off - 20/03/2024.
- Participation in EU and national industry events: Club H_2 Sud, May and October 2024.
- HyUSPRe final conference, Utrecht - June 19, 2024; EAGE - GET24, November 6, 2024.
- European Hydrogen Week, in Brussels - Nov 18-22, 2024.
- Method definition and conceptual design in progress for the demonstrator, achieved by the end of February 2025.

FUTURE STEPS AND PLANS

- 2024-2025: Study analyses for the Manosque demonstration site and SaltHy site replicability.
- 2026-2027: Construction phase.
- 2027-2029: Implementing 100 injections and withdrawal cycles at the Geomethane site. Studying Hydrogen reactions under various pressures. Comparing results with the theoretical model forecast.
- From 2029: Commercial operations: 6000 t capacity at Manosque demonstration site, 5200 t at Harsefeld.

PROJECT TARGETS

Target source	Parameter	Target achieved?
Project's own objectives	To develop and implement two conversion processes from natural gas or brine cavern to hydrogen storage	
	To perform 100 H_2 cycles with a duration from 1 h to 1 week for a cavern having the potential of 3 000 tons of H_2. Flow rate variation of up to 1 t/h	
	To study the local hydrogen value chain and the techno-economic impacts on local actors, and to upscale and deploy H_2 storage along the European Hydrogen Backbone	
	To demonstrate the safety and environmental acceptability of commercial storage of H_2 in salt caverns	

H_2REF-DEMO

HYDRAULIC COMPRESSION FOR HIGH CAPACITY HYDROGEN REFUELLING STATION DEMONSTRATION

Project ID	101101517
PRR 2026	Pillar 2 - H_2 Storage and Distribution
Call Topic	HORIZON-JTI-CLEANH$_2$-2022-02-08
Project Total Costs	5 786 712.50
Clean H_2 JU Max. Contribution	4 617 384.88
Project Period	01-01-2023 - 30-06-2026
Coordinator Beneficiary	CENTRE TECHNIQUE DES INDUSTRIES MÉCANIQUES, FR
Beneficiaries	H_2NOVA, UNIVERSITA DEGLI STUDI DI MODENA E REGGIO EMILIA, HYDAC TECHNOLOGY GMBH, HYDROGEN-REFUELING-SOLUTIONS, UNIVERSITE DE TECHNOLOGIE DE COMPIEGNE, FABER INDUSTRIE SPA

https://heavy-v.h2ref.eu/

PROJECT AND GENERAL OBJECTIVES

H_2REF-DEMO aims to develop further and quintuple the innovative compression concept developed in H_2REF to address large-vehicle refuelling applications that require hydrogen to be dispensed at rates of hundreds of kg/h, such as refuelling bus fleets every evening at bus depots and refuelling trucks and trains. The concept is particularly well-suited for scaling up, thanks to the scalability of fluid power and composite pressure vessel technologies. As it incorporates the intrinsic modularity of fluid power technology together with that of pressure vessel technology, this disruptive solution will enable different expected hydrogen supplies to be addressed cost-effectively and reliably, particularly those most suitable for large-scale refuelling applications where daily consumption exceeds 1 ton.

- On-site production.
- Road delivery with high-pressure trailers (e.g. 500 bars, in carbon composite), as these have an effective payload of around one ton.

Large-scale hydrogen refuelling involves two distinct types of compression:

- **Compression of hydrogen production for storage**. As production is the supply chain function with the highest cost, it tends to be carried out through continuous (24/7) operation of production devices sized based on daily consumption. Storage of the hydrogen produced requires compression at the same rate to keep storage size and footprint within acceptable limits.
- **Compression of stored hydrogen for high-capacity dispensing**. This compression function brings hydrogen from storage – that is a fixed vessel storing hydrogen produced on-site, a fixed vessel into which hydrogen has been delivered by trailer, or a trailer - maintaining the pressure required for dispensing at the rate required when dispensing takes place, for example at the rate required when dispensing takes place, for example at any time of the day when vehicles pull-in to refuel, or almost continuously during a certain time frame (e.g. 4-6 hours per day at a bus depot). The feed pressure for dispensing is typically higher than that for storage; the required throughput is also higher (since dispensing occurs only part of the time).



NON-QUANTITATIVE OBJECTIVES

The main goal of the project is to develop and test at full scale a High Capacity Compression Module (HCCM) capable of either hydrogen compression for storage before dispensing (1.2 t/d) or hydrogen compression for high capacity 35 MPa dispensing (150 kg/h 2.5 kg/min), with 1 year demonstration of use for high capacity refuelling of heavy duty vehicles in a commercially operated refuelling station. Particular attention will be given to optimising the design to minimise costs.

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PROGRESS, MAIN ACHIEVEMENTS AND RESULTS

The project made substantial progress, particularly in design activities, procurement processes, and preparation of the full HCCM test system.

Key achievements included:

- Completion of multi-physical modelling of the HCCM within the 500-hour test configuration.
- Procurement, construction, and factory acceptance testing (FAT) of the Hydraulic Power Pack (HPP).
- Detailed design of the gas skid and of the HCCM test facility.
- Preparation of the complete HCCM test area.
- Procurement of long-lead items for the gas skid and construction of the gas skid frame.
- Development of process GRAFCETs for system control.
- Identification and sourcing of bladder materials (HNBR and ECO).
- Manufacturing of bladder prototypes (ECO and HNBR).
- Definition of the CE-compliance approach for accumulators.
- Manufacturing of accumulator shells (Type I and Type II).
- Engagement with OEMs for heavy-duty vehicle demonstration activities, which received positive feedback following initial reluctance.

FUTURE STEPS AND PLANS

- Continue endurance testing, progressing beyond the current 50 000 cycles towards 200 000 bladder cycles and a 500-hour HCCM hydrogen test.
- Perform performance validation to achieve a target flow rate of 150 kg/h and confirm key energy performance indicators.
- Launch a real-life heavy-duty vehicle (HDV) refuelling demonstration, initiating a one-year operational phase.
- Carry out techno-economic analysis, including updated total cost of ownership (TCO) and performance assessment.
- Finalise dissemination and standardisation activities, including recommendations, scientific publications, and the final project event.

PROJECT TARGETS

Target source	Parameter	Unit	Target	Target achieved?	SoA result achieved to date (by others)	Year for reported SoA result
Project's own objectives	CAPEX	k€/(kg/day)	1.2		2.2	2024
	Bladder durability	cycles	20 000		N/A	N/A

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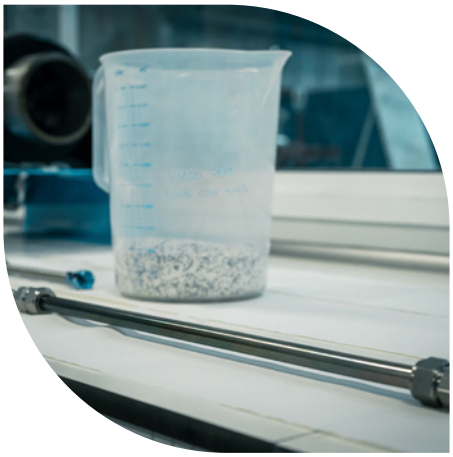
HERMES

HYDROGEN-EFFICIENT PURIFICATION USING MEMBRANES IN INDUSTRIAL GAS STREAMS

Project ID	101192352
PRR 2026	Pillar 2 - H2 Storage and Distribution
Call Topic	HORIZON-JTI-CLEANH2-2024-02-03
Project Total Costs	7 722 046.01
Clean H2 JU Max. Contribution	5 943 423.08
Project Period	01-01-2025 - 31-12-2028
Coordinator Beneficiary	HYDROGEN ONSITE, SL
Beneficiaries	FONDAZIONE BRUNO KESSLER, TECHNISCHE UNIVERSITEIT EINDHOVEN, FUNDACION TECNALIA RESEARCH and INNOVATION, Türkiye Petrol Rafinerileri Anonim Sirketi, SNAM SPA, INTRACT INOVASYON DANISMANLIK LIMITED SIRKETI

https://hermes-h2.eu/



PROJECT AND GENERAL OBJECTIVES

HERMES (Hydrogen Efficient Purification Using Membranes in Industrial Gas Streams) aims to develop and demonstrate efficient, cost-effective membrane-based technologies for hydrogen recovery and purification from industrial gas mixtures with varying hydrogen concentrations. The project combines two complementary technologies: ultra-thin palladium-alloy membranes, which offer highly selective hydrogen separation, and carbon molecular sieve membranes (CMSMs), which provide an alternative operating at lower temperatures without critical raw materials. HERMES targets the demonstration of two integrated prototypes; each designed to separate 100 kg of hydrogen per day and reach Technology Readiness Level 7 (TRL7). The prototypes will be validated at a TUPRAS refinery in Türkiye and at SNAM's closed-loop facility in Italy, covering five industrial study cases involving refinery streams, natural hydrogen and syngas.

NON-QUANTITATIVE OBJECTIVES

Beyond achieving high hydrogen recovery and purity, HERMES seeks to improve sustainability, flexibility and industrial applicability of membrane-based hydrogen separation. The project promotes more efficient use of critical raw materials through palladium-efficient membrane designs and palladium recovery and reuse, while developing complementary carbon molecular sieve technologies. HERMES also aims to facilitate the integration of membrane systems into industrial environments, considering operational flexibility, safety and reliability from the design stage. In parallel, the project supports knowledge transfer, stakeholder engagement, and the development of viable pathways for exploitation and replication to enable wider industrial adoption.



PROGRESS, MAIN ACHIEVEMENTS AND RESULTS

During its first 18 months (January 2025–June 2026), HERMES established the scientific and engineering foundations for its two industrial demonstration systems. The consortium defined five industrial study cases, developed and validated membrane permeation models against experimental data, and completed the Basic Engineering and preliminary safety assessments for both prototypes.The consortium made significant progress in both membrane technologies. New palladium-silver membrane formulations demonstrated promising separation performance while offering opportunities to reduce palladium consumption. The team also demonstrated technically viable palladium recovery and reuse routes. In parallel, carbon molecular sieve membranes progressed from single tubular elements to compact multichannel configurations, with encouraging initial results for hydrogen perme

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ation and selectivity. A preliminary techno-economic assessment was completed for both technologies across the five study cases. The team also developed initial market analyses, business models, and exploitation roadmaps, establishing the basis for subsequent industrial validation and commercialisation.

FUTURE STEPS AND PLANS

The next phase of HERMES will focus on completing membrane development, scaling up manufacturing and validation, and progressing detailed engineering, procurement, and preparation for prototype construction. The two demonstration systems will subsequently be manufactured, integrated and commissioned at the TUPRAS refinery in Türkiye and SNAM's facility in Italy. Each prototype is planned to operate for at least 3,000 hours under representative conditions, generating evidence on hydrogen recovery, purity, energy efficiency, durability, safety and operational reliability. The demonstration results will support the final techno-economic, environmental, and life-cycle assessments, as well as the refinement of strategies for industrial exploitation, replication, and commercialisation.

HQE

HYQUALITY EUROPE

Project ID	101101447
PRR 2026	Pillar 2 - H_2 Storage and Distribution
Call Topic	HORIZON-JTI-CLEANH$_2$-2022-02-09
Project Total Costs	3 453 685.00
Clean H_2 JU Max. Contribution	3 453 685.00
Project Period	01-01-2023 - 31-05-2026
Coordinator Beneficiary	SINTEF AS, NO
Beneficiaries	EIFER EUROPAISCHES INSTITUT FÜR ENERGIEFORSCHUNG EDF KIT EWIV, AIR LIQUIDE FRANCE INDUSTRIE, ORLEN LABORATORIUM SPÓLKA AKCYJNA, ENGIE ENERGIE SERVICES, L'AIR LIQUIDE SA, EMCEL GMBH, ENGIE, LINDE GMBH, TOYOTA MOTOR EUROPE NV, ZENTRUM FÜR BRENNSTOFFZELLEN-TECHNIK GMBH, NPL MANAGEMENT LIMITED, ZENTRUM FÜR SONNENENERGIE - UND WASSERSTOFF - FORSCHUNG BADEN - WÜRTTEMBERG, DEUTSCHES ZENTRUM FÜR LUFT- UND RAUMFAHRT E.V.

http://hyqualityeurope.eu

PROJECT AND GENERAL OBJECTIVES

HQE's goal is to increase the reliability of hydrogen refuelling stations (HRSs) and the confidence of investors, operators and consumers in them. The objectives are:

- Collect representative data on the quality of hydrogen in European HRSs (300 spot samples in 100 HRSs).
- Develop an occurrence class and promote a risk assessment approach.
- Establish an open-source database to compile the results to allow HRS operators to take a risk assessment approach to ensure hydrogen quality.
- Test a network of six hydrogen analysis laboratories to certify them at EU level.
- Demonstrate the effectiveness of online analysis.
- Standardise hydrogen quality sampling and analysis methodologies for EU HRSs.
- Aid future research by defining the occurrence class of at least four new impurities beyond those listed in EN17124:2022 and ISO 21087:2019.

NON-QUANTITATIVE OBJECTIVES

HQE has extensively contributed to the development of ISO 14687, 19880-9 and 19880-8.

PROGRESS, MAIN ACHIEVEMENTS AND RESULTS

The work of collecting information from HRS operators and performing sampling and analysis has started. The first laboratory comparison has been completed, with nine laboratories participating. All impurities listed in ISO 14687 were present in the comparison, which is the first of its kind. A hydrogen quality workshop was hosted by ISO, ASTM, and the National Renewable Energy Laboratory to disseminate early project results.

FUTURE STEPS AND PLANS

The project will continue sampling and analysis, working towards a target of collecting 300 samples, and will further conduct laboratory intercomparisons. The project will also install online quality monitoring at three HRSs.

PROJECT TARGETS

Target source	Parameter	Unit	Target	Achieved to date by the project	Target achieved?
Project's own objectives	Number of samples collected from HRS	Number	200	100	
	Online monitoring of HRS quality	Months	12	3	

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HYDRA

DIAGNOSTIC TOOLS AND RISK PROTOCOLS TO ACCELERATE UNDERGROUND HYDROGEN STORAGE

Project ID	101192337
PRR 2026	Pillar 2 - H_2 Storage and Distribution
Call Topic	HORIZON-JTI-CLEANH$_2$-2024-02-01
Project Total Costs	3 016 110.22
Clean H_2 JU Max. Contribution	3 016 110.22
Project Period	01-01-2025 - 29-02-2028
Coordinator Beneficiary	UNIVERSITETET I BERGEN, NO
Beneficiaries	NEW ZEALAND INSTITUTE FOR EARTH SCIENCE LIMITED, ISODETECT GMBH, EQUINOR ASA, Helios Aragon Exploration S.L, UNIPER ENERGY STORAGE GMBH, BUNDESANSTALT FUER GEOWISSENSCHAFTEN UND ROHSTOFFE, TRINITY ENERGY STORAGE SL, RAG AUSTRIA AG, Neptune Energy Deutschland GmbH, Hardie Pacific Limited, KARLSRUHER INSTITUT FUER TECHNOLOGIE, THE UNIVERSITY OF EDINBURGH, CENTRICA ENERGY STORAGE LIMITED, AGENCIA ESTATAL CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS, OMV EXPLORATION and PRODUCTION GMBH,INSTITUTE OF GEOLOGICAL AND NUCLEAR SCIENCES LIMITED, UNIVERSITA DEGLI STUDI DI NAPOLI FEDERICO II, TECHNISCHE UNIVERSITAT CLAUSTHAL, IGas Energy plc

https://hydrahydrogen.eu/

PROJECT AND GENERAL OBJECTIVES

The overall goal of the HyDRA project is to characterise hydrogen-consuming microbial activity and its interactions with storage formations, to establish guiding principles that mitigate risk and enable the accelerated deployment of underground storage in porous media within the European hydrogen ecosystem.

This goal will be achieved through ten quantifiable objectives, including: the development of standardised field sampling protocols and biogeochemical laboratory methods; mapping microbial taxonomic and functional diversity across Europe; the creation of models to upscale laboratory findings for site-specific microbial risk assessment; the delivery of a fast-track site selection tool incorporating a predictive microbial risk index; and the update of guidelines to support storage site operators (SSOs) in site-specific risk identification and management.

By addressing the full range of geological and subsurface conditions across European storage sites, the interdisciplinary HyDRA consortium, together with associated SSOs, will assess microbial risks linked to hydrogen storage in porous reservoirs. Across twelve work packages, the project will generate fundamental insights into microbial risk and mitigation strategies for underground hydrogen storage.

NON-QUANTITATIVE OBJECTIVES

With an interdisciplinary and interdependent workflow spanning microbiology, geosciences, geophysics and geochemistry, porous media modelling, and safety and risk assessment, HyDRA focuses on the complex interplay between microbial activity, geochemistry, and hydrogen flow during underground hydrogen storage in porous media.

Addressing this knowledge gap, across the full range of site-specific and operational conditions, including both active and prospective storage sites, as well as natural hydrogen seeps, will support the development and standardisation of site-specific and general guidelines, as well as regulatory frameworks, to enable accelerated and widespread deployment of underground hydrogen storage across Europe.

PROGRESS, MAIN ACHIEVEMENTS AND RESULTS

The project's planned activities and deliverables are progressing as expected. The first eight fluid samples from porous rock reservoirs are currently being incubated under a hydrogen atmosphere to simulate underground hydrogen storage, with gas composition monitored regularly to track microbial hydrogen consumption.

In 2025, two scientific articles were published:

- Viveros, F. E., N. Liu, and M. A. Fernø (2025). *Biogeochemical Interactions and Their Role in Underground Hydrogen Storage in Europe*. **Minerals**, 15(9), 929. https://doi.org/10.3390/min15090929
- Visentini, A. F., J. J. Hidalgo, L. Cueto-Felgueroso, and M. Dentz (2025). *Gas Spreading and Mixing in Heterogeneous Porous Media for Underground Hydrogen Storage*. **International Journal of Hydrogen Energy**, 146, 149753. https://doi.org/10.1016/j.ijhydene.2025.05.383

Additionally, consortium members have presented the project at numerous events, conferences, and workshops.

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PROJECT SRIA TARGETS

Target source	Parameter	Target	Target achieved?
Project's own objectives	Exploitation Activities	2	✓
	Peer-Reviewed Scientific Publications	2	
	Standardised methodologies for microbial risk assessment of underground H_2 porous media storage	> 7	
	Cross-European sampling campaign of porous rock reservoirs: samples from gas reservoirs samples from aquifers	> 20 > 10	
	Taxonomic and functional mapping of microorganism diversity: samples from porous rock reservoirs and samples from natural hydrogen seeps	> 30 > 10	
	Quantify geochemical reaction products across the spectrum of European UHS sites	> 10	
	Determine microbial kinetics across European geochemical characteristics	> 20	⚙
	Determine coupled bio-geochemical effects on reservoir flow dynamics and mechanical integrity. Selected storage sites, microbial and geochemical environments	> 4	
	Derive models that enhance laboratory bio-geochemical/mechanical data	-	
	Upscale laboratory bio-geochemical findings for site-specific risk assessment	-	
	Fast-track site selection tool with predictive microbial risk index across the full spectrum of European sites. Updated guidelines to support SSOs in the risk identification and management	-	

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HYGHER

HYDROGEN HIGH PRESSURE SUPPLY CHAIN FOR INNOVATIVE AND COST EFFICIENT DISTRIBUTION

Project ID	101137867
PRR 2026	Pillar 2 - H_2 Storage and Distribution
Call Topic	HORIZON-JTI-CLEANH$_2$-2023-02-04
Project Total Costs	6 769 096.25
Clean H_2 JU Max. Contribution	4 991 009.88
Project Period	01-01-2024 - 31-12-2026
Coordinator Beneficiary	EIFER EUROPAISCHES INSTITUT FÜR ENERGIEFORSCHUNG EDF KIT EWIV, DE
Beneficiaries	STEINBEIS INNOVATION GGMBH, UNIVERZA V LJUBLJANI, RE.CO. MA. S.R.L., FRAUNHOFER GESELLSCHAFT ZUR FÖRDERUNG DER ANGEWANDTEN FORSCHUNG E.V., HYPE, HYPE ASSETS, EIFHYTEC

https://hygher.eu/

PROJECT AND GENERAL OBJECTIVES

HYGHER aims to demonstrate the maturity of an innovative high-pressure hydrogen distribution value chain. This will include the installation of an innovative filling centre capable of compressing hydrogen at high pressure and the operation of two new high-pressure trailers to supply the fleet of taxis operated by HYPE in the Paris region. With a total budget of over 6.7 M €, the seven consortium partners are working to improve and integrate all components across the new value chain. Through targeted efforts in innovative compression, circularity, and safety, HYGHER will enable sustainable and cost-efficient hydrogen distribution, removing one of the main barriers to the broader deployment of hydrogen mobility. The project started in 2024 and is expected to last 3 years.

NON-QUANTITATIVE OBJECTIVES

The main objective of HYGHER is to demonstrate the feasibility of an innovative, cost-efficient, and reliable high-pressure value chain by combining various technologies ready for large-scale demonstration. The main progress expected beyond the state-of-the-art is:

- Build an innovative filling centre equipped with a metal hydride compressor, a mechanical booster, and cascade storage, enabling efficient distribution of over 2 t/day at 500 bars.
- Build two innovative trailers, each with a capacity of 1.25 t of hydrogen, operating at 500 bar and equipped with advanced control, monitoring, and communication systems to ensure efficiency and interoperability.
- Adapt a standard HRS by integrating 500-bar trailers into smart storage cascade management, significantly improving efficiency and demonstrating increased capacity.
- Install and operate the entire value chain in the Paris region, close to trans-European transport network corridors, thereby strengthening the EU hydrogen infrastructure and preparing for replication and mass deployment.
- Demonstrate the new value chain under real commercial conditions by operating the equipment with HYPE's fleet of FCEV taxis and other 350-bar and 700-bar FCEVs.
- Validate the safety of the overall concept at 500 bar and prepare for a 700-bar upgrade by reviewing regulations, codes, and standards, and performing safety analyses on system components and the overarching value chain.

PROGRESS, MAIN ACHIEVEMENTS AND RESULTS

During the second year of the project, the consortium concentrated its efforts on the following activities:

- Advanced modelling and simulation of different configurations of the Filling Centre and trailer, resulting in significant progress in the metal hydride compressor design.
- Completion of the trailer design phase, supported by extensive simulation results.
- Preliminary engineering studies on station inlet connections and compressor bypass, enabling 500 bar operation and supporting a cascade filling concept in combination with the trailer system.
- Selection of the demonstration site, which is currently undergoing the permitting process with the relevant authorities.
- Completion of the RCS review, with detailed site-specific safety assessments; HAZOP studies of key subsystems are currently ongoing.
- Definition of reference and project scenarios for techno-economic analysis, including the establishment of clear system boundaries.

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FUTURE STEPS AND PLANS

- Preparation of a promotional project video.
- Optimisation of the design of sub-systems.
- Preparation of the construction phase for all subsystems (ordering of components and planning the construction in the workshops).
- Data collection for the techno-economic assessment study, life cycle analysis and scale-up analysis.

PROJECT SRIA TARGETS

Target source	Parameter	Unit	Target	Target achieved?
Project's own objectives	Number of innovative trailers built, equipped with type IV hydrogen vessels, and a capacity of 1,25 tons of hydrogen each, at an operating pressure of 500 bar	Number	2	
	Innovative filling centres built, equipped with a 500-bar metal hydride compressor, a 1 000-bar mechanical booster and cascade storage enabling efficient distribution of 2.15 t/d at 500 bar	t/day	2.15	
	Standard HRS adapted by integrating 500 bar trailers into the smart storage cascade management and thereby significantly improving efficiency while demonstrating a capacity increase from 400 kg/d to 2t/d	kg/day	2 000	
	Energy efficiency of the gaseous H_2 value chain doubled, from the filling centre to the HRS nozzle, by reducing energy consumption from 10 kWh/kg to 4.6 kWh/kg	kwH/kg	4.6	
	TRL from TRL 6 to TRL 8	TRL	8	
	Safety of the overall concept at 500 bars was validated and prepared for the 700-bar upgrade	bar	500	
	Techno-economic analysis performed and TCO improvement demonstrated, resulting in a decrease in specific costs of H_2 logistics from 4.45€/kg down to 1.48€/kg	€/kg	1.48	

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HYLICAL

DEVELOPMENT AND VALIDATION OF A NEW MAGNETOCALORIC HIGH-PERFORMANCE HYDROGEN LIQUEFIER PROTOTYPE

Project ID	101101461
PRR 2026	Pillar 2 - H_2 Storage and Distribution
Call Topic	HORIZON-JTI-CLEANH$_2$-2022-02-03
Project Total Costs	4 677 848.75
Clean H_2 JU Max. Contribution	4 677 848.75
Project Period	01-01-2023 - 31-12-2027
Coordinator Beneficiary	INSTITUTT FOR ENERGITEKNIKK STI, NO
Beneficiaries	UNIVERSIDAD DE SEVILLA, TECHNISCHE UNIVERSITAT DARMSTADT, SUBRA A/S, UNIVERSITA DI PISA, ENGIE, SHELL GLOBAL SOLUTIONS INTERNATIONAL BV, IBERDROLA CLIENTES SOCIEDAD ANONIMA, DANMARKS TEKNISKE UNIVERSITET, HELMHOLTZ-ZENTRUM DRESDEN-ROSSENDORF EV, UNIVERSITY OF ULSTER, Alfa Laval Golbey SAS, ASOCIATIA ENERGY POLICY GROUP, MAGNOTHERM SOLUTIONS GMBH

https://www.hylical.eu

PROJECT AND GENERAL OBJECTIVES

HyLICAL will contribute to:

- Achieving an energy demand of 8 kWh/kg and a reduction in liquefaction cost of 20% for small liquefaction volumes of 1-5 TPD/day.
- Reduced capital expenditures (CAPEX) and operating expenses (OPEX) by at least 20% in addition to the targeted energy savings.
- Decentralised (local) production of liquid hydrogen (LH_2), reducing the need for distribution and transport across long distances.
- Coupling of the magnetocaloric hydrogen liquefaction technology to hydrogen production from renewables (green hydrogen) for off-grid configurations.
- Integration into conventional liquefaction plants to increase their overall energy efficiency.
- Application of the processes for liquefaction of hydrogen and boil-off management of LH_2 tanks.
- Development and validation of a new magnetocaloric high-performance hydrogen liquefier prototype.

NON-QUANTITATIVE OBJECTIVES

- Development of an innovative concept for hydrogen liquefaction that is different from what is used today.
- Increased efficiency and reduced costs of hydrogen liquefaction technologies.
- Contribution to the roll-out of next-generation liquefaction technology to new bulk hydrogen production plants.
- Positive impact on other Hydrogen Europe roadmaps related to liquid hydrogen.
- Improvement of the sustainability and circularity aspects related to the liquefaction of hydrogen.

PROGRESS, MAIN ACHIEVEMENTS AND RESULTS

- Prediction of more than 150 new materials and compositions using machine learning and computational materials design.
- Characterisation of more than 30 materials with respect to their thermo-magnetic and structural properties.
- Initial simulations of an active magnetic regenerator operating in the cryogenic temperature range.
- Construction of a test bench for the characterisation of magnetocaloric materials under cryogenic, process-relevant conditions.

The first iteration of the liquefier, named HyDRA, was put into operation in September 2025 and serves as a test platform for materials development and proof-of-concept validation.

FUTURE STEPS AND PLANS

- Upscaling and processing of 5–7 of the most promising materials to bridge the required temperature span (20–80 K).
- Production of regenerator beds using atomization techniques.
- Fabrication of heat exchanger geometries with enhanced heat transfer performance using 3D printing.
- Detailed device-level simulations of the active magnetic regenerator (AMR) and its integration into the liquefaction system, including heat exchangers, cold box, and liquid nitrogen pre-cooling.
- Construction of the liquefier prototype and performance testing using optimised materials.

PROJECT TARGETS

Target source	Parameter	Unit	Target	Target achieved?
Project's own objectives	Energy efficiency	kWh/kg	8	
	Liquefaction cost	€/kg	1.5	

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HYPSTER

HYDROGEN PILOT STORAGE FOR LARGE ECOSYSTEM REPLICATION

Project ID	101006751
PRR 2026	Pillar 2 - H_2 Storage and Distribution
Call Topic	FCH-02-7-2020
Project Total Costs	15 514 301.73
Clean H_2 JU Max. Contribution	4 999 999.00
Project Period	01-01-2021 - 30-06-2025
Coordinator Beneficiary	STORENGY S.A.S., FR
Beneficiaries	ENVIRONMENTAL RESOURCES MANAGEMENT LIMITED, ELEMENT ENERGY, ELEMENT ENERGY LIMITED, AXELERA - ASSOCIATION CHIMIE-ENVIRONNEMENT LYON ET RHÔNE-ALPES, EQUINOR ENERGY AS, INOVYN CHLORVINYLS LIMITED, INSTITUT NATIONAL DE L'ENVIRONNEMENT INDUSTRIEL ET DES RISQUES -INERIS, ÉCOLE POLYTECHNIQUE, STORENGY FRANCE, ERM FRANCE, S.A.S. BROUARD CONSULTING, ASSOCIATION POUR LA RECHERCHE ET LE DÉVELOPPEMENT DES MÉTHODES ET PROCESSUS INDUSTRIELS, ESK GMBH

https://hypster-project.eu/

PROJECT AND GENERAL OBJECTIVES

HyPSTER aims to demonstrate the industrial-scale operation of cyclical hydrogen storage in salt caverns to support the emergence of the hydrogen energy economy in Europe in line with Hydrogen Europe's overall road mapping. The cavern is located in Etrez in Auvergne-Rhône-Alpes, France. For the production of green hydrogen, the Etrez storage site will rely on local renewable energy sources and a 1 MW PEM electrolyser. In the long run, this facility will produce 400 kg of hydrogen per day (equivalent to the consumption of 16 hydrogen-powered buses). The project's objective is to test industrial-scale green hydrogen production and storage in salt caverns, and to assess the technical and economic reproducibility of the process at other sites throughout Europe.

NON-QUANTITATIVE OBJECTIVES

- Assessment of the economic feasibility of cyclical hydrogen storage in salt caverns.
- Analysis of risk and environmental impacts.
- Definition of guidelines for regulation and normative adaptation in Europe.
- Study of the techno-economic replicability in Europe.
- Microbiological analysis.

PROGRESS, MAIN ACHIEVEMENTS AND RESULTS

- The workover of well EZ53 was completed in 2023.
- All civil, piping, electrical, instrumentation, and automation works have been executed.
- All procured equipment has been installed and connected, except for the electrolyser stacks.
- Numerical simulation models for hydrogen storage in the salt cavern have been adapted.
- A risk analysis of underground hydrogen storage in the salt cavern has been performed.
- Commercial and microbiological analyses have been initiated.
- Cold commissioning of the electrolyser has started (without hydrogen).
- The site inauguration took place in September 2023. It was a key milestone and a highlight in the project's life.

FUTURE STEPS AND PLANS

- Delivery of electrolyser stacks.
- Hydrogen tightness tests.
- Hydrogen cycling tests.
- Hydrogen production.
- Project wrap-up activities and final workshop.

PROJECT TARGETS

Target source	Parameter	Unit	Target	Target achieved?
Project's own objectives	Power	MW	1	
	H_2 mass	Kg	2 000	
	CAPEX	€/kg	450	
	OPEX	€/kg	1	

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LH_2CRAFT

SAFE AND EFFICIENT MARINE TRANSPORTATION OF LIQUID HYDROGEN

Project ID	101111972
PRR 2026	Pillar 2 - H_2 Storage and Distribution
Call Topic	HORIZON-JTI-CLEANH$_2$-2022-02-06
Project Total Costs	5 627 595.94
Clean H_2 JU Max. Contribution	5 627 595.94
Project Period	01-06-2023 - 31-05-2027
Coordinator Beneficiary	HYDRUS ANOTATI SYNEKTIKI MICHANIKI ETAIREIA SYMVOULON ANONYMI ETAIREIA, EL
Beneficiaries	UNIVERSITY OF STRATHCLYDE, TWI LIMITED, FOUNDATION WEGEMT - A EUROPEAN ASSOCIATION OF UNIVERSITIES IN MARINE TECHNOLOGY AND RELATED SCIENCES, GABADI, S.L., AMERICAN MPIRO OF SIPING HELLENIC MONOPROSOPI ETAIREIA PERIORISMENIS EVTHINIS, HD KOREA SHIPBUILDING and OFFSHORE ENGINEERING CO., LTD., ETHNICON METSOVION POLYTECHNION, EASN TECHNOLOGY INNOVATION SERVICES BVBA, PANEPISTIMIO PATRON, RINA SERVICES SPA, CEGELEC NDT-PSC, TECHNISCHE UNIVERSITAET DRESDEN, BUREAU VERITAS MARINE and OFFSHORE REGISTRE INTERNATIONAL DE CLASSIFICATION DE NAVIRES ET DE PLATEFORMES OFFSHORE

https://lh2craft.eu/

PROJECT AND GENERAL OBJECTIVES

The LH_2CRAFT project aims to develop next-generation, sustainable, commercially attractive, and safe solutions for the long-term storage and long-distance maritime transportation of liquid hydrogen (LH_2), with potential applications as fuel in selected use cases. It focuses on an innovative membrane-type cargo containment system designed for large-scale storage (up to 200 000 m³ at −253 °C), which will be demonstrated and validated through a 10-ton (180 m³) prototype.

The project investigates alternative conceptual designs while embedding safety and risk assessments from the earliest design stages, targeting cargo containment systems that go beyond the current state of the art and are comparable in scale to LNG carriers. Key subsystems, including storage, handling, distribution, safety, and monitoring, are defined to ensure the modularity and scalability of the overall concept.

LH_2CRAFT aims to achieve Approval in Principle (AiP) from major classification societies, with support from three IACS members. The validation strategy includes detailed design, construction, and testing of the reduced-scale prototype. In parallel, the project develops a preliminary integrated ship design and performs cost assessments, targeting boil-off rates as low as 0.5% per day.

A lifecycle modelling framework and life cycle assessment (LCA) are developed to evaluate environmental impacts, compare design and retrofit strategies, and support sustainability and recyclability considerations across the full value chain. Overall, the project contributes to strengthening European leadership in maritime innovation, supporting the development of international regulatory standards, fostering highly skilled jobs, and enabling the transition toward a hydrogen-based energy system.

NON-QUANTITATIVE OBJECTIVES

- Advance LH_2 maritime storage and transport through safe, sustainable, and commercially viable next-generation solutions.
- Develop an innovative membrane-type cargo containment system with integrated storage, handling, safety, and monitoring functions.
- Embed safety and risk assessment early in the design to ensure robustness and regulatory compliance.
- Enable modular and scalable solutions compatible with existing industrial and ship design practices.
- Integrate system-level ship design and lifecycle modelling, including environmental impact assessment.
- Support the development of future regulatory frameworks and classification standards for large-scale LH_2 transport.
- Contribute to Europe's leadership in maritime innovation and the hydrogen economy transition.



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PROGRESS, MAIN ACHIEVEMENTS AND RESULTS

The project has completed the conceptual design of the Cargo Containment System (CCS), providing a solid basis for further engineering development and system integration. In parallel, the basic design of the Handling, Distribution, Safety, and Monitoring Subsystems (HDMSS) has been finalised, ensuring coherent integration of operational and safety functions within the vessel architecture.

A major milestone was the successful issuance of Approval in Principle (AiP) for both the CCS and HDMSS for the 200 000 m³ LH_2 carrier concept, confirming compliance with relevant classification and safety expectations at the concept level.

Testing and assessment requirements for the LH_2 cargo containment system have been defined, establishing the verification framework for subsequent development phases. Detailed engineering of the prototype LH_2 tank has been completed, alongside the design of a reduced-scale experimental test model for performance validation under representative conditions.

Alternative conceptual design solutions have been developed and assessed through desktop studies, with emphasis on modularity and scalability. In addition, qualitative and quantitative evaluations have been performed through technical workshops covering both CCS and HDMSS, supporting iterative refinement of the 200 000 m³ LH_2 carrier concept.

FUTURE STEPS AND PLANS

- Completion of remaining testing activities for Cargo Containment System (CCS) materials to validate performance under cryogenic and operational conditions.
- Finalisation of the preliminary LH_2 carrier ship design to consolidate system-level integration and demonstrate vessel feasibility at an industrial scale.
- Completion of alternative conceptual design solutions (desktop studies), enabling comparative evaluation and down-selection of optimal design pathways.
- Finalisation of the detailed design phase of the Handling, Distribution, Safety, and Monitoring Subsystems (HDMSS), ensuring readiness for integration.
- Manufacturing and testing of both the small-scale experimental model and the prototype LH_2 tank to validate design assumptions and structural integrity.
- Execution of qualitative and quantitative assessment activities through technical workshops on desktop study cases, supporting expert validation and design refinement.
- Upgrading of the Approval in Principle (AiP) status for the LH_2 containment system, reflecting increased design maturity and compliance with classification requirements.
- Completion of Life Cycle Assessment (LCA) and Life Cycle Cost (LCC) analyses to assess environmental and economic performance across the system lifecycle.
- Definition and implementation of a KPI-based evaluation framework for CCS solutions to enable structured benchmarking and comparison of design alternatives.

PROJECT TARGETS

Target source	Parameter	Target achieved?
Project's own objectives	Safe, cost-effective, and energy-efficient storage and transportation of large LH_2 quantities over longer distances	
	Design modular and scalable LH_2 storage to large dimensions, similar to those of existing LNG carriers	
	Achieve AiP for CCS concept and general approval by major IACS classification societies	
	Develop an LH_2 cargo containment system (CCS) for shipping that exceeds the sizes currently demonstrated	
	Develop a preliminary integrated ship design and conduct the corresponding cost estimate.	

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NICOLHY

NOVEL INSULATION CONCEPTS FOR LH_2 STORAGE TANKS

Project ID	101137629
PRR 2026	Pillar 2 - H_2 Storage and Distribution
Call Topic	HORIZON-JTI-CLEANH$_2$-2023-02-03
Project Total Costs	1 999 628.75
Clean H_2 JU Max. Contribution	1 999 585.00
Project Period	01-01-2024 - 31-12-2026
Coordinator Beneficiary	BUNDESANSTALT FÜR MATERIALFORSCHUNG UND -PRÜFUNG, DE
Beneficiaries	ALMA MATER STUDIORUM - UNIVERSITÀ DI BOLOGNA, ETHNICON METSOVION POLYTECHNION, NORGES TEKNISK-NATURLIGE UNIVERSITET (NTNU), DEUTSCHES ZENTRUM FÜR LUFT- UND RAUMFAHRT E. V.

http://nicolhy.eu

PROJECT AND GENERAL OBJECTIVES

The NICOLHy project aims to develop a novel insulation concept based on Vacuum Insulation Panels (VIPs) that enables the safe, cost- and energy-efficient storage of large quantities of liquefied hydrogen (LH_2). Such large-scale LH_2 storage technology is essential for establishing a hydrogen economy at scales between 40 000 m³ and more than 200 000 m³ of LH_2.

However, new design concepts are required, as currently available technologies for small- and medium-scale storage are not suitable for scaling up. Key limitations include long production times due to complex process chains, low failure tolerance, and spherical tank geometries, which can reduce payload by up to 50% compared to more efficient shapes.

The proposed NICOLHy concept addresses these challenges through a modular, open-form system that is time- and cost-efficient in production, operation, and maintenance, highly failure-tolerant, and applicable for both onshore and offshore applications. The consortium brings together expertise in cryothermodynamics, marine engineering, chemistry, process engineering, and safety engineering.

Technical objectives include:

- Design of a scalable LH_2 tank, including thermal insulation and support structure, ensuring energy efficiency, sustainability, reduced costs, and improved safety performance.
- Definition of materials and prediction of overall thermal insulation performance.
- Testing of the novel insulation concept at laboratory scale.
- Safety and risk analysis for operational and fire scenarios.
- Assessment of circularity, sustainability, and scalability of the proposed concept.

NON-QUANTITATIVE OBJECTIVES

- Increase awareness and acceptance of LH_2.

PROGRESS, MAIN ACHIEVEMENTS AND RESULTS

Design study on liquefied hydrogen tanks.

- Life Cycle Assessment (LCA) study on large-scale liquefied hydrogen tanks based on Vacuum Insulation Panel (VIP) insulation systems.
- HAZOP study on different tank concepts.
- Testing of materials and vacuum insulation panels under relevant operating conditions.
- Dissemination, exploitation, and communication of project results to a wide range of stakeholders.

FUTURE STEPS AND PLANS

- Testing of novel insulation concepts using a large-scale test rig.
- Publication of design guidelines on novel insulation concepts for the storage of LH_2.
- Benchmarking of different novel insulation concepts.

PROJECT TARGETS

Target source	Parameter	Unit	Target	Target achieved?	SoA result achieved to date (by others)	Year for reported SoA result
Project's own objectives	LH_2 tank capex	€/kg	20		100	2020
	LH_2 boil-off	Mass-%	0.1		0.3	2020

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OPTHYCS

OPTIC FIBRE-BASED HYDROGEN LEAK CONTROL SYSTEMS

Project ID	101101415
PRR 2026	Pillar 2 - H_2 Storage and Distribution
Call Topic	HORIZON-JTI-CLEANH$_2$-2022-02-02
Project Total Costs	2 499 428.75
Clean H_2 JU Max. Contribution	2 499 428.75
Project Period	01-01-2023 - 31-12-2025
Coordinator Beneficiary	ENAGAS TRANSPORTE SA, ES
Beneficiaries	FEBUS OPTICS, FUNDACIÓN PARA EL DESARROLLO DE LAS NUEVAS TECNOLOGÍAS DEL HIDRÓGENO EN ARAGÓN, FUNDACIÓN TECNALIA RESEARCH and INNOVATION, NATRAN, LUMIKER APLICACIONES TECNOLÓGICAS SOCIEDAD LIMITADA, GERG LE GROUPE EUROPÉEN DE RECHERCHES GAZIERES

https://opthycs.eu/

PROJECT AND GENERAL OBJECTIVES

OPTHYCS developed an innovative optical fiber–based sensing system for continuous hydrogen (H_2) leak detection, contributing to the safety and sustainability of future hydrogen energy systems.

Recognising the need for effective hydrogen-specific leak detection solutions, OPTHYCS combined:

- Advanced thin-film coating materials
- Optimised deposition processes for Fiber Bragg Gratings (FBGs)
- Integration of Fiber Bragg Gratings (FBG) and Distributed Acoustic Sensing (DAS) technologies
- Real-time data processing software.

NON-QUANTITATIVE OBJECTIVES

The system enables continuous, fast-response hydrogen (H_2) leak detection, including in remote or hard-to-access environments across the hydrogen value chain, covering production, storage, transmission, and end-use infrastructure (including both new and repurposed pipelines).

PROGRESS, MAIN ACHIEVEMENTS AND RESULTS

The OPTHYCS system reached TRL 6 for the FBG-based sensing system and TRL 7–8 for the distributed sensing system. The project successfully demonstrated the feasibility of the combined solution and its potential for more advanced operational validation. Given the higher integration complexity and the focus on high-value applications, a dedicated exploitation roadmap has been defined to increase the TRL further, outlining a tailored development pathway that goes beyond individual sensing technologies.

Laboratory validation

- Established testing protocols controlling humidity, temperature, and hydrogen concentration.
- Sensors demonstrated hydrogen sensitivity beyond previously reported FBG-based hydrogen sensors in the literature.

Prototyping and manufacturing

- Development of first-generation FBG-based hydrogen leak detection prototypes.
- Exploration of multiple coating materials and sensor configurations.
- System optimisation, including FBG interrogators and signal interpretation software.
- Significant progress toward industrial-ready sensing technology.

Field demonstration

- Six field campaigns conducted across different use cases.
- Successful hydrogen leak detection in semi-confined and buried environments.
- Fast and robust system response under diverse environmental conditions.

FUTURE STEPS AND PLANS

A detailed exploitation roadmap has been defined to:

- Advance from prototype validation to large-scale deployment.
- Integrate the sensing system into industrial process control systems.
- Validate system performance in real industrial environments.
- Ensure long-term operation under harsh and variable conditions.

The ultimate goal is to deliver a fully deployable, reliable, and scalable hydrogen safety monitoring solution.

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PROJECT TARGETS

Target source	Parameter	Unit	Target	Target achieved?
Project's own objectives	Minimum leak concentration detected	%	0.4	
	Time of response	sec	30 (Max. response time of 1 sec at a concentration of 0.4% -vol.)	
	Detection threshold	ln/min	0.4 (blending operation) 1.2 in pure H_2)	
	Time of recovery	sec	20 – 60 (depending on application)	
	Potential interferences	-	The sensor's sensitivity to hydrogen is not affected by the presence of other gases	

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PILGRHYM

PRE-NORMATIVE RESEARCH ON INTEGRITY ASSESSMENT PROTOCOLS OF GAS PIPES REPURPOSED TO HYDROGEN AND MITIGATION GUIDELINES

Project ID	101137592
PRR 2026	Pillar 2 - H_2 Storage and Distribution
Call Topic	HORIZON-JTI-CLEANH$_2$-2023-02-02
Project Total Costs	3 999 073.75
Clean H_2 JU Max. Contribution	3 999 073.75
Project Period	01-01-2024 - 31-12-2027
Coordinator Beneficiary	NATRAN, FR
Beneficiaries	UNIVERSIDAD DE BURGOS, FLUXYS BELGIUM SA, ONDERZOEKSCENTRUM VOOR AANWENDING VAN STAAL NV, SNAM S. P.A., GERG LE GROUPE EUROPEEN DE RECHERCHES GAZIERES, FUNDACION PARA EL DESARROLLO DE LAS NUEVAS TECNOLOGIAS DEL HIDROGENO EN ARAGON, SINTEF AS, COMMISSARIAT A L ENERGIE ATOMIQUE ET AUX ENERGIES ALTERNATIVES, ENAGAS TRANSPORTE SA, FRAUNHOFER GESELLSCHAFT ZUR FORDERUNG DER ANGEWANDTEN FORSCHUNG EV, FUNDACION TECNALIA RESEARCH and INNOVATION

https://pilgrhym.eu/

PROJECT AND GENERAL OBJECTIVES

PilgrHYm is an interdisciplinary project that aims to contribute to the decarbonisation of the energy sector by providing a European roadmap with comprehensive guidelines for assessing the feasibility of safely and efficiently integrating pure H_2 into existing natural gas infrastructure.

NON-QUANTITATIVE OBJECTIVES

- Develop a database of material characterisation testing on representative steel grades of the EU gas grids, including tensile, fracture toughness and fatigue crack growth (FCG) properties.
- Establish harmonised testing protocols to support the repurposing of natural gas lines to accommodate hydrogen.
- Develop a numerical modelling approach for simulating and predicting hydrogen-assisted fracture and fatigue.
- Optimise a more realistic fatigue crack growth rate master curve for the purpose of assessing fitness-for-service, for low delta K values corresponding to the actual operating domain of the EU gas grids.
- Identify existing and/or innovative technologies for mitigation compatible with operational constraints.
- Engage with stakeholders to ensure cooperation and awareness.
- Facilitate the uptake and exploitation of PilgrHYm results by the academic community, technology developers and end-users.

PROGRESS, MAIN ACHIEVEMENTS AND RESULTS

PilgrHYm delivered three main public reports:

- A literature and standard review focused on material mechanical testing in pressurised hydrogen gas. This review describes testing procedures across more than 27 standards, highlighting their inconsistencies and gaps in pressurised hydrogen testing environments.
- A literature review of innovative modelling approaches, including more than 30 papers and four model frameworks, covering state-of-the-art modelling for fracture and fatigue applications.
- A transmission system operator (TSO) inventory which collects data on the transmission steel networks present in Europe. The questionnaire was sent to all EU TSOs



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- and to various associations representing EU TSOs (GERG, ENTSOG, EPRG, and CEN TC234). A total of 23 onshore TSOs replied, accounting for more than 78% of the total European grid length.

PilgrHYm has selected 12 materials for testing (2 for round-robin tests and 10 for the main testing campaign). The materials will be dispatched to the project's testing laboratories in 2025. The testing protocols have been established. The round robin test ended in June 2025. The results will be shared in a later update.

FUTURE STEPS AND PLANS

Following the round-robin test, the main testing campaign for the other ten materials will be conducted. In parallel, numerical models will be developed. The expected outcomes of the project are:

- Definition of optimised testing procedures for hydrogen compatibility assessment of pipeline steels.
- Assessment of novel time and cost-effective experimental procedures for material qualification in a hydrogen environment.
- Development of a database summarising the characterised relevant properties of pipeline materials in hydrogen gas.
- New and innovative models for hydrogen-induced fracture and fatigue cracking simulation.
- Development of improved and more cost-effective FCG-master curves, with a reduced number of experimental tests.

PROJECT TARGETS

Target source	Parameter	Unit	Target	Target achieved?
Project's own objectives	Number of km of the European grid covered - Information collected on the EU and connected countries H_2 grid	km	156 054	✓
	Different steel microstructures to be assessed (including 8 base materials, 2 welds, and 2 heat-affected zones)	Number	12	
	Dedicated testing protocols for H_2 environments (tensile test, fracture toughness test and test on hollow specimen)	Number	4	
	Reports on suitable innovative technologies with proposed testing protocols	Number	1	
	Guidelines (reports) on experimental characterisation of mechanical properties, mitigation techniques and master curves	Number	2	
	Mitigation techniques identified	Number	10	⚙
	Numerical approach based on the performed experimental results	Number	1	
	Optimisation of design codes and standards with reduced over-conservatism vs ASME B31.12 (reduction of over-conservatism on the master curve)	%	60	
	Fracture models	Number	1	
	Fatigue models	Number	1	
	Reduction of total testing time for fracture toughness (time reduction)	%	20	
	Dissemination of stakeholder analysis for the use cases and organised workshops and events	Number	5	
	Dissemination of PilgrHYm's results towards the scientific, academic and standardisation community	Number	2	

REMEDHYS

RECYCLED METALS FOR ABOVEGROUND HYDROGEN STORAGE

Project ID	101192503
PRR 2026	Pillar 2 - H_2 Storage and Distribution
Call Topic	HORIZON-JTI-CLEANH$_2$-2024-02-02
Project Total Costs	3 996 168.95
Clean H_2 JU Max. Contribution	3 996 168.95
Project Period	01-01-2025 - 31-12-2028
Coordinator Beneficiary	INSTITUTT FOR ENERGITEKNIKK STI, NO
Beneficiaries	STUHFF MASCHINEN - UND ANLAGENBAU GMBH, UNIVERSITÉ PARIS XII VAL DE MARNE, METHYDOR SRL, HELMHOLTZ-ZENTRUM HEREON GMBH, UNIVERSITÉ LYON 1 CLAUDE BERNARD, CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE (CNRS), INGENION GMBH, UNIVERSITÀ DEGLI STUDI DI TORINO, FONDAZIONE BRUNO KESSLER, POMETON S.P.A

https://www.remedhys.eu/

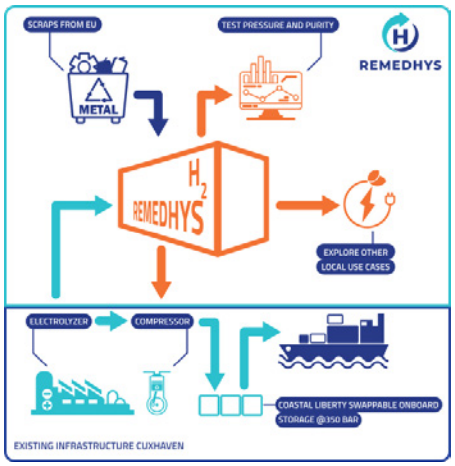
PROJECT AND GENERAL OBJECTIVES

REMEDHYS will advance the maturity of aboveground solid-state hydrogen storage solutions based on metal hydrides (MHs) by validating, in a real end-use scenario, a modular hydrogen storage system with a capacity of 100 kg H_2 and a density of at least 40 kg H_2/m³ at the storage-container level. REMEDHYS will adopt a novel approach to MH production, using recycled raw materials sourced in Europe and cost-efficient, highly automated manufacturing technologies to achieve capital expenditures (CAPEX) below €600/kg H_2 by 2030. The MH-based hydrogen storage system will be integrated with a 2 MW PEM electrolyser in Cuxhaven, Germany, which supplies hydrogen to the hydrogen-powered offshore service vessel *Coastal Liberty*.

NON-QUANTITATIVE OBJECTIVES

The implementation of MH-based hydrogen storage technologies developed in REMEDHYS aims to:

- Increase storage efficiency, as waste heat from the electrolyser, as well as other heat sources, depending on the specific application, can be used during hydrogen desorption from MHs;
- Increase safety, as hydrogen is stored in MHs at low pressure (≤50 bar) and is chemically bonded to the MH, preventing the sudden release of large amounts of H_2;
- Reduce the geometrical footprint, as low-pressure storage and chemical bonding of hydrogen reduce safety distances compared to compressed and liquid hydrogen storage;
- Circumvent the need for compression or liquefaction for large-scale intermediate storage, thereby simplifying the overall hydrogen handling and distribution infrastructure and reducing both capital expenditures (CAPEX) and operating expenses (OPEX);



- Promote circular economy approaches to minimise costs and the use of critical raw materials (CRMs), as well as mitigate the impact of volatile raw material supply chains;
- Validate MH-based storage technology at TRL 5 and demonstrate its feasibility and advantages for large-scale aboveground storage of 10–20 tonnes of H_2, e.g. for heavy-duty hydrogen refuelling stations

PROGRESS, MAIN ACHIEVEMENTS AND RESULTS

The first year of REMEDHYS has progressed in four areas:

- Selection of sustainable starting materials sourced in Europe, which were tested for the laboratory-scale synthesis of hydrogen storage alloys and pellets;
- Establishment of the infrastructure for the industrial production of the REMEDHYS hydrogen storage alloy;
- Development of the preliminary design of modular MH-based hydrogen storage units to be used in the REMEDHYS hydrogen storage system;

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- Definition of system specifications and operational strategies for proper integration at the Cuxhaven demonstration site

FUTURE STEPS AND PLANS

- Full characterisation of hydrogen storage alloys and pellets produced at laboratory scale, and the initiation of large-scale production of the hydrogen storage alloy;
- Finalisation of the design of REMEDHYS' modular MH-based hydrogen storage system, and testing of a single unit to validate the design;
- Conducting a risk assessment and finalising the P&ID and operational control strategies for the REMEDHYS hydrogen storage system;
- Initiating the analysis of national and international standards to identify gaps in current regulations, codes, and standards for aboveground hydrogen storage using metal hydrides.

PROJECT TARGETS

Target source	Parameter	Unit	Target	Target achieved?	SoA result achieved to date (by others)	Year for reported SoA result
Project's own objectives	Cost of raw material and binder	€	15		35	N/A
	MH-forming alloy production from recycled metals	tons	10		N/A	N/A
	Hydrogen density	$KgH_2/m3$	40		37.5	2023

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RHEADHY

REFUELLING HEAVY DUTY WITH VERY HIGH FLOW HYDROGEN

Project ID	101101443
PRR 2026	Pillar 2 - H_2 Storage and Distribution
Call Topic	HORIZON-JTI-CLEANH$_2$-2022-02-10
Project Total Costs	4 734 730.00
Clean H_2 JU Max. Contribution	3 999 381.50
Project Period	01-02-2023 - 31-01-2027
Coordinator Beneficiary	ENGIE, FR
Beneficiaries	BENKEI, FAURECIA HYDROGEN SOLUTIONS FRANCE, ENGIE ENERGIE SERVICES, ZENTRUM FUR BRENNSTOFFZELLEN-TECHNIK GMBH, FAURECIA SYSTEMES D ECHAPPEMENT SAS, LAUDA DR. R. WOBSER GMBH and CO KG, ALFA LAVAL VICARB SAS, TESCOM EUROPE GMBH CO KG, HYDROGEN-REFUELING-SOLUTIONS, EMERSON PROCESS MANAGEMENT FLOW B.V

https://rheadhy.eu/

PROJECT AND GENERAL OBJECTIVES

RHeaDHy's main goal is to develop components and hydrogen refuelling stations to enable the implementation, testing and market introduction of new very-high-flow refuelling protocols for heavy-duty vehicles.

NON-QUANTITATIVE OBJECTIVES

- Design and assemble a very-high-flow hydrogen refuelling line. The main goal is to provide components and refuelling lines that meet the required performance and operating conditions (very-high-flow rate, pressure, temperature, dynamic behaviour), with an optimal trade-off between performance and the distribution of constraints among components.
- Develop new components needed for high-flow refuelling. The main goals are (i) to develop new very-high-flow components, such as cooling technology, flow meters, valves, heat exchangers, and make them ready-to-commercialise; (ii) to develop an advanced bidirectional communication interface; (iii) to test, optimise and adapt components already in the prototype phase of their development, such as breakaway, hose, nozzle and receptacle assembly.
- Develop and demonstrate a new protocol for refilling storage systems. The main goal is to demonstrate new standardised refuelling protocols for heavy-duty vehicles developed by ISO TC 197 WG24 or other standardisation bodies.
- Ensure the fast and efficient refill of storage systems with H_2 at low cost. The main goal is to demonstrate the protocols by using components under the conditions mentioned above.

Standardise and certify components for hydrogen refuelling stations to ensure a fast deployment (WP6). The main goal is to contribute to standard development through participation in ISO TC 197 and CEN 268 WG5, and to obtain certifications for all components according to the relevant standards (ISO TC 197, CEN 268 WG5, OIML R139).

PROGRESS, MAIN ACHIEVEMENTS AND RESULTS

After three years of development, the project is transitioning into the demonstration phase. All new components compatible with very high-flow hydrogen refuelling have been manufactured, including valves and regulators, flow meters, heat exchangers, cooling systems, and breakaway, hose, nozzle, and receptacle assemblies (the latter provided by external partners). These components have been assembled into two dispensers.

The dispensers are planned to be tested at two different sites. The first site, ZBT in Duisburg (Germany), was upgraded during 2025 to enable testing under appropriate conditions. The dispenser arrived at the end of 2025 and has been installed since then. After resolving initial leakage issues, the first tests were conducted at the beginning of 2026. Additional preliminary tests are still required before the consortium can fully enter the test matrix phase.

The second testing site, HRS in Champagnier (France), is currently undergoing a transformation. Some delays have been encountered, but site commissioning and testing activities are planned throughout 2026.

FUTURE STEPS AND PLANS

With the ZBT site fully equipped, commissioning tests are just beginning. After validation, testing with new protocols will proceed.

Installation at HRS is ongoing and is expected to be completed by mid-2026, after which the planned test campaigns will commence.

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PROJECT TARGETS

Target source	Parameter	Unit	Target	Target achieved?
Project's own objectives	Pressure regulator and shut-off valve compatible with very high flow rate and high pressure (1 000 bar)	g/s	170 (mean flow rate) 300 (peak flow)	✓
	Peak flow for prototype breakaway, nozzle, and hose	g/s	300	
	Number of refuelling simulations performed	Number	1 000	
	Flow-measuring device compatible with very high flow rates, targeting > 100 kg total mass per refuelling	g/s	170 (mean flow rate) 300 (peak flow)	
	Time for a refill of a 100-kg HD truck storage test system	minutes	10	
	Time for refuelling: heat exchanger and cooling system; hydrogen dispensed below -30°C	minutes	10	
	Number of refuelling events demonstrated for the fully integrated chain	Number	300	
	Mean time between failures	days	72	
	Annual maintenance cost	€/kg	0.5	
	CAPEX for the HRS 700 bar (200-1 000 kg/d)	k€	1.5 - 4	

ROAD TRHYP

ROAD TRAILER DESIGN - USE OF TYPE V THERMOPLASTIC TUBE WITH LIGHT COMPOSITE STRUCTURE FOR HYDROGEN TRANSPORT

Project ID	101101422
PRR 2026	Pillar 2 - H_2 Storage and Distribution
Call Topic	HORIZON-JTI-CLEANH$_2$-2022-02-07
Project Total Costs	2 642 912.59
Clean H_2 JU Max. Contribution	2 499 999.50
Project Period	01-01-2023 - 30-06-2026
Coordinator Beneficiary	L AIR LIQUIDE SA, FR
Beneficiaries	SEGULA SLOVENSKO S.R.O, CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE CNRS, UNIVERSITÉ DE POITIERS, ARKEMA FRANCE SA, ENVITEST J. PACHOLSKI SPÓŁKA JAWNA, ÉCOLE NATIONALE SUPÉRIEURE DE MÉCANIQUE ET D'AÉROTECHNIQUE, SEGULA ENGINEERING, COVESS NV, POLITECHNIKA WROCLAWSKA, EFECTIS FRANCE

http://https://road-trhyp.eu/

PROJECT AND GENERAL OBJECTIVES

Today, existing hydrogen transport solutions rely on tube trailers operating at working pressures of 200-300 bar. This approach is inefficient in terms of transported quantities and supply costs for large refuelling stations, particularly given the expected ramp-up in fuel cell vehicle deployment.

The overall objective of the ROAD TRHYP project is to develop and validate a trailer integrating new thermoplastic composite tubes (Type V) to maximise hydrogen transport capacity while meeting end-user requirements (including safety and decontamination capabilities) and applicable regulations, at low cost. By the end of the project, the consortium aims to design a trailer capable of transporting 1.5 tonnes of hydrogen using 700-bar tubes, with capital expenditure below 400 €/kg.

This solution will reduce the number of transport rotations between production and delivery sites, thereby lowering the environmental footprint of compressed hydrogen transport and enabling a reduction in compressor size at hydrogen refuelling stations.

In parallel, the project will investigate new fire-testing methodologies and safety barriers to support the adoption of Type V technology.

ROAD TRHYP's broader ambition is to strengthen Europe's value chain for Type V technologies. The project targets manufacturers across Europe who may benefit from the developed processes and materials. Beyond trailer applications, the knowledge generated on composite materials is expected to benefit stakeholders in mobility and in hydrogen storage for inter-seasonal energy storage. Ultimately, the project contributes to achieving the European Green Deal by supporting hydrogen as a widely deployed energy carrier by 2030.

NON-QUANTITATIVE OBJECTIVES

Formulation of regulatory recommendations to accelerate the technology's deployment.

PROGRESS, MAIN ACHIEVEMENTS AND RESULTS

- Design of the Type V cylinder is complete, with initial tests showing a gravimetric index more than 7% higher.
- One Type V cylinder licence sold to ROTH$_2$ for certification, expected by the end of 2026.
- Trailer design finalised, demonstrating the capability to store 1.5 tonnes of hydrogen at 700 bar.
- Life cycle assessments of Type I, Type IV, and Type V trailers are complete, showing improved performance for the Type V solution.
- Key parameters identified for drying Type V cylinders to achieve 5 ppm water content, enabling compliance with hydrogen quality specifications for fuel cell applications.
- Recommendations on interoperability between hydrogen trailers and refuelling stations are finalised.
- Overall results confirm the technical and environmental advantages of Type V technology and support its path towards certification and commercial deployment.

FUTURE STEPS AND PLANS

- Bonfire test to assess whether the Type V cylinder leaks or bursts, and to validate a simulation model of Type V behaviour under engulfing fire conditions.
- Filling and unfilling tests of a Type V cylinder to validate a model predicting temperature evolution during filling and emptying operations.

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PROJECT TARGETS

Target source	Parameter	Unit	Target	Target achieved?
Project's own objectives	Design Type V 700 bar tube	%	5.3	⚙
	Water content in Hydrogen	ppm	< 5	
	Ability of the Type V tank to pass a bonfire test	-	-	
	CAPEX	€/kg H_2 stored	400	✓
	Formulation of regulatory recommendations aiming at faster deployment of the technology	-	Present recommendation to WG ISO TC 197 regarding interoperability between HRS and trailrs	

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SINGLE

ELECTRIFIED SINGLE STAGE AMMONIA CRACKING TO COMPRESSED HYDROGEN

Project ID	101112144
PRR 2026	Pillar 2 - H_2 Storage and Distribution
Call Topic	HORIZON-JTI-CLEANH$_2$-2022-02-04
Project Total Costs	2 989 671.25
Clean H_2 JU Max. Contribution	2 989 671.25
Project Period	01-05-2023 - 30-04-2026
Coordinator Beneficiary	COORSTEK MEMBRANE SCIENCES AS, NO
Beneficiaries	SINTEF AS, AGENCIA ESTATAL CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS, GEA ENERGIA CRIO SL, FONDAZIONE ICONS, UNIVERZA V LJUBLJANI, UNIVERSITAT POLITÈCNICA DE CATALUNYA

https://singleh2.eu/

PROJECT AND GENERAL OBJECTIVES

SINGLE aims to demonstrate the competitive advantages of proton ceramic electrochemical reactors for producing high-purity, pressurised hydrogen (up to 20 bar) from ammonia. This goal will be achieved through the implementation of an innovative proton ceramic electrochemical reactor stack design, integrated into a module capable of operating at a scale of 10 kg of hydrogen per day. To reach this capacity, the module will comprise twenty individual stacks.

NON-QUANTITATIVE OBJECTIVES

- Optimise the catalytic activity of the proton ceramic electrochemical reactor for ammonia dehydrogenation.
- Optimise and qualify proton ceramic electrochemical reactor stacks and system components.
- Fabricate proton ceramic electrochemical reactor stacks, including the design, assembly, construction and testing of the 10 kg H_2/day module.
- Assess the life cycle, value chain economics and critical raw materials.
- Carry out dissemination, communication and standardisation activities.

PROGRESS, MAIN ACHIEVEMENTS AND RESULTS

- Catalytic activity and stability of Ni/BCZY support have been optimised by infiltration of active metal.
- Candidate alloy materials have been identified for constructing and safely operating reactor housing under ammonia conditions.
- Cells, KETs and stacks have been manufactured.

FUTURE STEPS AND PLANS

- Stacks for the 10-kg/day H_2 module will be fabricated.
- Design, assembly, construction, and testing of the 10-kg H_2/day module.
- Life cycle, value chain economics, and critical raw materials will be assessed.

PROJECT TARGETS

Target source	Parameter	Unit	Target	Achieved to date by the project	Target achieved?	SoA result achieved to date (by others)	Year for reported SoA result
Project's own objectives	Ammonia conversion (CATALYST)	%	> 98 at 600 °C	99.2	✓	98 % at 650 °C	2022
	Durability (CATALYST)	%	< 1 %/kh decrease in conversion at 600 °C	-		N/D for >1kh	2022
	Current density (CELL)	A/cm2	> 1	-		0.8	2022
	ASR (Current collector/electrode/ electrolyte) (CELL)	Ωcm2	< 0.5	-		1.2	2022
	NH3 conversion (CELL)	%	> 99.9	-		> 99.98	2022
	Faradaic efficiency (CELL)	%	> 98	-		98	2022
	Hydrogen recovery (CELL)	%	> 99	-		99	2022
	Durability (CELL)	%/kh voltage degradation on cell level at 0.75 Acm	0.8	-		0.8	2022
	Total current (STACK)	A	>85	44		67	2022
	NH3 conversion (STACK)	%	>99.8	98.4 (at 750°C)		N/A	N/A
	Faradaic efficiency (STACK)	%	95	96 (at 10 bar, 700°C)		>98	2022
	Hydrogen Recovery (STACK)	%	>98	86 (at 650°C)		98	2022
	Pressure Tolerance	Bar	30	15		31	2022
	Hydrogen Purity	%	>99.99	-		>99.99	2022
	Efficiency HHV	%	>90	-			
	NH3 Conversion (10kg/day MODULE)	%	>90	-			
	NH3 Conversion (10kg/day MODULE)	%	>99.5	-		N/A	N/A
	Hydrogen Recovery (10kg/day MODULE)	%	>95	-			
	Number of hours operated at 10 kg/day	hours	>500	-			
	Pressure tolerance	bar	25	-			

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UNLOHCKED

UNLOCKING THE POTENTIAL OF LOHCS THROUGH THE DEVELOPMENT OF KEY SUSTAINABLE AND EFFICIENT SYSTEMS FOR DEHYDROGENATION

Project ID	101111964
PRR 2026	Pillar 2 - H_2 Storage and Distribution
Call Topic	HORIZON-JTI-CLEANH$_2$-2022-02-05
Project Total Costs	2 941 312.75
Clean H_2 JU Max. Contribution	2 941 312.75
Project Period	01-06-2023 - 31-05-2026
Coordinator Beneficiary	UNIVERSIDAD DEL PAÍS VASCO/ EUSKAL HERRIKO UNIBERTSITATEA, ES
Beneficiaries	NOORDWES-UNIVERSITEIT, FRAMATOME GMBH, HYGEAR BV, Heraeus Precious Metals GmbH and Co. KG, HYGEAR OPERATIONS BV, CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE CNRS, HYGEAR TECHNOLOGY AND SERVICES BV, HYGEAR HYDROGEN PLANT BV, HYGEAR FUEL CELL SYSTEMS BV, COMMISSARIAT A L ENERGIE ATOMIQUE ET AUX ENERGIES ALTERNATIVES

https://unlohcked.cnrs.fr/

PROJECT AND GENERAL OBJECTIVES

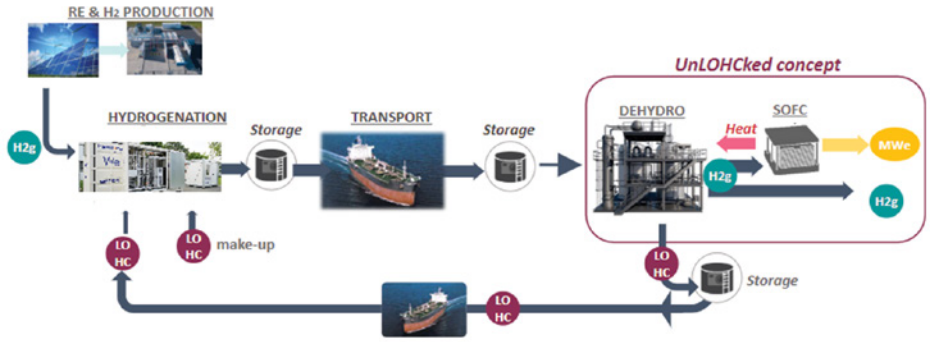
By advancing breakthrough research on liquid organic hydrogen carrier (LOHC) technologies, UnLOHCked aims to develop a radically disruptive, versatile and scalable LOHC dehydrogenation plant. Firstly, highly active and stable catalysts that do not rely on critical raw materials will be developed to enable LOHC dehydrogenation at moderate temperatures. Secondly, a solid oxide fuel cell system will be developed for thermal integration with the dehydrogenation process. The heat demand of the dehydrogenation unit will be fully met by the fuel cell, which will also generate electricity. The surplus hydrogen will be exported. When fully integrated, these innovative systems will significantly increase the overall efficiency of hydrogen and electricity production from LOHC (> 50%).

The main objectives of this project are:

- To develop a critical raw material (CRM)-free or low-CRM catalyst with high conversion, selectivity and productivity for dehydrogenation.
- To scale up one of the developed catalysts from grams at laboratory scale to multiple kilograms for the demonstration plant.
- To develop a breakthrough integrated system in which the reactor is thermally coupled to an SOFC, simplifying the dehydrogenation plant and improving thermal efficiency.
- To demonstrate the feasibility of producing hydrogen and generating renewable electricity from LOHC-stored hydrogen by heat integration between endothermic hydrogen release and exothermic fuel cell operation.

NON-QUANTITATIVE OBJECTIVES

- To reduce capital expenditure (i.e. owing to the use of less expensive materials, no chemical reagents, no cleaning cycles, and extended material lifetime) and operational expenditure (i.e. owing to continuous mode of operation and optimised process controls).
- To decrease the cost of hydrogen transport and to demonstrate the feasibility and cost-effectiveness of LOHC technologies, from onshore tank to onshore tank, all-inclusive.
- To develop a scale-up plan, through a techno-economic analysis, to improve techno-economic viability and to include comparisons with alternative hydrogen technologies for long-distance transport.
- To develop a dissemination, exploitation and communication plan targeting key stakeholders and end-users at EU and international levels to maximise the impact of UnLOHCked results.
- To put the EU at the forefront of hydrogen technologies, ensuring a competitive and commercial advantage in Europe to incentivise future investments.



PRR 2026 PILLAR
H_2 Storage and Distribution

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- To reduce the environmental impact of hydrogen technologies by reducing the use and release of toxic substances and CRMs with a significant environmental impact.
- To contribute to the European Green Deal Goals through a fully CO_2-free dehydrogenation system.

PROGRESS, MAIN ACHIEVEMENTS AND RESULTS

After the first year and a half, UnLOHCked is in the middle of scaling up a low-CRM catalyst.

So far, UnLOHCked has achieved catalysts with conversions, selectivities and productivities higher than the state-of-the-art and is reaching the project's key performance indicators.

FUTURE STEPS AND PLANS

- Continue scaling up the catalyst from lab scale to industrial scale to meet the project targets.
- Continue the reactor design for the dehydrogenation unit, integrated with a solid-state fuel cell unit.

PROJECT TARGETS

Target source	Parameter	Unit	Target	Target achieved?
Project's own objectives	Grade of conversion	%	>95	✓
	Catalyst selectivity	%	>99.8	
	Catalyst productivity in dehydrogenation	g H_2/g catalyst/min	>0.02	
	No dissemination materials	Number	>8 (website, social media, videos, etc.)	
	No peer-reviewed scientific publications and patents	Number	>10 publications and ≥1 patents	
	Catalyst productivity in dehydrogenation	kg H_2/day	10	
	Catalytic stability	%	Leaching of active material <0.1%/cycle Loss of performance < 0.1%/cycle: Grade of conversion >95%	
	Catalyst selectivity	%	>99	
	Hydrogen carrier specific energy consumption	kWh input/kg H_2 recovered	>17	
	Operating hours	hours	>500	⚙
	Overall efficiency	%	>50	
	H_2 production	kg/day	10	
	Overall efficiency (electrical)	%	>50	
	Reduction in CAPEX and OPEX	%	CAPEX: 65 OPEX: 80	
	Hydrogen carrier delivery cost	€/kg	<2.5	
	H_2 Production (TEA)	kg H_2/day	100-1 000	
	Reduction in the footprint	%	75	
	Reduction in CO_2 emissions	% in the end-to-end UnLOHCked process	>90	

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