D6.9 Annual Data Reporting for the Clean Hydrogen JU - 2025

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Project Acronym	AMON
Project Title	Development of a next generation AMmONia FC system
Type	HORIZON JU Research and Innovation Actions
Project Coordinator	Matteo Testi (FBK)
Project Duration	January 1, 2023 – March 31, 2027 (51 Months)
Deliverable No.	D6.9
Dissemination Level	PU
Work Package	WP6 – Project Management
Task	T6.7 KPI Reporting
Lead beneficiary	1 (FBK)
Contributing beneficiary(ies)	-
Due date of deliverable	31 March 2025 (M27)
Actual submission date	20 May 2025

History of Changes

Revision Version	Date	Changes	Changes made by (Partner)
1.0	Feb 2025	Submission of data in the Knowledge Database of the JU	Ilaria Alberti (FBK)
2.0	20.04.2025	First draft	Ilaria Alberti (FBK)
3.0	19.05.2025	Changes in stationary values. Final draft, following data approval on the platform	Dario Montinaro (SE), Sookyung Kang (FBK)

Table of Content

Introduction

Data Collection is part of the Annual Knowledge Management activities of the Clean Hydrogen JU, whose goal is to become the European Hydrogen Knowledge Hub, serving the entire hydrogen community.

This deliverable reports the data uploaded in the platform by the AMON partners in February 2025 and focuses on the Technology KPI Monitoring tabs.

The four research objects to be submitted with regards to AMON were (i) D&E activities, (ii) Results, (iii) Safety and (iv) Stationary.

01. AMON Objectives

AMON project aims at developing a novel system for the utilization and conversion of Ammonia into electric power at high efficiency using a solid oxide fuel cell.

The project will deal with the design of the basic components of the system including the fuel cell, an ammonia burner, ammonia resistant heat exchangers, the engineering of the whole Balance of Plants, and validation of the compliance with ammonia use for all the specific parts and components. Optionally, depending on system needs, an ammonia cracker and anode gas recirculation will be developed.

High temperature electrolysers have demonstrated in several activities the capacity to outreach high performances in lab scale prototypes and validation tests. The project will deal with the design of the basic components of the system including the fuel cell, the ammonia cracker, the ammonia burner and an anode gas recirculation, the engineering of the whole Balance of Plants, and the validation of the compliance with ammonia use for all the specific parts and components.

For the development of the solid oxide fuel cell, a G8X cell from SolydEra will be utilized, first validated in a laboratory at the level of single cells, for electrochemical properties, degradation and post-mortem analysis, at the level of single repeating units for the validation of interconnects and sealing components, and at the level of stacks and stack modules.

An overall Ammonia fuel cell system will be engineered and manufactured to be tested in a relevant environment in a port area. The final system will be the size of 8 kW stack module, with an ammonia cracker and a heat management system. It will aim at an overall electrical efficiency in the range of 70%. AMON will be supported alongside the engineering by horizontal strategic support on critical and open issues involving use of Ammonia with fuel cells, such as safety assessment, on techno-economic analysis, on modelling at multiscale and multiphysic levels, to consolidate, confirm and direct the engineering of the technology.

Despite the small pilot demonstration scale, AMON will propose scaled engineering for a system suitable to be applied in end uses such as ports, maritime environment, besides autonomous power systems. AMON will promote the use of Ammonia as a hydrogen carrier, to enhance the flexibility of the energy system.

Economic and Social Objectives

01. Diversification and security of energy supply
02. Unlock wide markets potential and foster efficient conversion systems to decarbonize hard-to-abate sectors such as maritime, autonomous power systems, where volumetric density and long-term storage solutions are key requirements.
03. Raise industrial interest in ammonia and foster the development of new markets and new jobs.

Scientific Objectives

01. Design and develop a fuel cell stack module at a scale of 8 kWel, tested and qualified to convert ammonia into power, possibly using the internal reforming capacity of a solid oxide cell operating at high temperature and managing the power output through the control of the cell fuel utilization.
02. Qualify a system 100% tolerant to ammonia in all the components and related materials
03. Target 70% system electric efficiency
04. Qualify the system for at least 3000 hrs operation with demonstrated 90% availability in the operating hours and less than 3% degradation rate at nominal power condition measured over 1000 hours of continuous operation.

Scientific objectives are the source for the AMON targets, which are reported in the following figure.

PROJECT TARGETS

Target source	Parameter	Unit	Target
Project's own objectives	Partial load operation	% of nominal load	Dynamic range of operation for 30–100 % of nominal load
	FC system tolerance to ammonia	%	System fed by 100 % ammonia as fuel
	Degradation at CI and FU = 75 %	%/1 000 h	≤ 2.5
	Efficiency	%	70–65
	Availability	%	> 90
SRIA (2021–2027)	CAPEX 5–50 kWe	€/kW	5 000

Figure 1 AMON Project Targets. Source: Clean Hydrogen JU, Programme Review Report 2024.

02. JU Data Knowledge

Data Collection is part of the Annual Knowledge Management activities of the Clean Hydrogen JU, whose goal is to become the European Hydrogen Knowledge Hub, serving the entire hydrogen community.

The collection exercise is strictly linked to the Annual Programme Review and the Programme KPIs monitoring. Therefore, it aims to monitor technology progress and identify how each of the projects contributes to the Clean Hydrogen JU targets, objectives and indicators described in the SRIA. The review is important also to give inputs into topic definition for new calls for proposals, as well as to highlight the achievements and results and give feedback to policy.

Since 2019, the methodology to collect data has evolved several times. In 2025 a Knowledge Hub was created which includes all the main information of the project, its targets and its progress.

The main sections which also needs to be continuously updated are:

- Information for poster, which needs to be published yearly in the Programme Review Report
- Scientific publications
- Technology KPI Monitoring tabs, which is the focus of this deliverable and reports the data uploaded in the platform by the AMON partners in February 2025.

The four research objects to be submitted with regards to AMON were (i) D&E activities, (ii) Results, (iii) Safety and (iv) Stationary.

For each KPI there might be two types of parameters: descriptive and operations. *Descriptive parameters* define the item addressed, while *operational parameters* evolve according to the project.

03. KPIs Monitoring Tables

In this section, the tables for the four research objects will be included. The tables do not include all parameters but only those

- that do not include sensitive information, and
- for which AMON has available information for the year 2024.

Results

For each collection year (in this case, 2025), in the research object “Results”, the Consortium has to define the main result achieved in the previous year. FBK in collaboration with DTU decided to include the Design of an Ammonia Solid Oxide Fuel Cell.

Considering the sensitivity of information, the table will not be reported. However, we can report that the parameters were related to the market maturity of the result, the expected time to impact and the major difficulties encountered during the implementation phase.

Safety

The table was filled in by the project partner KIWA, in collaboration with all partners.

Descriptive parameters: The descriptive part focused on the presence of a Safety Management Plan, which is available.

Operational parameters:

Parameter	Description	Value	Period
Safety Workshops	Number of safety workshops (e.g. on research priorities, risk assessment, end-use safety, etc.)	10	2024
Type of project, "location"	Please select the type of location with the presence of hydrogen	Research in industry lab	2024
HELLEN or HIAD database event	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	No	2024
Incident/Event	Please indicate if the project has had any hydrogen-related event (near-miss, incident, accident) in the reference period	No events	2024
Public visibility, impact of a potential accident	Please indicate the project public visibility or the impact of a potential accident	Low	2024
Number of incidents/events	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	2024
Hydrogen Storage State	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)	<20.000 bar litre	2024
Average Hydrogen Consumption (or Production) Rate	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 kg/month	2024
Maximum Stored Hydrogen Inventory Mass	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	2024

D&E Activities

Parameter	Description	Value	Period
Peer-Reviewed Scientific Publications	How many peer-reviewed scientific publications made within the timeframe of this data collection exercise?	2	2024
Innovation Radar	Had any of the results been analysed by the Innovation Radar?	Yes	2024
Education & Training Activities	How many education and training activities performed by the project within the timeframe of this data collection exercise?	1	2024
Industry/Business Partners (dissemination activities)	How many dissemination activities targeted industrial or business partners last year?	3-5	2024
Lack of Regulation, Codes or Standards	Was the project implementation hindered due to lack of regulations, codes or standards?	Yes	2024
Standardisation Bodies (exploitation activities)	Was there any exploitation activities towards standardisation bodies?	Yes	2024
Dissemination Activities in total	How many dissemination activities performed since the beginning of the project?	121	2024
Do End Users exist?	Were there any exploitation activities towards end users?	Yes	2024
Dissemination Activities within the timeframe of this data collection exercise	How many dissemination activities performed within the timeframe of this data collection exercise?	60	2024
Was there any exploitation activities towards standardisation bodies		Yes	2024
Steps towards standardisation	Did any of the results participate/contribute in new regulations, codes or standards within the timeframe of this data collection exercise?	Yes	2024
Meetings with stakeholders	In how many meetings did the project arranged/participated to disseminate the results within the timeframe of this data collection exercise?	1	2024
Presentation of results in conferences, events and workshops	How many presentations of the results of the project were performed in conferences, events and workshops within the timeframe of this data collection exercise?	19	2024
On-going Dissemination Activities	How many of the planned dissemination activities are still on-going?	5	2024

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	2024
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	2024

Stationary

Descriptive parameters

Parameter	Description	Value	Accessibility
Country	Country in which the unit/system/vehicle/vessel/railcar is located, or its licence plates are issued	Italy	public
Does the fuel cell system include a fuel reformer?	Please answer the question: yes if fuel is reformed into hydrogen before entering the fuel cell or no if the fuel is fed directly into the fuel cell	Yes	public
Electrical power of stacks	Electrical power of each of the stacks in the fuel cell system.	8 KW	public
End user	Please specify the type of end-user/customer that the fuel cell system is delivering energy to, e.g type of building, industry process, etc.	ports, industries, onboard shipping, off-grid stationary power systems	public
Fuel	Fuel used as feed into the m-CHP unit (e.g natural gas/LPG/others)	Ammonia	public
Fuel cell technology	Technology of the fuel cell studied	SOFC - solid oxide fuel cell	public
Hydrogen tolerance	Percent amount of hydrogen that can blended into the hydrocarbon feed (usually natural gas) allowing normal functioning of the fuel cell module.	100 % (volume)	public
Land use / footprint	Base surface (width x depth) occupied by the stationary fuel cell module per unit of rated electrical capacity.	1 m2/kW	public
Lifetime of the fuel cell system	Time (years) that the fuel cell system, with its major components/parts being replaced, if applicable (e.g stack), is able to operate until an End-of-Life. Please specify your End-of-Life criterion.	15 y	public
NOx emissions at rated conditions	Measured emissions of nitrogen oxides (NOx), expressed as mgNOx/kWh, where kWh refers to the energetic content of the fed fuel-LHV. For certified units, information should be provided based on standard DIN EN 50465; method used should be specified	0 mg/kWh	public

Number of stacks	Number of stacks used in the fuel cell system	1	public
Rated system electrical efficiency (LHV)	Electrical efficiency of the APU system, lower heating value, as rated by the manufacturer	70 %	public
Rated system thermal efficiency (LHV)	Thermal efficiency at the FC system rated capacity expressed as thermal output vs the energetic content of the fuel- LHV. For certified units, information should be provided based on standards to be specified in the comment field.	12 %	public
Stack manufacturer	Manufacturer of the stack(s)	SolydEra	public
Technology	Technology type of the fuel cell	SOFC	public

Operational parameters

Parameter	Description	Value	Accessibility
Availability	Percent amount of time that the h2 production unit/truck/bus/car/MHV/mchp/bunker was able to operate versus the overall time that it was intended to operate over the timeframe of this data collection exercise	99 %	public
Days of operation	Total number of days in which the system(s) operated (excluding downtime) within the timeframe of this data collection exercise (sum for all units). Count any day in which the system(s) operated for any amount of time.	0 days	public
Degradation @ CI & FU=75%, if SOFC	Stack degradation defined as percentage power loss when run starting at nominal rated power at BoL for fuel composition specified by stack manufacturer at constant current intensity (CI) and fuel utilisation (FU) of 75%. For example, 0.125%/1,000h results in 10% power loss over a 10-year lifespan with 8,000 operating hours per annum. Values are for steady state operation. Minimum test time = 3,000 hours, if SOFC	0.2 %/1,000h	public

Operational and maintenance costs (OPEX)	O&M costs per kWh of electricity produced - Including running, overhaul, repair, maintenance labour costs; excluding stack replacement cost, fuel cost, insurances, taxes, etc. Please describe what is included & provide an avg value of all installations.	0.0183 EUR/kWh	public
Reliability	Mean time between failure of the FC that render the system inoperable without maintenance or avg time between successive failures leading to downtime: time that the FC is not able to operate includes (un)scheduled maintenance, repairs, overhaul etc	n/a	public
Stack Durability	Stack durability before reaching end of life (EoL). Please specify what do you consider EoL as a percentage (%) of voltage decrease compared to BoL in the comment field; specify current density and other operating conditions including fuel/oxidant type and utilisation at which the percentage of voltage decrease is considered, the method of determining this percentage and provide the operation history of the stack as complete and detailed as possible	60000 h	public
System roundtrip electrical efficiency in reversible operation	Roundtrip electrical efficiency is energy discharged measured on the primary point of connection (POC) divided by the electric energy absorbed, measured on all the POC (primary and auxiliary), over one electrical energy storage system standard charging/discharging cycle in specified operating conditions. Only valid for rSOC systems	65 %	public
Warm start time	Time required to reach the nominal rated power output when starting the device from warm standby mode (system already at operating temperature).	10 min	public

AMMONIA TO POWER

Clean Hydrogen Partnership

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