Annual data reporting for the Clean Hydrogen JU

D1.5 - Public

HyPowerGT – Demonstrating a hydrogen-powered gas turbine engine fuelled with up to 100% H_2

Version 01 – Date 24/02/2025

Abstract

This deliverable contains the information to be submitted in the 2025 Annual data reporting exercise for the Clean Hydrogen Joint Undertaking (CHJU).

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Executive Summary

The HyPowerGT is founded through the Clean Hydrogen Partnership and as a part of it, it is required to report annually in terms of technology progress and contribution towards the CHJU targets, objectives and indicators described in the SRIA. The reporting is managed by the Clean Hydrogen Joint Undertaking throughout the duration of the Horizon Europe and is happening in the Clean Hydrogen Knowledge Hub platform. The information is submitted by default as public, but the projects can request for certain fields to be considered as "confidential" except for the fields that constitute or directly inform KPIs of the Clean Hydrogen JU.

The input provided via the reporting is used for the annual Program Review and will constitutes the basis information provided to the Programme Review Report for 2025. Based on this information selected projects will be invited to present their progress on the Innovation Forum (November 2025).

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Nonmenclature / List of abbreviations

Term/Acronym, Abbreviations	Explanation
CHJU	Clean Hydrogen Joint Undertaking
CHP	Combined heat and power
DLE	Dry Low-emissions
DNS	Direct numerical simulation
EU	European Union
FMECA	Failure mode effects and criticality analysis
GT	Gas Trurbine
HSE	Health, Safety & Enviromment
IPR	Intellectual Property Rights
NG	Natural Gas
NOx	Nitric Oxide
OpenAIRE	Open Access Infrastructure for Research in Europe
PUB	Public
SRIA	Strategic Research and Innovation Agenda
TRL	Technology Readiness Level

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1. Introduction on information for reporting

The information to be submitted in the CH Knowledge Hub is summarized below. The information is filled in on the Clean Hydrogen Knowledge Hub platform and required under respective tabs. Part of the information it is automatically recalled from the "*Continuous reporting*" in EU Funding & Tenders Portal, as for the following tabs: Project Overview and Progress.

In the Project targets tab, the following project targets are already appointed to the HyPowerGT project by CHJU.

In the information for Posters tab, we provide information for the one-page poster of the Programme Review Report 2025, for the HyPowerGT project.

For the Technology KPI Monitoring tab, respective Research Object (RO) were appointed to the project, described as Dissemination, Results and Safety. The reporting under each RO is happening concerning predefined parameters (descriptive and operational) by the CHJU. Some of the information provided it in the operational parameters, is to be kept confidential, see the respective screenshots in *subsection 1.5*.

Below it is summarized the information provided for the respective tabs, given in subsections for each of them.

1.1. Project overview

To fulfil commitments to CO_2-free power generation and to achieve EU independency from external energy resources (REPowerEU), significant advancement for both gas turbines combustion systems and gas turbine industrialisation are necessary that enable decarbonising power generated by gas turbines while increasing thermal and mechanical efficiency by adopting cogeneration systems The HyPowerGT project aims at moving technological frontiers to enable gas turbines to operate on hydrogen without dilution. The core technology is a novel dry-low emission combustion technology (DLE H_2) capable of handling mixtures of natural gas and hydrogen with concentrations up to 100% H_2. The combustion technology has been successfully validated at TRL5 (early 2021) retrofitted on the combustion system of a 13 MWe industrial gas turbine. Besides ensuring low emissions and high efficiency, the DLE H_2 combustion technology offers fuel flexibility and response capability on a par with modern gas turbine engines fired with natural gas. The new technology will be fully retrofittable to existing gas turbines, thereby providing opportunities for refurbishing existing assets in industry (CHP) and offering new capacities in the power sector for load levelling the grid system (unregulated power) and for mechanical drives. The DLE H_2 technology adheres to the strictest specifications for fuel flexibility, NOx emissions, ramp-up rate, and safety, stated in the Strategic Research and Innovation Agenda 2021-2027. Three main objectives were stated for the project. Objective 1 aims at providing a safe and

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efficient low-emission H_2 combustion system retrofittable to gas turbine engines in the 10-20 MWe class. The project shall provide a novel dry-low emission hydrogen combustion system (DLE H_2) retrofittable to gas turbines in the 10-20 MWe class, aimed at offering response power to stabilise and increase the reliability of the electrical energy system. Emphasis is placed on the ability to retrofit the existing heat and power generation systems with gas turbines capable of operating with up to 100% hydrogen, while guaranteeing high efficiency, low NOx emissions, and operational flexibility at the level of typical values obtained under conditions similar to those of natural gas combustion, pursuant to the call. To achieve objective 1, results will include dedicated studies on concepts concerning safety issues and plant integration enabling operations of the retrofit gas turbine unit with up to 100% hydrogen, documented availability of a gas turbine prototype equipped with the DLE H_2 system and availability of required amounts of hydrogen to conduct the engine test campaign, a report on detailed simulations aimed at defining the expected performances of a cogeneration system including durability of the gas turbine and adequate retrofittability of the DLE H_2 combustion system of existing gas turbines in the 10-20 MWe class properly demonstrated and justified Objective 2 is related to demonstrating operating capabilities of a simple-cycle gas turbine at full operating conditions with fuel compositions admixed with hydrogen up to 100% H_2. The key-enabling technology will first be refined and demonstrated in relevant environment at TRL6. Then a system demonstrator will be planned, developed, and built into an operational environment, and subsequently demonstrated at TRL7. This endeavour will require at least 60 aggregated fired hours, and the following characteristics of the system will be concluded and documented, with firm reference to specific targets of the key-performance indicators stated in the grant agreement. Emphasis is placed on (a) gas turbine flexibility, (b) content of hydrogen fuel during the start-up phase, (c) ability to operate at varying hydrogen content, (d) minimum ramp speed, and (e) proper safety level with regard to related systems and applications. Objective 3 aims to present pathways for decarbonised power generation through retrofits and up

1.2. Project targets

For the already appointed project targets, the HyPowerGT reports with “work in progress” for all the given targets.

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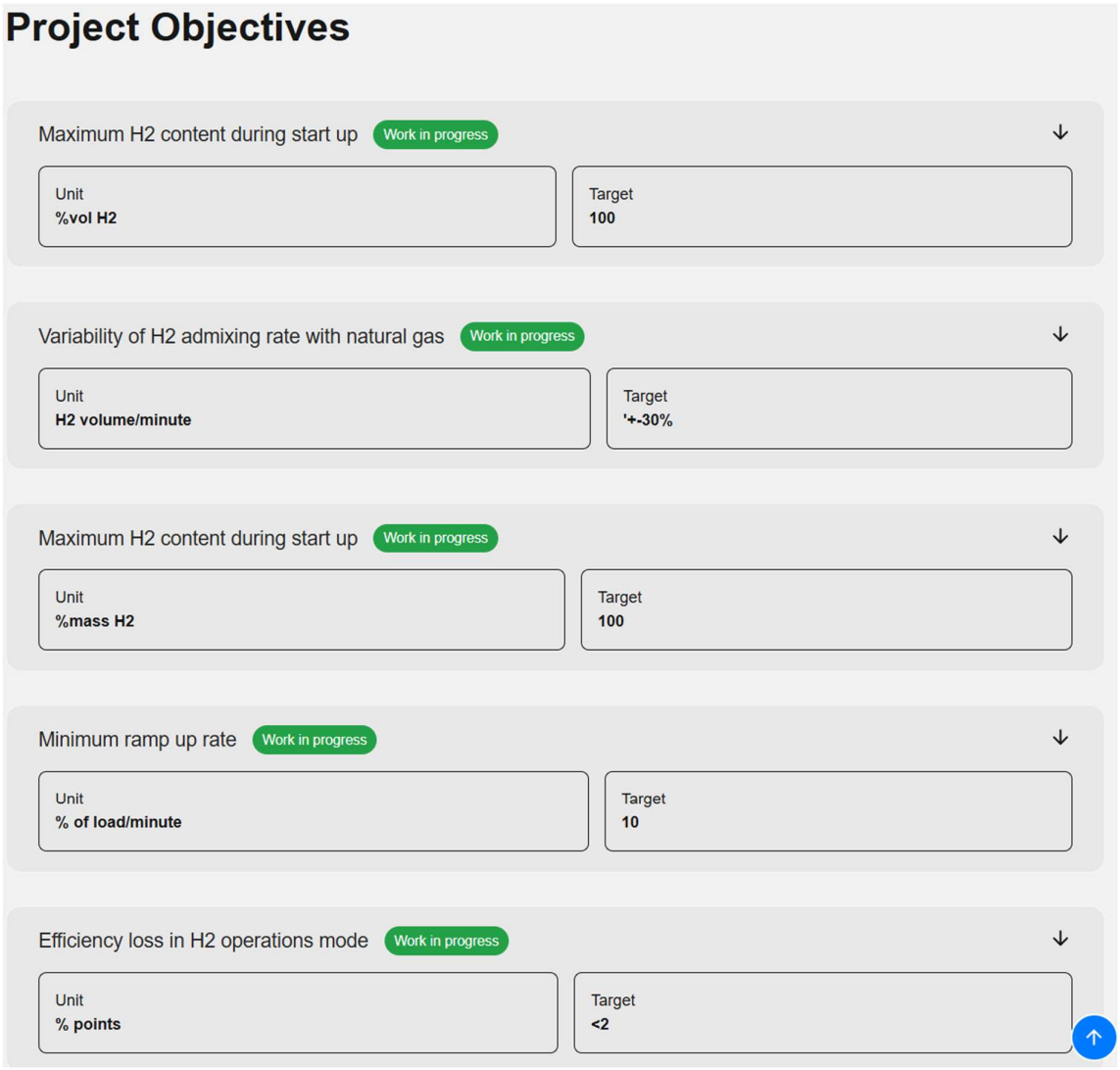

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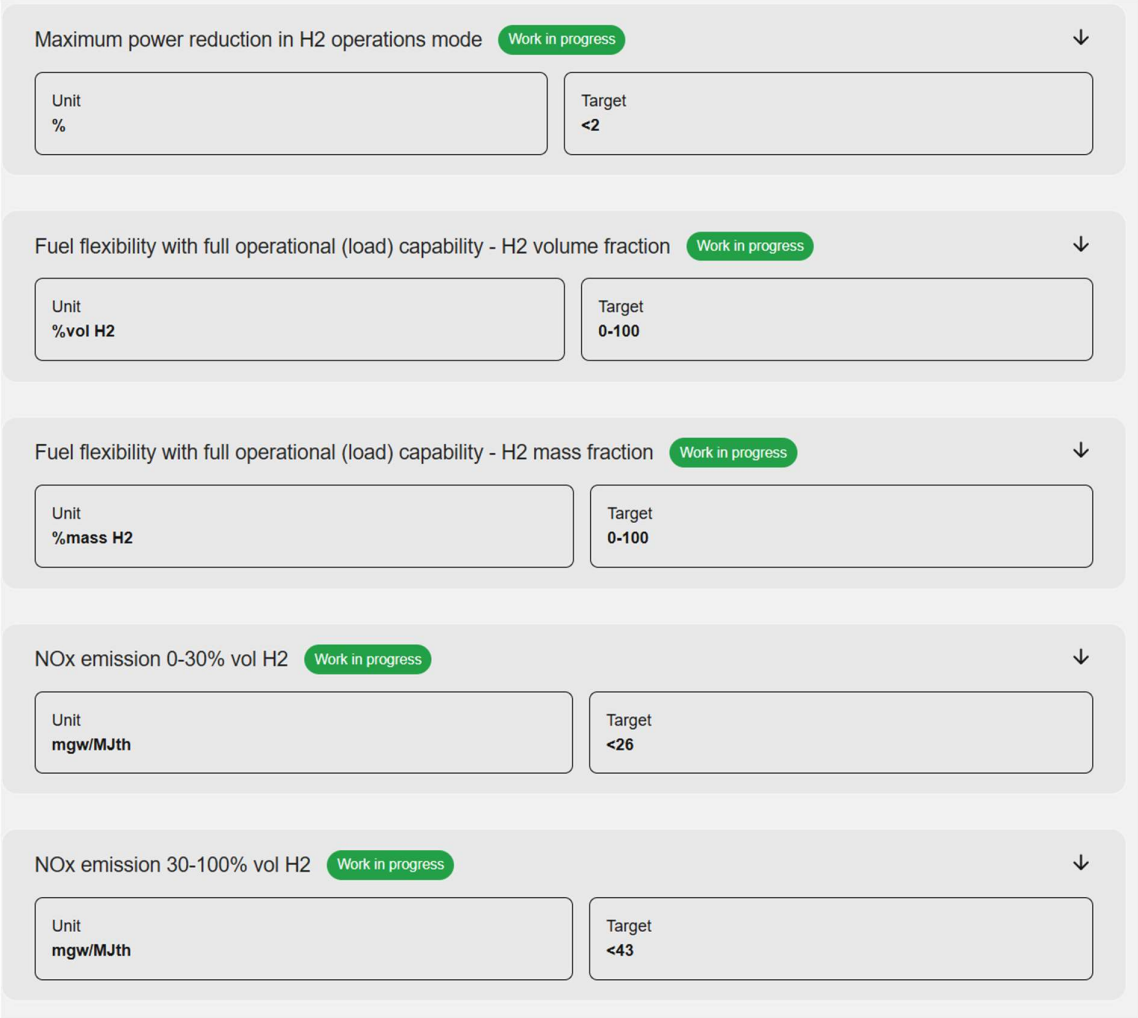

1.3. Progress

Project Context and General Objectives

The HyPowerGT project aims at moving technological frontiers to enable gas turbines to operate on hydrogen without dilution. The core technology is a novel dry-low emission combustion technology (DLE H_2) capable of handling mixtures of natural gas and hydrogen with concentrations up to 100% H_2. The combustion technology has been successfully validated at TRL5 (early 2021) retrofitted on the combustion system of a 13 MWe industrial gas turbine (NovaLT12). Besides ensuring low emissions and high efficiency, the DLE H_2 combustion technology offers fuel flexibility and response capability on a par with modern gas turbine engines fired with natural gas.

The new technology will be fully retrofittable to existing gas turbines, thereby providing opportunities for refurbishing existing assets in industry (CHP) and offering new capacities in the power sector for load levelling the grid system (unregulated power) and for mechanical

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drives. The DLE H_2 technology adheres to the strictest specifications for fuel flexibility, NOx emissions, ramp-up rate, and safety, stated in the Strategic Research and Innovation Agenda 2021-2027.
The new DLE H_2 combustion technology will be further refined and matured and, towards the end of the project, demonstrated at TRL7 on a 16.9 MWe gas turbine engine (NovaLT16) fired with fuel blends mixed with hydrogen from 0-100% H_2. Within this wide range, emphasis is placed on meeting pre-set targets for (a) fuel flexibility and handling capabilities, (b) concentration of hydrogen fuel during the start-up phase, (c) ability to operate at varying hydrogen contents, (d) minimum ramp speed, and (e) safety aspects pertaining to any level with regard to related systems and applications targeting industrial gas turbine engines in the 10-20 MWe class.
A digital twin will be developed to simulate performance and durability characteristics, emulating cyclic operations of a real cogeneration plant in the Italian paper industry. Three main objectives are targeted:

1.)To provide a safe and efficient low-emission H_2 combustion system retrofittable to gas turbine engines in the 10-20 MWe class: The project shall provide a novel dry-low emission hydrogen combustion system (DLE H_2) retrofittable to gas turbines in the 10-20 MWe class, aimed at offering response power to stabilise and increase the reliability of the electrical energy system.
Emphasis is placed on the ability to retrofit the existing heat and power generation systems with gas turbines capable of operating with up to 100% hydrogen, while guaranteeing high efficiency, low NOx emissions, and operational flexibility at the level of typical values obtained under conditions similar to those of natural gas combustion, pursuant to the call.

2.) To demonstrate operating capabilities of a simple-cycle gas turbine at full operating conditions with fuel compositions admixed with hydrogen up to 100% H_2: The key-enabling technology will first be refined and demonstrated in relevant environment at TRL6. Then a system demonstrator will be planned, developed, and built into an operational environment, and subsequently demonstrated at TRL7. This endeavour will require at least 60 aggregated fired hours, and the following characteristics of the system will be concluded and documented, with firm reference to specific targets of the key-performance indicators. Emphasis is placed on (a) gas turbine flexibility, (b) content of hydrogen fuel during the start-up phase, (c) ability to operate at varying hydrogen content, (d) minimum ramp speed, and (e) proper safety level with regard to related systems and applications.

3.) To present pathways for decarbonised power generation through retrofits and uptake of project's results: The project will present credible ways as to how the project's results can best be utilised - both commercially and economically. The work includes assessment of the methods used, transferability of the results to other gas turbine types and brands, as well as evaluation of the retrofit market.

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Work Performed

WP1: Project execution tools in place to facilitate the project implementation and internal financial and technical reporting.

WP2: DNS simulations performed, increasing robustness of burning-rate scaling and improving flashback model predictions. Designs for experimental setup were completed and purchase order developed.

WP3: TRL 6 test campaign instrumentation and rig refurbishment on track for demonstration tests at the end of 2025.

WP4: Established HSE procedures and safety plan, preliminary De-risking simulations of H_2 operated GT performed, FMECA workshop.

WP5: Road mapping work for positioning H_2 gas turbines towards the European energy transition initiated.

WP6: Dissemination material prepared including website, social media profile and the project was already featured and promoted at international conferences and other meetings

Progress beyond state of the art, expected results until end of the projects and potential impacts

Pushing technological frontiers is a demanding task. It is particularly demanding when dealing with hot, pressurised, reactive systems with exceedingly high energy density, as is the case with gas turbines. It is even more difficult when the fuel involves hydrogen in NG/H_2 mixtures where the hydrogen fraction comes close to 100% H_2, because, as already pointed out, even with a 90% vol mixing of H_2, only half of the mass flow is hydrogen. Moving the boundaries towards 100% hydrogen is thus an enormous challenge that requires profound understanding of several phenomenological aspects that each in their own way affect materials structural integrity, turbulent reactive flow conditions, heat of reaction, heat transfer, and combustion system stability, and which are affected by operating conditions via a most complex interaction between these phenomena.

The expected results and the related impacts are:

1.) Result: Resilient, retrofittable combustion system enabling gas turbine operations with hydrogen admixed with natural gas up to 100% H_2. Significant response power in unit size up to 20 MWe to deliver dispatchable power on demand Reduced European dependency on fossil fuels from the 2030s to 2050
Impact: Retrofitting the DLE H_2 technology demonstrated, TRL7 Decarbonising the power system possible via H_2 GTs
Fulfilling goals under SRIA Pillar 3.2 and the Green Deal justified (on grid and CHP) European independence from fossil fuels ensured by 2050

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2.) Result: Technology demonstrated at TRL7 of DLE H_2 combustion system with 0-100% H_2, without compromising load, efficiency, and response, while meeting emission targets without diluents Pre-normative industrial safety standards for gas turbine operations in industry with 100% H_2 including retrofitting with DLE H_2 technology
Impact: Carbon-free el-power via hydrogen for load levelling of unregulated electric power Visibility for clean energy solutions fuelled with 100% H_2 aligned with the REPowerEU strategy with 20 Mtpa of H_2 deployed by 2030

3.) Result: Technology roadmap with structural plans as to how the outcome of the project can best be positioned to achieve the stated impact goals, aligned with the EU Green Deal and the JU SRIA 2021-2027 Pillar 3.2
Impact: Visibility for future markets and pathways towards impacts Emphasis placed on retrofit markets in industry (CHP), other opportunities, and new capacities Political issues raised and/or resolved based on project results.

1.4. Information for Posters

Project and general objectives

The HyPowerGT project aims at moving technological frontiers to enable gas turbines to operate on hydrogen without dilution. The core technology is a novel dry-low emission combustion technology (DLE H_2) capable of handling mixtures of natural gas and hydrogen with concentrations up to 100% H_2. The combustion technology has been successfully validated at TRL5 (early 2021) retrofitted on the combustion system of a 13 MWe industrial gas turbine (NovaLT12). Besides ensuring low emissions and high efficiency, the DLE H_2 combustion technology offers fuel flexibility and response capability on a par with modern gas turbine engines fired with natural gas.

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hydrogen contents, (d) minimum ramp speed, and (e) safety aspects pertaining to any level with regard to related systems and applications targeting industrial gas turbine engines in the 10-20 MWe class.

A digital twin will be developed to simulate performance and durability characteristics, emulating cyclic operations of a real cogeneration plant in the Italian paper industry.

Non-quantitative Objectives

1.)To provide a safe and efficient low-emission H_2 combustion system retrofittable to gas turbine engines in the 10-20 MWe class: The project shall provide a novel dry-low emission hydrogen combustion system (DLE H_2) retrofittable to gas turbines in the 10-20 MWe class, aimed at offering response power to stabilise and increase the reliability of the electrical energy system.
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3.) To present pathways for decarbonised power generation through retrofits and uptake of project's results: The project will present credible ways as to how the project's results can best be utilised - both commercially and economically. The work includes assessment of the methods used, transferability of the results to other gas turbine types and brands, as well as evaluation of the retrofit market.

Progress, main achievements and results

WP1: Project execution tools in place to facilitate the project implementation and internal financial and technical reporting.

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WP3: TRL 6 test campaign instrumentation and rig refurbishment on track for demonstration tests at the end of 2025.

WP4: Established HSE procedures and safety plan, preliminary De-risking simulations of H_2 operated GT performed, FMECA workshop.

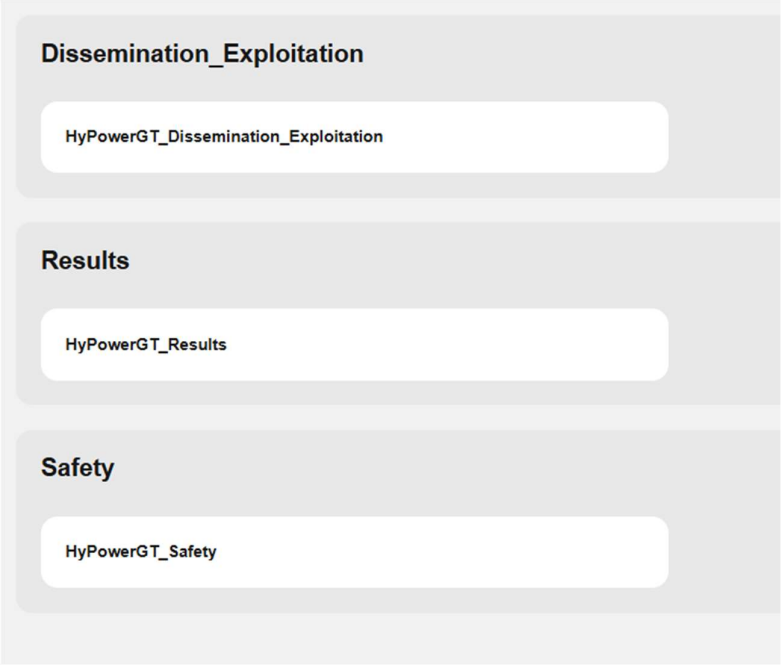
WP5: Road mapping work for positioning H_2 gas turbines towards the European energy transition initiated.

WP6: Dissemination material prepared including website, social media profile and the project was already featured and promoted at international conferences and other meetings

Future steps and plans

- TRL 6 Demonstration tests at the end of 2025
- Monitoring the safety engineering of the test campaigns and application of available models and tools for risk assessment
- Strengthen cooperation with sister projects

1.5. Technology KPI Monitoring



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Dissemination - Operational parameters

Parameter	Description	Value (2024)	Visibility (2024)
Business Model / Plan - Market Survey	Based on the results of the project, was any business model or plan developed or any market survey performed within the timeframe of this data collection exercise	No	Public
Dealflow	Did the project use any type of support provided through the Dealflow platform	No	Public
Delivered Dissemination Activities	How many of the planned dissemination activities delivered within the timeframe of this data collection exercise	9	Public
Did the project perform any other exploitation activities not mentioned above within the timeframe of this data collection exercise		Yes	Public
Did the project use any of the services provided by the Standardisation Booster		No	Public
Dissemination Activities in total	How many dissemination activities performed since the beginning of the project	9	Public
Dissemination Activities within the timeframe of this data collection exercise	How many dissemination activities performed within the timeframe of this data collection exercise	9	Public
Do End Users exist?	Was there any exploitation activities towards end users	No	Public
Education & Training Activities	How many education and training activities performed by the project within the timeframe of this data collection exercise	0	Public
EU Institutions / Policy Makers	How many dissemination activities targeted the EU Institutions or other policy makers within the timeframe of this data collection exercise	0	Public
Exploitation Activities performed within the timeframe of this data collection exercise	How many exploitation activities performed within the timeframe of this data collection exercise	1	Public
Horizon Results Booster	Did the project use any of the services provided by the Horizon Results Booster	No	Public
Horizon Results Platform	Did the project submit the exploitable results to the Horizon Results Platform	No	Public
Industry/Business Partners (dissemination activities)	How many dissemination activities targeted industrial or business partners last year	6-10	Public
Industry/Business Partners (exploitation activities)	Was there any exploitation activities towards industry/business partners	No	Public
Innovation Radar	Had any of the results been analysed by the Innovation Radar	No	Public
Innovators	Was there any exploitation activities towards innovators	No	Public
IPR Activities within the timeframe of this data collection exercise	Any intellectual property activities performed within the timeframe of this data collection exercise	Yes	Public
IPR-related Issues	Was the project implementation hindered due to IPR-related issues	No	Public
Lack of Financing	Was the project implementation hindered due to lack of financing	No	Public
Lack of Labor Skills	Was the project implementation hindered due to lack of labor skills	No	Public
Lack of Regulation, Codes or Standards	Was the project implementation hindered due to lack of regulations, codes or standards	No	Public
Meetings with stakeholders	In how many meetings did the project arranged/participated to disseminate the results within the timeframe of this data collection exercise	6	Public
On-going Dissemination Activities	How many of the planned dissemination activities are still on-going	0	Public
OpenAIRE_platform	Did the project participate in the open science platform OpenAIRE?	No	Public
Other Audience		Yes	Public
Other Dissemination Activities	Are there any other dissemination of results activities not included above within the timeframe of this data collection exercise	0	Public

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Other Exploitation Activities_	Please elaborate on any other exploitation activities within the timeframe of this data collection exercise	No.	Public
Other reasons	Was the project implementation hindered due to other reasons not included above	No.	Public
Other sources	Did the project use any type of support provided through any other source?	Support for dissemination activities was provided by ETN platforms (Hydrogen Working Group).	Public
Other Target Audiences	How many dissemination activities targeted other audiences not included above within the timeframe of this data collection exercise	0	Public
Patent Application	Did the project file/was granted with a patent within the timeframe of this data collection exercise	No	Public
Peer-Reviewed Scientific Publications	How many peer-reviewed scientific publications made within the timeframe of this data collection exercise	0	Public
Peer-Reviewed Scientific Publications in Open Research Europe	How many peer-reviewed scientific publications made within the timeframe of this data collection exercise published through the Open Research Europe platform	0	Public
Postponed or Cancelled Dissemination Activities	How many of the planned dissemination activities were postponed or cancelled within the timeframe of this data collection exercise	0	Public
Potential Investors / Users	Did the project manage to successfully promote the results to potential investors to upscale commercial production or to users communities (researchers or end users) within the timeframe of this data collection exercise	Yes	Public
Presentation of results in conferences, events and workshops	How many presentation of the results of the project were performed in conferences, events and workshops within the timeframe of this data collection exercise	6	Public
Research Communities	Was there any exploitation activities towards research communities	No	Public
Scientific/Research Communities	How many dissemination activities targeted the scientific/research communities within the timeframe of this data collection exercise	7	Public
Society / Specific End-Users Communities	How many dissemination activities targeted society or specific end-users communities within the timeframe of this data collection exercise	1-2	Public
Standardisation Bodies (dissemination activities)	How many dissemination activities targeted the standardisation bodies last year	0	Public
Standardisation Bodies (exploitation activities)	Was there any exploitation activities towards standardisation bodies	No	Public
Steps towards standardisation	Did any of the results participate/contribute in new regulations, codes or standards within the timeframe of this data collection exercise	No	Public
Trade Issues	Was the project implementation hindered due to trade issues	No	Public
Updated/revised D&E plan	Does the project have an updated/revised D&E plan?	Yes	Public
Was there any exploitation activities towards standardisation bodies		No	Public

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The HyPowerGT project is supported by the Clean Hydrogen Partnership and its members (GA 101136656) and the Swiss Federal Department of Economic Affairs, Education and Research, State Secretariat for Education, Research and Innovation (SERI).

Safety - Operational parameters

Description	Input	Value (2024)	Visibility (2024)
Please describe whether there are major gas companies involved, whether there is a long term experience with handling of hydrogen or flammable gases, or the whole consortium including those partners directly handling or designing the hydrogen system are new to the technology.	×	A list of safety experts working on the project has been provided as part of the draft safety plan.	Public
Please provide an average rate of the hydrogen produced or consumed. In the case of a batch/ storage container solution may be easily derived by multiplying inventory of the previous question by the number of refills/ discharges per month	×	<10 g/month	Restricted
Please indicate if the project reported, or has any outstanding hydrogen-related event to be reported, in the Hydrogen Event and Lesson LEarNed (HELLEN) database or the HIAD database	×	Other	Public
Pressure [bar] x Volume [liter], Please provide the conditions of the Hydrogen inventory within the project. Please do this equally for compressed, liquid and solid storage and finally sum up contributions from storage at different pressure level)	×	<100 bar litre	Restricted
Please indicate if the project has had any hydrogen-related event (near-miss, incident, accident) in the reference period	×	no events	Public
Please describe whether you have a safety officer named in the project, whether you have developed and you are maintaining a safety plan; do you have established educational and training measures addressing safety issues; do you report any mishaps and derive lessons learnt; do you build on pre-existing knowledge or experts available within or outside the consortium; do you consider to involve the EHSP	×	A general safety management plan is regularly compiled and reviewed. single safety plans for each campaign (3 in total) have also been developed, monitored and reviewed regularly and will be continued during project duration.	Public
Please provide the maximum mass of Hydrogen inventory. In case of several sites with hydrogen within the project please provide an indicative figure per relevant location in the comment box	×	>100 kg	Restricted
Please indicate the number of outstanding hydrogen-related events reported, in the Hydrogen Event and Lesson LEarNed (HELLEN) database or the HIAD database in the reference period	×	0	Public
Please indicate the project public visibility or the impact of a potential accident	×	High	Restricted
Number of safety workshops (e.g. on research priorities, risk assessment, end-use safety, etc.)	✓	1	Public
Please select the type of location with the presence of hydrogen	×	Research in industry lab	Restricted

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