ELVHYS - Enhancing safety of liquid and vaporised hydrogen transfer technologies in public areas for mobile applications

Federico Ustolin (NTNU) et al

1st Stakeholders' workshop
Paris, France, 21.06.2023

Co-funded by the European Union

Clean Hydrogen Partnership

UK Research and Innovation

ELVHYS project No. 101101381 is supported by the Clean Hydrogen Partnership and its members and the European Union. UK participants in Horizon Europe Project ELVHYS are supported by UKRI: University of Ulster (grant number 10063519) and Health and Safety Executive.

Pre - ELVHYS

Progress / Closed gaps

Fundamental/Modelling “Release”:

- ✓ Discharge coefficients for cryo- and cryocompressed releases
- ✓ Rainout phenomena better understood
- ✓ Fundamental data for mixing of large scale releases

Fundamental/Modelling “Ignition”:

- ✓ MIE and hot surface T determined for cryogenic conditions
- ✓ Empirical tests for RPT without fast reaction
- ✓ Electrostatics of cryogenic releases
- ✓ Worst case effects for small cryogenic inventories determined via variation of ignition time and position

Fundamental/Modelling “Combustion”:

- ✓ Flame length correlations validated
- ✓ σ, σcrit and run-up distance for DDT determined at cryogenic conditions
- ✓ …

PRESLHY

Pre - ELVHYS

Scientific Data Published

DOI: https://doi.org/105445/IR/ + ”KITOpen ID Nr”

Participant: KIT	KIT Open ID Nr.
WP3.1.b	1000145859
WP3.4	1000145885
WP5.1	1000147745
WP5.5	1000136188

Participant: KIT WP 4.4	KIT Open ID Nr.
Material: sand	1000145886
Material: concrete	1000145887
Material: water	1000145888
Material: gravel	1000145889

Participant: HSE	KIT Open ID Nr.
WP3	1000136281
WP4	1000136330
WP5	1000136285

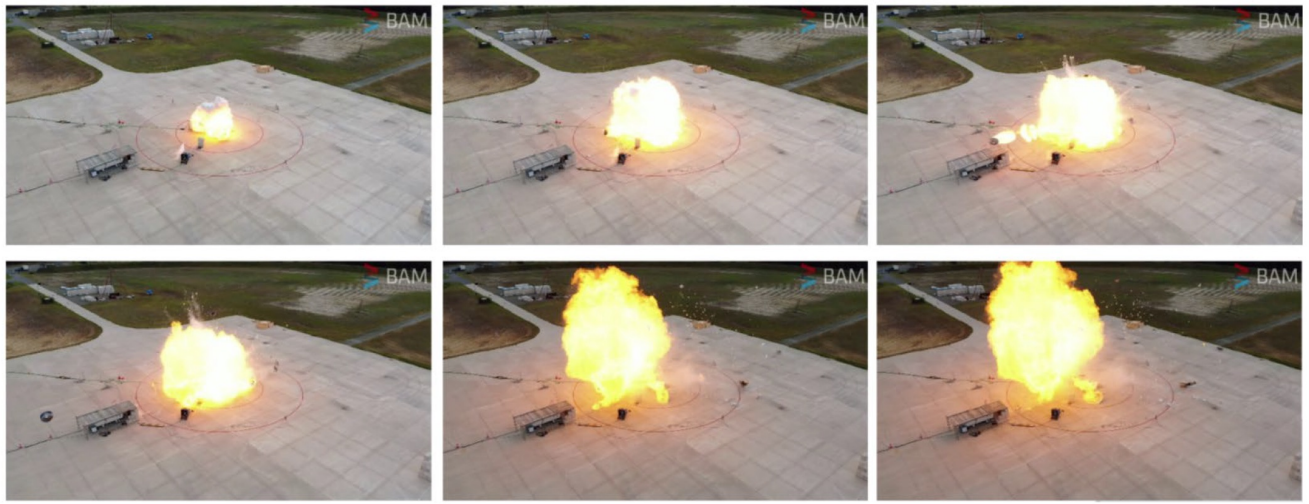
Participant: KIT WP 5.3 warm	KIT Open ID Nr.	Participant: KIT WP 5.3 cold	KIT Open ID Nr.
BR ratio: 0%	1000145890	BR ratio: 0%	1000145893
BR ratio: 30%	1000145891	BR ratio: 30%	1000145895
BR ratio: 60%	1000145892	BR ratio: 60%	1000145896

Pre - ELVHYS

SH2IFT Project Findings

Fundamental/Modelling “BLEVE”:

- ✓ Experiments performed and BLEVE observed at BAM
  (see van Wingerden, Kees, et al. *Chemical Engineering Transactions*, 2022, 90. Jg., S. 547-552)



Fundamental/Modelling “RPT”:

- ✓ RPT observed in BAM tests spilling LH2 on water
  (see van Wingerden, Kees, et al. "Experimental Investigation into the Consequences of Release of Liquified Hydrogen onto and under Water." (2022))

ELVHYS

Follow-up of PRESLHY

About

Funding programme: Horizon Europe

Budget: 2.0 M€

Duration: 2023-2026 (36 months)

Type: Research & Innovation Action

Objective: provide indications on inherently safer and efficient cryogenic hydrogen transfer technologies and protocols in mobile applications by proposing innovative safety strategies including selection of effective safety barriers and hazard zoning strategies, which are the results of a detailed risk analysis.

ELVHYS

Expected outcomes

1. Detailed risk analysis for LH2 transferring operations for mobile applications (ships, trucks, stationary tanks) fillings
2. Generic hazard distances for LH2 transferring operations in the different applications, also addressing SimOps
3. Guidelines for design of LH2 transferring facilities
4. Consensual loading procedures for LH2 transferring operations
5. Provide inputs for developing Standards, Technical Specifications, or Technical Reports at the international level

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ELVHYS – Consortium

NTNU (Coordinator)

Ulster University

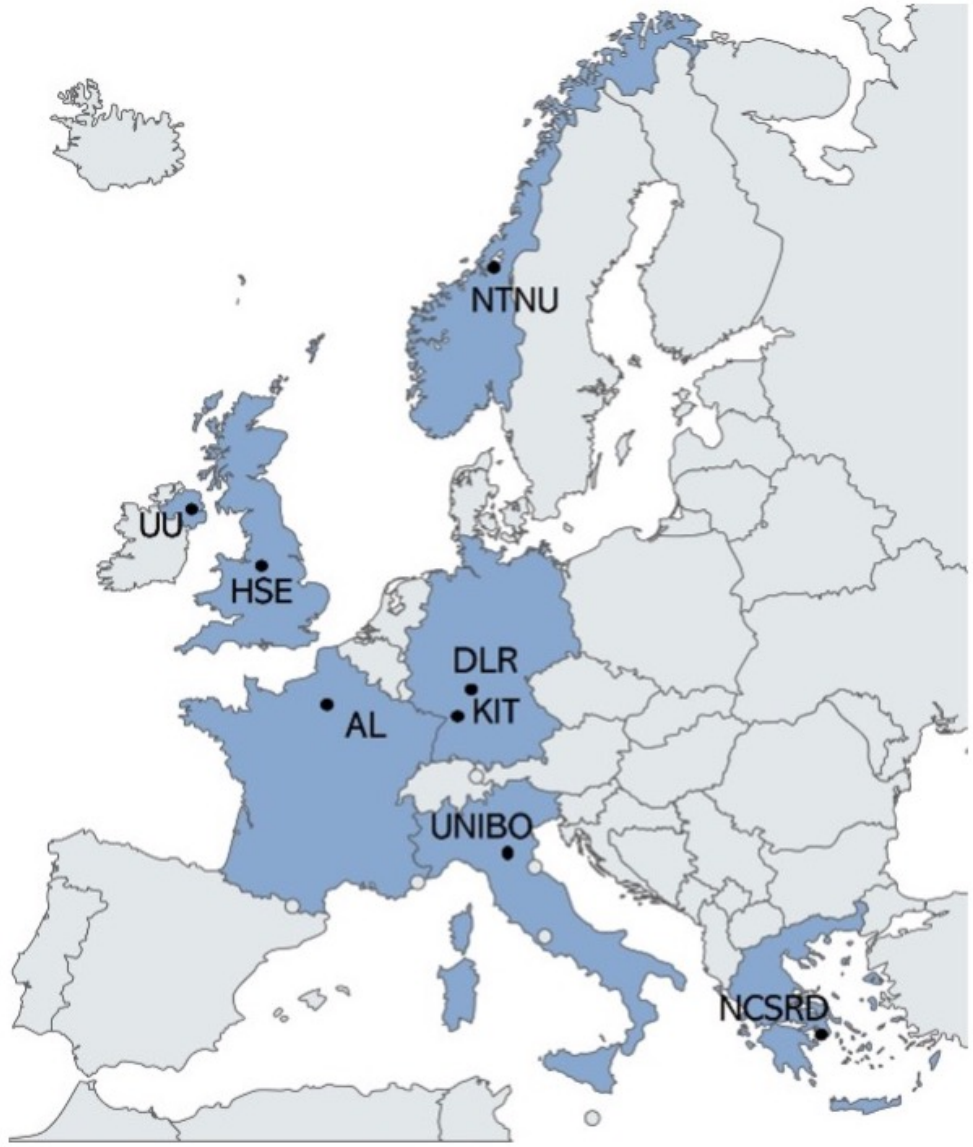
DEMOKRITOS

DLR

HSE

KIT
Karlsruher Institut für Technologie

Air Liquide



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ELVHYS – Stakeholder Advisory Board

- At the moment 26 organizations are included in the SAB
- The organizations are based in 8 European (Belgium, France, Germany, Italy, Norway, Sweden, The Netherlands, UK) and 4 non-European countries (Canada, China, Japan, USA)
- Type of organizations: industries and companies (8), research centres (6), universities (5), national public institutes (3), association (HySafe), intergovernmental org. (IEA), industry org. (Hydrogen Council), rail operator (SNCF)

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ELVHYS – Stakeholder Advisory Board

No	Organization	Type	Country
1	International Association for Hydrogen Safety (HySafe)	Association	Belgium
2	IEA	Intergovernmental org.	---
3	Hydrogen Council	Industry organization	---
4	Sandia National Laboratory	Research center	USA
5	Kawasaki Heavy Industries	Industry	Japan
6	Daimler	Industry	Germany
7	Airbus	Industry	France
8	DNV	Certification body	Norway/UK
9	HYEX	Company	Norway
10	Norled (MF Hydra – LH2 ferry project)	Company	Norway
11	University of Salerno	University	Italy
12	ISPRA - Italian National Institute for Environmental Protection and Research	Public body	Italy
13	PPG	Company	UK
14	RIVM - the Netherlands National Institute for Public Health and the Environment, Centre for Environmental Safety and Security	Public body	The Netherlands
15	SNCF - DIRECTION TECHNOLOGIES, INNOVATION ET PROJETS GROUPE (rail operator)	Operator	France
16	RISE	Research Centre	Sweden

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ELVHYS – Stakeholder Advisory Board

No	Organization	Type	Country
17	SINTEF industry	Research Centre	Norway
18	SINTEF Energy	Research Centre	Norway
19	Fellow, Royal Society for the Encouragement of Arts, Manufactures and Commerce (FRSA)	Global network of changemakers	USA
20	CEA (ESKHYMO project)	Research Centre	France
21	Forschungszentrum Jülich (STACY project)	Research Centre	Germany
22	Politecnico di Milano (e-SHyIPS project)	University	Italy
23	Shandong University (SDU)	University	China
24	University of Trieste	University	Italy
25	NavalProggetti srl (sHYpS project)	Company	Italy
26	University of Bergen	University	Norway

The SAB list can be found on the project website

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ELVHYS – Collaboration with other projects

Intention to establish collaborations with other projects related to LH2 and cryogenic hydrogen transfer and storage

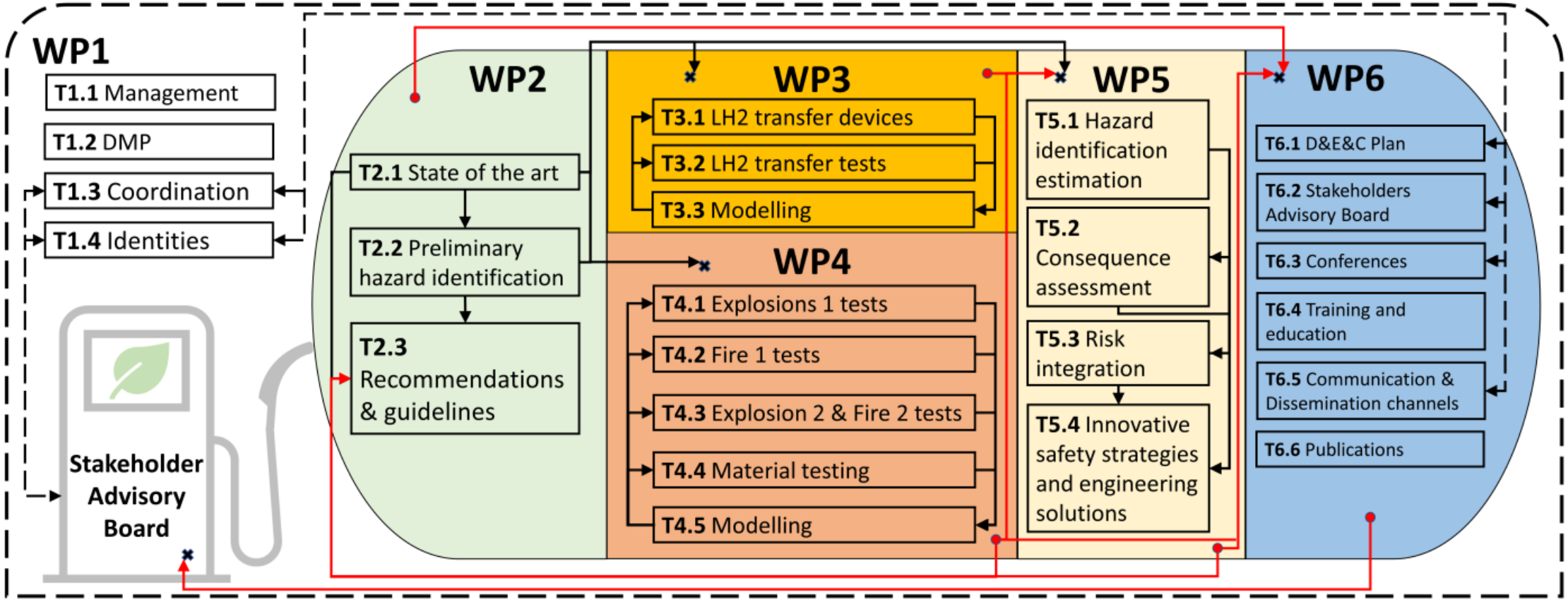
- **STACY** - Towards Safe Storage and Transportation of Cryogenic Hydrogen (EIG Concert Japan, 2022-2026, coordinator: Ernst-Arndt Reinecke, Julich, Germany)
- **MF Hydra** (LH2 ferry, Norway, Norled)
- **ESKHYMO** - Enhance Safety Knowledge for Hydrogen Measurements/Modelling in cryOgenic phase (France, 2022-2026, coordinator: Etienne Havret, CEA, France)

ELVHYS – Collaboration with other projects

Intention to establish collaborations with other projects related to LH2 and cryogenic hydrogen transfer and storage

- **e-SHyIPS** - Define the new guidelines for an effective introduction of hydrogen in maritime passenger transport sector (Horizon Europe, coordinator: Brendan Patrick Sullivan, Politecnico of Milano, Italy)
- **sHYpS -** Sustainable Hydrogen Powered Shipping (EU, coordinator (Horizon Europe, 2022-26, coordinator: Pierluigi Busetto, NAVAL PROGETTI, Italy)

ELVHYS – Work Plan



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ELVHYS – Work Plan

Work Packages

- WP1 - Project Management and Coordination
- WP2 - From industrial background and strategy to findings application
- WP3 - Cryogenic hydrogen transfer facilities performance
- WP4 - Fires and explosions from cryogenic hydrogen transfer facilities
- WP5 - Risk Analysis for selected cryogenic hydrogen transferring operations
- WP6 - Dissemination, exploitation and communication

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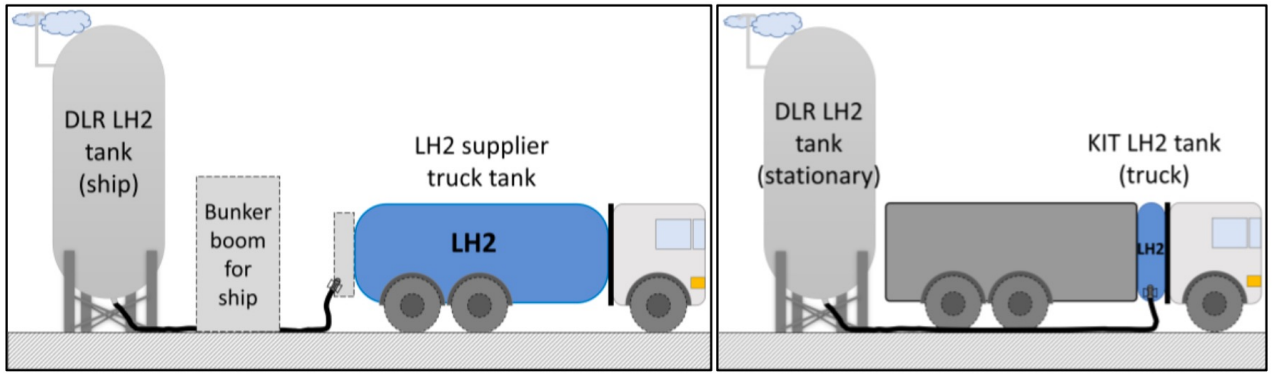
ELVHYS – Tasks

WP3 - Cryogenic hydrogen transfer facilities performance

- **Task 3.1** - LH2 transfer devices definition
- **Task 3.2** - LH2 transfer tests: bunkering, fuelling, refuelling, defueling
- **Task 3.3** - Support by theoretical and numerical studies for experimental setup, and numerical experiments to formulate cryogenic hydrogen transfer protocols



Tests will be carried out by DLR

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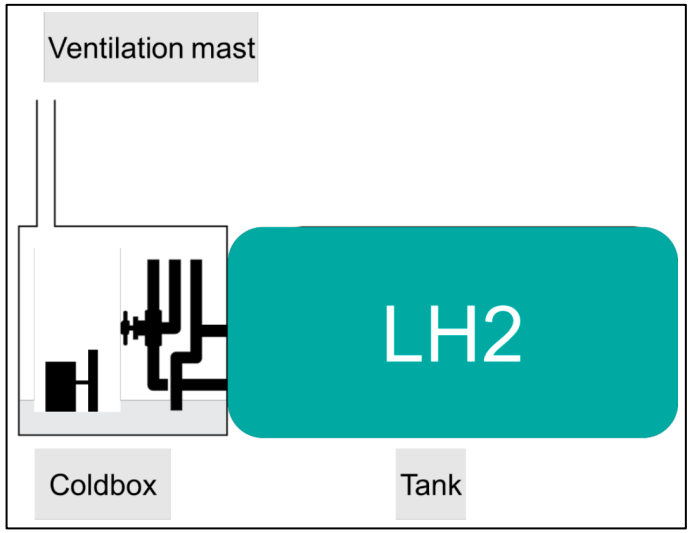
ELVHYS – Tasks

WP4 - Fires and explosions from cryogenic hydrogen transfer facilities

- **Task 4.1** – Oxygen enrichment and condensed phase explosions
- **Task 4.2** – Leakage into cold room/tank connection space considering barriers and obstacles



DNV test (Aaneby et al., 2021)

HSE test (Hooker et al., 2012)

Tests will be carried out by HSE

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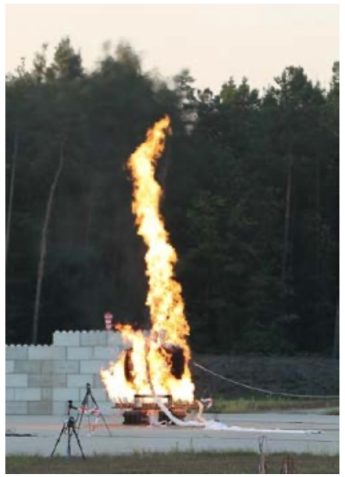
ELVHYS – Tasks

WP4 - Fires and explosions from cryogenic hydrogen transfer facilities

- **Task 4.3** – Performance of LH2 components and explosion consequences
- **Task 4.4** – Material testing against unignited and ignited jets (MLI, glass spheres, perlite layers and fire protecting wall) according to ISO 20088
- **Task 4.5** – Modelling in support of and utilising WP4 experimental activities

Tests will be carried out by KIT



SH2IFT test (Ødegård et al., 2022)

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ELVHYS – Tasks

WP5 - Risk Analysis for selected cryogenic hydrogen transferring operations

- **Task 5.1** – Hazard identification and damage state estimation
  - Sub-Task: 5.1.1 Hazard identification
  - Sub-Task: 5.1.2 Damage state of the installation resulting in the release of hydrogen
- **Task 5.2** – Consequence assessment
  - Sub-Task: 5.2.1 Modelling of accidental phenomena
  - Sub-Task 5.2.2: Vulnerability assessment
- **Task 5.3** – Frequency assessment and risk integration
  - Sub-Task: 5.3.1 Frequency of incident occurrence
  - Sub-Task: 5.3.2 Risk integration
- **Task 5.4** – Innovative safety strategies and engineering solutions
  - Sub-Task: 5.4.1 Safety barriers
  - Sub-Task: 5.4.2 Safety zoning strategies

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Thank you for your attention

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