

ELVHYS

ENHANCING SAFETY OF LIQUID AND VAPORISED
HYDROGEN TRANSFER TECHNOLOGIES IN PUBLIC
AREAS FOR MOBILE APPLICATIONS



Project ID	101101381
PRR 2025	Pillar 5 - Cross-cutting
Call Topic	HORIZON-JTI-CLEANH ₂ -2022-05-02
Project Total Costs	1 433 960.00
Clean H ₂ JU Max. Contribution	1 433 960.00
Project Period	01-01-2023 - 31-12-2025
Coordinator Beneficiary	NORGES TEKNISK-NATURVITENSKAPELIGE UNIVERSITET NTNU, NO
Beneficiaries	KARLSRUHER INSTITUT FUER TECHNOLOGIE, HEALTH AND SAFETY EXECUTIVE, UNIVERSITY OF ULSTER, L AIR LIQUIDE SA, NATIONAL CENTER FOR SCIENTIFIC RESEARCH "DEMOKRITOS", DEUTSCHES ZENTRUM FUR LUFT - UND RAUMFAHRT EV, ALMA MATER STUDIORUM - UNIVERSITA DI BOLOGNA

<https://elvhys.eu/>

PROJECT AND GENERAL OBJECTIVES

ELVHYS addresses a critical gap in international standards related to liquid and cryogenic hydrogen transferring technologies for mobile applications such as filling trucks, ships, and stationary tanks. Since there is limited experience in this area today, significant challenges for safety and efficiency in hydrogen transfer operations exist. ELVHYS has the overarching objective to develop inherently safer and more efficient liquid and cryogenic hydrogen technologies and protocols for mobile applications.

This objective is pursued through innovative safety strategies and engineering solutions, including the selection of effective safety barriers and hazard zoning strategies. The project utilises an interdisciplinary approach, combining experimental, theoretical, and numerical studies to address various aspects of liquid and cryogenic hydrogen transfer.

Key objectives of the ELVHYS project include:

- Providing a comprehensive report on the state-of-the-art of cryogenic hydrogen transfer operations, including knowledge gaps, international standards, regulatory challenges, and safety strategies.
- Identifying hazards and incident scenarios associated with cryogenic hydrogen transferring operations and prioritising areas with the highest risk and least knowledge.
- Conducting experimental campaigns to investigate cryogenic hydrogen transfer operations and associated phenomena, such as releases, fires, and explosions.
- Developing and validating numerical simulation models for cryogenic hydrogen transfer operations and mitigation techniques.
- Proposing innovative safety strategies and engineering solutions based on experimental and modelling results.
- Disseminating project results to the fuel cell and hydrogen community, including authorities, standard development organisations,

and other stakeholders.

- Contributing to the development of international standards for cryogenic hydrogen transferring technologies.

These objectives are achievable thanks to the expertise and resources of the consortium members, who possess unique experimental facilities, theoretical and numerical research capabilities, and practical experience in hydrogen safety. ELVHYS aims to not only fill existing knowledge gaps but also to lay the groundwork for sustainable impact through continued collaboration and dissemination beyond the project duration. By addressing these objectives, ELVHYS seeks to significantly enhance the safety and efficiency of cryogenic hydrogen transferring technologies on a global scale.

NON-QUANTITATIVE OBJECTIVES

ELVHYS will contribute to many objectives of the Clean Hydrogen JU SRIA such as (i) increase the level of safety and (ii) support the development of regulations, codes and standards (RCS) for hydrogen technologies and applications.

- Increasing the safety level of hydrogen technologies and applications is the cornerstone of the ELVHYS project. It will be addressed through top-edge research that closes numerous knowledge gaps in the understanding of the underlying physical phenomena governing liquid hydrogen transfer, specifically heat and mass transfer at cryogenic temperatures and under multiphase flow conditions. The project will advance the state-of-the-art through the generation of new knowledge, the development of innovative prevention and mitigation strategies, and the proposal of risk-informed recommendations and guidelines for cryogenic hydrogen transfer technologies.
- Supporting the development of RCS for hydrogen technologies and applications, with the focus on standards that will be

addressed through the developed science-based recommendations for RCS, beyond the state-of-the-art guidelines on fuelling, bunkering and transfer procedures.

PROGRESS, MAIN ACHIEVEMENTS AND RESULTS

Key Achievements of ELVHYS in the field of cryogenic and liquid hydrogen (LH₂) transfer technologies are:

- **Operational insights and best practices:** Extensive data collection from existing LH₂ facilities helped define best practices and establish a baseline for safe and effective transfer operations.
- **Ecosystem Mapping:** A comprehensive overview of the LH₂ transfer infrastructure, technologies, and applications was developed.
- **System Design & Safety Devices:** Detailed Piping and Instrumentation Diagrams (P&IDs) were created, along with an inventory of current safety devices used in LH₂ systems.
- **Safety-Focused Research Programme:** A dedicated research plan was established to address safety challenges specific to LH₂ transfer systems.
- **Risk Analysis & Methodological Review:** Initial risk analyses were conducted, and gaps in existing safety approaches were identified for further investigation.
- **Regulations, Codes, and Standards (RCS):** A complete list of relevant RCS and regulatory bodies was compiled to ensure alignment with international safety standards.

- **Fire & Explosion Modelling Support:** Computational models were selected to simulate fire and explosion scenarios, aiding in hazard assessment and mitigation planning.
- **LH₂ Transfer Modelling Tools:** Engineering tools were developed to simulate LH₂ transfer processes, which will be validated through physical tests.
- **Experimental Testing:**
 - Successful tests in November 2024 on (i) Condensed phase explosion scenarios and (ii) LH₂ release into cold environments.
 - Experimental setups for (i) Fire and BLEVE (Boiling Liquid Expanding Vapor Explosion) tests on LH₂ hoses; (ii) Material resistance tests under LH₂ jet impingement.
 - Transfer System Test Readiness: LH₂ transfer experimental setups were designed and reviewed, with readiness assessments ensuring test safety and effectiveness.
- **Hazard Identification & Consequence Analysis:** Comprehensive hazard assessments were completed, and preliminary consequence analyses were performed for selected LH₂ transfer scenarios.

FUTURE STEPS AND PLANS

ELVHYS aims to provide a supportive regulatory and standardisation framework.

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	Safety, PNR/RCS Workshops	Number/year	2	2	✓	1	2020
	Impact on standards at scope	Number/project	1	0.6	⚙️	0.6	2020