ANNEX to GB decision no. CleanHydrogen-GB-2024-15

Clean Hydrogen JOINT UNDERTAKING (Clean Hydrogen JU)

WORK PROGRAMME 2025

Clean Hydrogen Partnership

In accordance with the Council Regulation (EU) 2021/2085 and with Article 33 of the Financial Rules of the Clean Hydrogen Joint Undertaking.

The work programme is made publicly available after its adoption by the Governing Board.

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Acronyms and abbreviations

AD	Administrator
AEL	Alkaline Electrolysis
AEMEL	Anion Exchange Membrane Electrolysis
AFIR	Alternative Fuel Infrastructure Regulation
AST	Assistant
AS-T	Accelerated-stress test
AWP	Annual Work Programme
BOA	Back Office Arrangements
BoP	Balance of Plant
CAS	Common Audit Services
CAPEX	Capital Up-front Expenditure (Investment)
CCM	Catalyst-coated membrane
CEF	Connecting Europe Facility
CEF-T	Connecting Europe Facility Transport
CEM	Clean Energy Ministerial
CEPT	Clean Energy Transition Partnership
CHP	Combined Heat and Power
CIC	Common Implementation Centre
CINEA	European Climate Infrastructure and Environment Executive Agency
CO_2	Carbon Dioxide
CRM	Critical Raw Materials
CRMA	Critical Raw Materials Act
CRMS	Critical Raw and Strategic Materials
CSA	Coordination and Support Actions
D&E	Dissemination and Exploitation
DG	Directorate General
DPO	Data Protection Officer
EC	European Commission, also shortened as Commission
ECA	European Court of Auditors
EFTA	European Free Trade Association
EHO	European Hydrogen Observatory
EHS&CP	European Hydrogen Sustainability and Circularity Panel
EHSP	European Hydrogen Safety Panel
EIB	European Investment Bank

ECH2A	European Clean Hydrogen Alliance
EIC	European Innovation Council
EISMEA	European Innovation Council and SMEs Executive Agency
ERA	European Research Area
ERDF	European Regional Development Fund
ETS	Emission trading system (also seen as EU ETS)
EU	European Union
EU ETS	EU Emission Trading System
EUR	Euro currency (€)
E-HRS- AS	European Hydrogen Refuelling Stations Availability System
EURATOM	European Atomic Energy Community
E&P	Exploration and Production
F2P	Feedback to Policy
FAQ	Frequently Asked Questions
FC	Fuel Cell
FCH	Fuel Cell and Hydrogen
FCH (2) JU	Fuel Cells and Hydrogen Joint Undertaking. FCH 2 JU (2014-2020/Horizon 2020) succeeded FCH JU (2008-2014/FP 7) [1]
FCS	Fuel Cell System
FID	Financial investment decision
FP	European Union's Framework Programmes for research and technological development. FP7 refers to the seventh programme (period 2007-2013), H2020 to the eighth (period 2014-2020), while Horizon Europe to the ninth (period 2021-2027).
FTE	Full-time equivalent
FWC	Framework Contract
GB	Governing Board
GDL	Gas diffusion layer
GHG	Greenhouse Gases
GO	Guarantees of Origin
GW	Gigawatt; GW_e refers to GW electric.
H_2	Hydrogen
H2020	Horizon 2020. European Union's Framework Programmes for research and technological development. H2020 refers to the eighth (period 2014-2020)
H2V	Hydrogen Valley
HDV	Heavy-Duty Vehicles

HE	Horizon Europe
HIAD	Hydrogen Incident and Accident Database
HR	Human Resources
HRS	Hydrogen Refuelling Station
HTCP	Hydrogen Technology Collaboration Programme
IA	Innovation Actions
IAS	Internal Audit Services
ICT	Information and Communications Technology
IDMS	Innovation and Document Management System
IEA	International Energy Agency
IPHE	International Partnership on hydrogen and fuel cells in the economy
IEC	International Electrochemical Commission
IKAA	In-kind Contribution for additional activities
IED 2.0	Industrial and Livestock Rearing Emissions Directive 2.0.
ILCD	International Reference Life Cycle Data System
IPCEI	Important projects of common European interest
IPHE	International Partnership for Hydrogen and Fuel Cells in the Economy
IP	Intellectual Property
IR	Innovation Radar
IPR	Intellectual Property Rights
IRENA	International Renewable Energy Agency
ISAA	Integrated Situational Awareness and Analysis
ISO	International Standardization Organization
IT	Information Technology
IWG	Implementation Working Group
JPP	Joint Procurement Plan
JRC	Joint Research Centre of the European Commission
JU	Joint Undertaking. For the scope of this document, when used as standalone, this acronym is used specifically to refer to the Clean Hydrogen Joint Undertaking. In all other instances or when not obvious the name Clean Hydrogen JU is used.
KPI	Key Performance Indicator
kW	Kilowatt; kW_{th} refers to kW thermal.
kWh	Kilowatt-hour; kWh_e refers to kWh electric, while kWh_{th} to kWh thermal.
LAP	Legal and Administrative Processes
LCA	Life-Cycle Assessment

LCCA	Life-Cycle Cost Assessment
LCSA	Life-Cycle and Sustainability Assessment
LCI	Life Cycle Inventory
LDV	Light Duty Vehicles
LHV	Low Heating Value
LOI	Letters of Intent
LT	Low Temperature
MEA	Membrane Electrode Assembly
MGA	Model Grant Agreement
MS	Member state
MSCA	Marie Sklodowska Curie Action
MTBF	Mean time between failures
Mt	Million Tonnes
N/A	Not available
NO_x	Nitrogen Oxides
NG	Natural Gas
NGO	Non-Governmental Organisations
NZIA	Net Zero Industry Act
OCT	Overseas countries and territories
OEM	Original equipment manufacturers
OPEX	Operational Expenditure
PCCEL	Proton Conducting Ceramic Electrolysis
PDA	Project Development Assistance
PEM	Proton Exchange Membrane
PEMEL	Proton Exchange Membrane Electrolysis
PEMFC	Proton Exchange Membrane Fuel Cell
PFAS	Per- and Polyfluoroalkyl Substances
PFSA	Perfluorinated sulfonic acid
PGM	Platinum Group Metals
PMO	Paymaster Office of the European Commission
PNR	Pre-Normative Research
PO	Clean Hydrogen JU Programme Office
POC	Proof of Concept
PPMT	Public Procurement Management Tool
PV	Photovoltaic

PP	Procurement Plan
P4P	Process for Planet Partnership
Q1-4	Quarter 1-4
R&I	Research and Innovation
R&D	Research and Development
RED II	Renewable Energy Directive
RAFS	Research Family Anti-Fraud strategy
RCS	Regulations, Codes and Standards
RCS SC	Regulations, Codes and Standards Strategy Coordination
RIA	Research and Innovation Actions
RFNBO	Renewable Fuels of Non-Biological Origin
RTO	Research and Technology Organisations
SAF	Sustainable Aviation Fuel
SSbD	Safe and sustainable-by-design
SBA	Single Basic Act; referring to the regulation establishing the Joint Undertakings under Horizon Europe.
SET-Plan	Strategic Energy Technology Plan
SG	Stakeholders group
SLA	Service Level Agreement
SNE	Seconded National Expert
SME	Small and Medium-sized Enterprise
SoA	State-of-the-Art
SOEL	Solid Oxide Electrolysis
SOFC	Solid Oxide Fuel Cell
SRIA	Strategic Research and Innovation Agenda for 2021-2027 of the Clean Hydrogen Joint Undertaking (previously MAWP Multi-Annual Work Programme).
SRIA-HE/HER	Strategic Research and Innovation Agenda for 2021-2027 of Hydrogen Europe and Hydrogen Europe Research
SRG	States Representative Group
SSOs	Storage System Operators
TC	Technical Committee
TCO	Total Cost of Ownership
TEA	Techno-Economic Assessment
TEN	Trans-European Network.
TEN-E	Trans-European Energy Network.

TEN-T	Trans European Transport Network.
TF	Task Force
TIM	Tools for Innovation Monitoring
TRL	Technology Readiness Level
UK	United Kingdom
UN-ECE	United Nations Economic Commission for Europe
US, USA	United States of America
VRE	Variable Renewable Energy
WP	Work Programme
WEC	Website Evidence
ZEWT	Zero Emission Waterborne Transport

1. Introduction

Clean Hydrogen JU Vision

Support a sustainable hydrogen economy, contributing to EU's climate goals

Clean Hydrogen JU Mission

Facilitate the transition to a greener EU society through the development of hydrogen technologies.

1.1. Mission statement of Clean Hydrogen JU

This document represents the **Annual Work Programme for 2025 of the Clean Hydrogen Joint Undertaking** (hereafter also Clean Hydrogen JU[1], or simply as "the JU"), outlining the scope and details of its activities for the year 2025 including its related budget.

The overall goal of the Clean Hydrogen JU is to support research and innovation (R&I) activities in the Union in clean hydrogen solutions and technologies, under European Union's (EU) funding programme for research and innovation, Horizon Europe[2], and in synergy with other EU initiatives and programmes. The Clean Hydrogen JU is the continuation of the successful Fuel Cell and Hydrogen Joint Undertakings (FCH JU and FCH 2 JU), under the EU's Framework Programme for research and technological development, period 2007-2013(FP7) and, for period 2014-2020, Horizon 2020 (H2020) respectively.

The Clean Hydrogen JU will contribute to the European climate neutrality goal by producing noticeable, quantifiable results towards the development and scaling up of hydrogen production, storage, distribution and end use applications. This will help develop a number of hydrogen technologies, which are currently either not competitive or have a low technology readiness level but are expected to contribute to the 2030 energy and climate targets and most importantly make possible climate neutrality by 2050.

The research and innovation activities of the Clean Hydrogen JU will address areas related primarily to the production of clean hydrogen, as well as the distribution, storage and end use applications of clean hydrogen in hard to abate sectors. They will be guided mostly by EU's Hydrogen Strategy[3] and the policy developments in this context such as the European Green Deal[4] and REPowerEU[5], contributing to its implementation.

The Clean Hydrogen JU will aim to accelerate the development and deployment of the European value chain for safe and sustainable clean hydrogen technologies, strengthening its competitiveness and with a view to supporting notably small and medium enterprises (SMEs), accelerating the market entry of innovative competitive clean solutions. The final goal is to contribute to a sustainable, decarbonised and fully integrated EU energy system, and to the EU's Hydrogen Strategy, playing an important role in the implementation of its roadmap

[1] For purposes of communication with the public, often the name Clean Hydrogen Partnership is also used instead of the legal name of the JU. In the present document only the legal name is used.
[2] Regulation (EU) 2021/695 establishing Horizon Europe – the Framework Programme for Research and Innovation, OJ L 170, 12.5.2021, p. 1–68.
[3] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0301
[4] https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en
[5] COM/2022/230 final

towards climate neutrality.

To this end, cross-cutting aspects such as safety, circularity and sustainability will be embedded continuously throughout the entire Clean Hydrogen JU Programme, guiding and underpinning the activities undertaken within. Concerning circularity and sustainability aspects, in particular, it is foreseen that activities will not only address these aspects as part of the "post-development" assessment, but also for orientating and/or while looking for solutions and/or taking decisions (e.g. materials selection) to develop a product, technology and/or a value chain in a more sustainable and circular manner. In this sense, "Safety and circularity by design" will become essential aspects across the Clean Hydrogen JU Programme.

1.2. Background and link with the Strategic Research and Innovation Agenda

This document establishes the fourth Annual Work Programme (AWP) of the Clean Hydrogen Joint Undertaking, outlining the scope and details of its activities for the year 2025. The Clean Hydrogen JU is a unique public-private partnership supporting research and innovation in hydrogen technologies in Europe. In November 2021 the Clean Hydrogen JU was set up, within the Horizon Europe, as a Joint Undertaking by the Council Regulation establishing the Joint Undertakings under Horizon Europe[6] (also referred to as Single Basic Act – SBA). Its aim is to contribute to the Union's wider competitiveness goals and leverage private investment by means of an industry-led implementation structure.

Hydrogen is expected to play a critical role in filling the gap between electrification and the hard-to-abate sectors, such as high temperature heat applications in industry and heavy-duty transport, including maritime and aviation. Hydrogen can be used as a feedstock, a fuel, an energy carrier and an energy storage medium, and thus has many possible applications across industry, transport, power and buildings sectors. Most importantly, when produced sustainably, it does not emit CO_2 (Carbon Dioxide) emissions. It is therefore an important part of the overall solution to meet the 2050 climate neutrality goal of the European Green Deal.

In July 2020 the Commission adopted the Energy System Integration[7] and Hydrogen Strategies[8]. Together they aim to address a vision on how to accelerate the transition towards a more integrated and clean energy system, in support of a climate neutral economy. The Energy System Integration Strategy addresses the planning and operation of the energy system "as a whole", across multiple energy carriers, infrastructures, and consumption sectors. The Strategy sets out 38 actions to implement the necessary reforms, including the promotion of renewable and low-carbon fuels, including hydrogen, for sectors that are hard to decarbonise.

The Hydrogen Strategy aims to create an enabling environment to scale up renewable and low carbon hydrogen supply and demand for a climate-neutral economy. Building on the Commission's New Industrial Strategy for Europe[9] and the Recovery Plan for Europe[10], the Strategy sets out a vision of how the EU can turn hydrogen into a viable solution to decarbonise different sectors over time. It also tries to address the issue that hydrogen

[6] Council Regulation (EU) 2021/2085 of 19 November 2021 establishing the Joint Undertakings under Horizon Europe and repealing Regulations (EC) No 219/2007, (EU) No 557/2014, (EU) No 558/2014, (EU) No 559/2014, (EU) No 560/2014, (EU) No 561/2014 and (EU) No 642/2014. OJ L 427/17 of 30.11.2021
[7] Strategy for Energy System Integration. COM(2020) 299 final.
[8] A Hydrogen Strategy for a climate neutral Europe. COM(2020) 301 final.
[9] New Industrial Strategy for Europe. COM(2020) 102 final.
[10] Europe's moment: Repair and Prepare for the Next Generation. COM(2020) 456 final.

production is today almost completely fossil-based, as low-carbon hydrogen is not yet cost-competitive. To achieve this, the strategy outlines several key actions and presents three strategic phases in the timeline up to 2050. Most notably, it sets the ambitious goal of installing at least 6 Gigawatts (GW) of renewable hydrogen electrolysers in the EU by 2024 and 40 GW of renewable hydrogen electrolysers by 2030.

On 11 December 2020, the Council adopted conclusions on steps to be taken towards creating a hydrogen market for Europe.[11] The conclusions gave political guidance to the implementation of the EU Hydrogen Strategy presented by the European Commission on 8 July 2020. In its conclusions, the Council recognised the important role of hydrogen, especially from renewable sources, and the need for the hydrogen market to be significantly scaled up, asking the Commission to further elaborate and implement the EU Hydrogen Strategy. The pathway towards the roadmap's objectives should use joint programmes, be cost-efficient and prioritise energy efficiency and electrification from renewable sources. The Council also sees the need to develop an ambitious hydrogen roadmap and strategy for climate neutrality in the end-use sectors, which makes use of flexible policies.

In December 2020, 22 EU countries and Norway signed a manifesto paving the way for a clean hydrogen value chain and committing to launch 'important projects of common European interest' (IPCEIs) in the hydrogen sector. The signatories committed to jointly design and coordinate IPCEIs. They also agreed that projects should cover the full clean hydrogen value chain — from renewable and low-carbon hydrogen production to hydrogen storage, transmission and distribution, and hydrogen application, notably in industrial sectors. Following an assessment by the European Commission, the first set of clean hydrogen projects, named Hy2Tech, received approval in July 2022. These 41 projects located in 15 EU countries will receive up to €5.4 billion in public funding. This is expected to unlock an additional €8.8 billion in private investments. The second group of clean hydrogen projects, named Hy2Use, received approval from the European Commission in September 2022. These 35 projects in 13 EU countries will receive up to €5.2 billion in public funding, which is expected to attract an additional €7 billion in private investments.

On 19 May 2021, the European Parliament also adopted a resolution[12] on the European Strategy for Hydrogen. The Members of the Parliament requested for incentives to encourage demand and to create a European hydrogen market and fast deployment of hydrogen infrastructure. They also emphasised the need to phase out fossil-based hydrogen as soon as possible, while certification should be applied to all hydrogen imports, similar to EU-produced hydrogen. Finally, they requested to assess the possibility of repurposing existing gas pipelines for the transport and underground storage of hydrogen.

On 28 June 2021 the first ever Climate Law for Europe[13] was adopted, writing into law the goals set out in the European Green Deal. The first European Climate Law sets the goal of climate-neutrality by 2050 and includes a binding EU climate target for reducing net greenhouse gas (GHG) emissions by at least 55% by 2030 compared to 1990, significantly increasing the previous 2030 target of 40% agreed a few years back in 2014.

To achieve these ambitious goals, the European Commission adopted on 14 July 2021 the 'Fit for 55' package[14] of policy proposals to make the EU's climate, energy, land use, transport

[11] European Council conclusions, 10-11 December 2020.
[12] European Parliament resolution of 19 May 2021 on a European Strategy for Hydrogen (2020/2242(INI))
[13] Regulation (EU) 2021/1119 establishing the framework for achieving climate neutrality and amending Regulations (EC) No 401/2009 and (EU) 2018/1999 ('European Climate Law').
[14] 'Fit for 55': delivering the EU's 2030 Climate Target on the way to climate neutrality, COM(2021) 550, July 2021.

and taxation policies fit for this target. It is a broad package, containing 13 different proposals approaching the goal of emission reductions from many different angles, with both targeted and horizontal policy measures. Increasing renewable energy, energy efficiency and member states' non-ETS targets, while strengthening the EU emission trading system (EU ETS), including creating a new ETS for buildings and road transport. Restructuring energy taxation in Europe – including the introduction of a carbon border adjustment mechanism –, but also revising the CO_2 emission standards for new cars. Accelerating the development of alternative fuel infrastructure, while at the same time promoting the use of sustainable fuels in Aviation and Maritime. Creating a social climate fund and acknowledging the importance of forests and land use in achieving our climate goals. Its proposals were complemented in Quarter 4 (Q4) 2021 with the Hydrogen and Gas markets Decarbonisation Package[15] and in Q4 2022 with the CO_2 Standards on Heavy-Duty Vehicles[16].

As the first step in the implementation of the EU Hydrogen Strategy, the 'Fit for 55' package contains a number of measures aiming to promote the production and use of hydrogen and hydrogen-based fuels in the different sectors of the economy. The revised Renewable Energy Directive[17] proposes the extension of the EU-wide certification system for renewable fuels to include hydrogen[18], as well as targets for transport[19] and industry[20] that include renewable hydrogen consumption. Additional financial incentives for hydrogen are foreseen by the revision of the EU ETS proposal,[21] which shall extend to maritime, establish emissions trading for transport and buildings; and include electrolytic hydrogen under ETS, thus making low carbon hydrogen eligible for free allowances. Further incentives shall be given through the preferential taxes for the use of low carbon hydrogen, foreseen in the revision of the Energy Taxation Directive.[22] Hydrogen is promoted specifically in the transport sector by three additional targeted proposals: the more stringent CO_2 standards for Cars and Vans;[23] the revision of the Alternative Fuel Infrastructure Regulation, requiring hydrogen refuelling stations serving both cars and lorries to be deployed by 2030 in all urban nodes and every 200 km along the TEN-T (Trans European Transport Network) core network; and the FuelEU Maritime proposal promoting strongly low carbon hydrogen and hydrogen-based fuels (including methanol and ammonia).

The 'Fit-for-55' package is complemented by the proposals for the new Gas Markets Decarbonisation package[24], released on 15 December 2021, aiming to enable the decarbonising of the gas networks and revise the EU gas rules to facilitate the market entry for renewable and low-carbon gases, mainly biomethane and hydrogen, and remove any

[15] The combined evaluation roadmap and inception impact assessment of the initiative can be found here. This initiative aims to address a number of issues associated with gas markets and networks, including hydrogen.
[16] Announced on August 2021, timeline can be found here.
[17] Proposal for a Directive as regards the promotion of energy from renewable sources. COM (2021) 557 final.
[18] Renewable Fuels of Non-Biological (RFNBO) now include renewable hydrogen.
[19] at least 2.6% share of RFNBO in the energy supplied to the transport sector
[20] 50% of the hydrogen used for final energy and non-energy purposes should come from RFNBO
[21] Establishing a system for greenhouse gas emission allowance trading with the Union. COM (2021) 551 final.
[22] Restructuring the Union framework for taxation of energy products and electricity, COM (2021) 563 final.
[23] Regulation 2023/851 as regards strengthening the CO_2 emission performance standards for new passenger cars and new light commercial vehicles in line with the Union's increased climate ambition (https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32023R0851).
[24] New EU framework to decarbonise gas markets, promote hydrogen and reduce methane emissions (https://ec.europa.eu/commission/presscorner/detail/en/ip_21_6682)

undue regulatory barriers. The revised gas markets and hydrogen regulation[25] and directive[26] aim to establish a market for hydrogen, create the right environment for investment, and enable the development of dedicated infrastructure, including for trade with third countries: market rules in two phases similar to the existing ones for natural gas, new governance structure in the form of the European Network of Network Operators for Hydrogen, removal of tariffs for cross-border interconnections and lowering tariffs at injection points, introduction of a certification system for low-carbon gases, consumer empowerment and protection etc. This is to ensure that the gas market framework is in line with the Fit for 55 ambitions.

In May 2022, the European Commission presented the REPowerEU Plan[27] to respond to the unprecedented global energy market disruption caused by Russia's invasion in Ukraine. Renewable hydrogen is recognised as a crucial contributor to reaching the REPowerEU Plan objectives to reduce the dependence of Russian fossil fuels and to accelerate green transition.

To accelerate the deployment of renewable hydrogen, the European Commission allocated an additional funding of €200 million to the overall budget of the Clean Hydrogen JU, with the aim to double the number of Hydrogen Valleys by 2025 and to be matched by the same amount by the private members. We should also aim to have at least one Hydrogen Valley established in each Member State.

Also, the EU External Energy Strategy[28] was adopted as a part of the REPowerEU Plan. This strategy promotes diversification of energy supplies and renewable hydrogen investments and indicates the possibility that the European Commission concludes hydrogen partnerships with reliable partner countries and by kick-starting a global hydrogen market. This includes cooperation on renewable hydrogen. The strategy envisages three major hydrogen import corridors to the EU – from the North Sea region (Norway and United Kingdom), the Southern Mediterranean and Ukraine, as soon as conditions allow.

The EU has now a fully-fledged legislative framework for the production, consumption, infrastructure development and market rules for a future hydrogen market, as well as binding quotas for renewable hydrogen consumption in industry and transport. Including the revised Regulation on CO2 emission limits for Cars and Vans[29], ETS Directive[30], Regulation on Alternative Fuels Infrastructure[31], Renewable Energy Directive[32], FuelEU Maritime Regulation[33]. On 21 May 2024, the EU adopted the Regulation[34] and Directive[35] establishing common internal market rules for renewable and natural gases and hydrogen and reforming the existing EU gas legislation setting out EU rules for hydrogen market- and infrastructure development. It includes also a definition of low-carbon hydrogen.

To ensure that the hydrogen is produced from renewable energy sources and achieves at least 70% greenhouse gas emissions savings, the Commission adopted in February 2023 two

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[25] Regulation on the internal markets for renewable and natural gases and for hydrogen (recast). COM/2021/804 final (https://ec.europa.eu/energy/sites/default/files/proposal-revised-gas-markets-and-hydrogen-regulation.pdf)
[26] Directive on common rules for the internal markets in renewable and natural gases and in hydrogen. COM/2021/803 final (https://ec.europa.eu/energy/sites/default/files/proposal-revised-gas-markets-and-hydrogen-directive.pdf)
[27] COM/2022/230 final.
[28] EU external energy engagement in a changing world. SWD(2022) 152 final.
[29] Regulation (EU) 2023/851, OJ 25.4.2023
[30] Directive (EU) 2023/959, OJ 16.5.2023
[31] Regulation (EU) 2023/1804, OJ 22.9.2023
[32] Directive (EU) 2023/ 2001, OJ 31.10.2023
[33] Regulation (EU) 2023/1805, OJ 22.09.2023
[34] Regulation (EU) 2024/ 1789, OJ 15.07.2024
[35] Directive (EU) 2024/ 1788, OJ 15.07.2024

delegated acts:

- The Delegated Act on a methodology for renewable fuels on non-biological origin,[36] defines under which conditions hydrogen, hydrogen-based fuels, or other energy carriers can be considered as renewable fuels of non-biological origin (RFNBO). The methodology also includes rules for (i) the temporal and geographical correlation between the electricity production unit and the fuel production, and (ii) ensuring that the fuel producer is adding to the renewable deployment or to the financing of renewable energy[37].
- The Delegated Act establishing a minimum threshold for greenhouse gas (GHG) emissions savings of recycled carbon fuels[38] provides a methodology for calculating life-cycle GHG emissions for RFNBOs. It takes into account GHG emissions across the full lifecycle of the fuels, including upstream emissions, emissions associated with taking electricity from the grid, from processing, and those associated with transporting these fuels to the end-consumer.

In March 2023 a number of new proposals affecting also the hydrogen sector were introduced by the Commission. The adopted Electricity Market Reform[39] provides the option for Member States to introduce new, or adapted, market-based support schemes to promote storage and demand response, which could lead to the incentivisation of hydrogen storage for power generation.

In parallel, the EC proposed the Net-Zero Industry Act (NZIA)[40] as one of the pillars of the Green Deal Industrial Plan[41], aiming that the Union's overall strategic net-zero technologies manufacturing capacity, including hydrogen technologies, approaches or reaches at least 40% of the Union's deployment needs by 2030. This will be possible through measures that facilitate investments, incentivise demand and up- and re-skill Europe's labour force via the so-called Net-Zero Industry Academies. These Academies will aim to enable the training and education of 100.000 learners each, within three years of their establishment, to contribute to the availability of skills required for the net-zero technologies and consolidate the existing European's industry leading role in fostering the establishment of small and medium-sized enterprises. The Critical Raw Materials Act (CRMA)[42] is the other pillar, proposing a renewed European approach to the use of raw materials and the revival of Europe's sustainable materials market, focusing on the extraction, processing, recycling, monitoring and diversification of Critical Raw Materials (CRM). Availability and future prices of CRMs will affect the market growth of electrolysers and fuel cells.

Another important step towards scaling up production of renewable hydrogen in the EU is the first pilot auction of €800 million funded by the Innovation Fund under the umbrella of the EU Hydrogen Bank[43], which was launched on 23 November 2023. The Hydrogen Bank, implemented by the European Commission, aims to unlock private investments in hydrogen

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[36] Commission Delegated Regulation (EU) 2023/1184 of 10 February 2023.

[37] The Act clarifies the principle of "additionality" for hydrogen set out in the EU's Renewable Energy Directive, meaning that renewable hydrogen must be produced exclusively using additional renewable power plants (to incentivize an increase in the volume of renewable energy available to the grid), and that the hydrogen will only be produced during the hours that the renewable energy asset is producing electricity (hourly temporal correlation), and only in the area where the renewable electricity asset is located (geographical correlation).

[38] Commission Delegated Regulation (EU) 2023/1185 of 10 February 2023.

[39] Regulation (EU) 2024/1747, OJ 26.06.2024 and Directive (EU) 2024/1711, OJ 26.06.2024

[40] COM(2023) 161 final/16.3.2023: https://ec.europa.eu/commission/presscorner/detail/en/IP_23_1665

[41] COM(2023) 62 final/1.2.2023: https://ec.europa.eu/commission/presscorner/detail/en/ip_23_510

[42] COM(2023) 160 final/16.3.2023 https://ec.europa.eu/commission/presscorner/detail/en/ip_23_1661

[43] https://climate.ec.europa.eu/news-your-voice/news/upcoming-eu-hydrogen-bank-pilot-auction-european-commission-publishes-terms-conditions-2023-08-30_en

value chains in the EU and in third countries by connecting renewable hydrogen supply with the emerging demand by European off-takers and thus to establish an initial market for renewable hydrogen. The objectives of the auction are to reduce the cost gap between renewable and fossil hydrogen in the EU, allow for price discovery and renewable hydrogen market formation, de-risk European hydrogen projects and reduce administrative burdens.

On 28 November 2023, the Commission adopted the first Union list of the Projects of Common Interest and Projects of Mutual Interest[44] under the new Trans-European energy network regulation (TEN-E).[45] This list included for the first-time hydrogen projects, such as networks, electrolysers, reception facilities and storages. In 2024, the Commission has approved two more IPCEIs to support hydrogen infrastructure (IPCEI Hy2Infra[46]) and the mobility and transport sectors (IPCEI Hy2Move[47]) More hydrogen-related legislative initiatives concluded in 2024. The Industrial and Livestock Rearing Emissions Directive[48] (IED 2.0) exempted electrolysers under 50 tons/day of hydrogen production from the same national permitting rules, giving small to medium electrolysers the possibility to speed up deployment. The Electricity Market Design (EMD) reform[49] recognises hydrogen as a key energy storage medium encouraging investments in storage infrastructure and production of renewable and low-carbon hydrogen, It also promote support mechanisms to alleviate risks for potential investments (e.g. two-way Contracts for Differences to incentivise large scale green hydrogen projects). The hydrogen and gas decarbonisation package[50] introduces a new regulatory framework for dedicated hydrogen infrastructure. Finally, the Commission proposed an encompassing strategy to move towards EU industrial leadership in advanced materials[51] proposed an encompassing strategy to move towards EU industrial leadership in advanced materials aiming to ensure a sustainable and uninterrupted supply of these materials for the successful ramp up of the hydrogen, aiming to ensure a sustainable and uninterrupted supply of these materials for the successful ramp up of the hydrogen sector.

In March 2024, the Commission adopted the Strategic Technologies for Europe Platform (STEP) [52] to boost investments in critical technologies in Europe: clean and resource efficient technologies, digital and deep innovation technologies and biotechnologies. STEP will mobilise resources from existing EU programmes to support the development and manufacturing of these critical technologies, while safeguarding and strengthening the respective value chains, as well as associated services and skills critical for and specific to the development and manufacturing of the final products. In line with Article 2 of the STEP Regulation, in May 2024 the Commission issued a Guidance Note where hydrogen technologies were included in a non-exhaustive list of technologies that could be considered within the scope of STEP.

In line with all the policy developments described above, it is crucial that the Clean Hydrogen JU continues to support its new and on-going projects and develop technology solutions that will help materialise the benefits of hydrogen technologies in support of the high-level EU

[44] https://energy.ec.europa.eu/publications/delegated-regulation-first-union-list-projects-common-and-mutual-interest_en
[45] Regulation (EU) 2022/869, OJ 3.6.2022
[46] https://ec.europa.eu/commission/presscorner/api/files/document/print/en/ip_24_789/IP_24_789_EN.pdf
[47] https://ec.europa.eu/commission/presscorner/api/files/document/print/en/ip_24_2851/IP_24_2851_EN.pdf
[48] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L_202401785
[49] https://energy.ec.europa.eu/topics/markets-and-consumers/electricity-market-design_en
[50] https://energy.ec.europa.eu/topics/markets-and-consumers/hydrogen-and-decarbonised-gas-market_en
[51] https://research-and-innovation.ec.europa.eu/document/download/0fcf06ea-c242-44a6-b2cb-daed39584996_en

[52] Regulation (EU) 2024/795, OJ 29.2.2024

policy agenda.

To achieve this, the Strategic Research and Innovation Agenda (SRIA)[53] of the Clean Hydrogen JU describes an extensive number of research and innovation activities, covering the areas of renewable hydrogen production, as well as hydrogen transmission, distribution and storage, alongside selected fuel cell end-use technologies. Several scientific challenges, priorities and objectives have been identified, which are described in detail in Section 1.3 and are addressed by the research and innovation actions listed in the SRIA.

In parallel, the SRIA foresees parallel activities, aiming to support the research and innovation agenda and reinforce it, including:

- Seeking synergies with other partnerships and programmes;
- Facilitating the market uptake of hydrogen via a number of Task Forces and Panels[54];
- Enlarging the knowledge base around hydrogen via the knowledge management activities;
- Building awareness and acceptance of the hydrogen technologies, through communication activities, but also the dissemination and exploitation of project results;
- Supporting the European Commission in the implementation of its international cooperation agenda in research and innovation.

The present Annual Work Programme 2025 of the Clean Hydrogen Joint Undertaking consists of the next implementation step of the SRIA. It includes a Call for Proposals, along the lines of the research and innovation actions listed in the SRIA, with an overall indicative budget of EUR 184.5 million. The Call budget includes EUR 80 million (from the RePowerEU plan budget) which will be exclusively used to support the Hydrogen Valleys call topics. In addition, specific actions are foreseen to implement complementary activities in line with what is described in the SRIA (see section 1.3.3). The budget of the Call also includes additional EUR 20 million from United Kingdom (UK) appropriations which are available to support projects in the reserve lists and will be allocated according to the Governing Board strategic priorities.

1.3. Strategy for the implementation of the programme

1.3.1. Implementation Strategy

The Clean Hydrogen JU has been set up to achieve a number of objectives described in the European legislation or its SRIA:

- The objectives of the Horizon Europe Programme, as described in Article 3 of the Horizon Europe Regulation, including contributing to the Union policy objectives;
- The objectives set out in the SBA establishing the Clean Hydrogen JU, both common for all Joint Undertakings and the specific ones for the Clean Hydrogen JU, as described in Articles 3 to 5 and 73-74 of the SBA;
- The research objectives set out in the SRIA per research area.

In general, the Clean Hydrogen JU aims to accelerate the development and deployment of

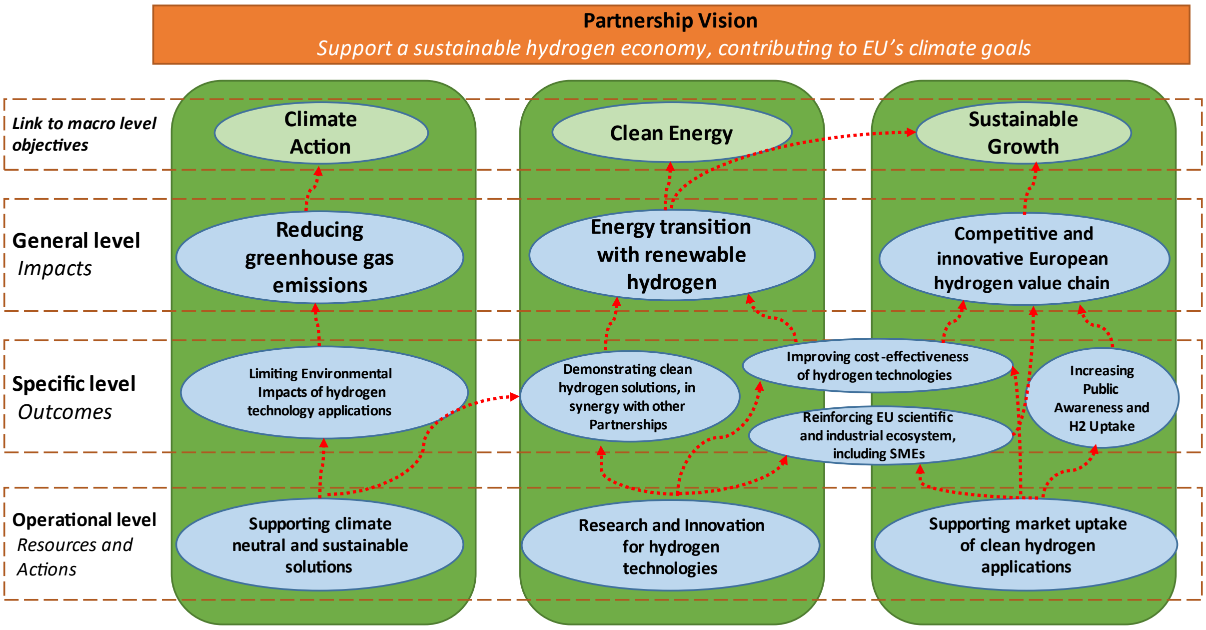
[53] A revision of the SRIA is under preparation, to be adopted in 2024, to align it with all policy and technology developments since the start of this Programme. The revised SRIA will be the basis for the Clean Hydrogen JU activities during the second part of its lifetime (2025-2027).
[54] Regulations, Codes and Standards Strategy Coordination Task Force, the European Hydrogen Safety Panel and the Sustainability and Circularity Panel.

the European value chain for safe and sustainable clean[55] hydrogen technologies, strengthening its competitiveness and with a view to supporting notably SMEs, accelerating the market entry of innovative competitive clean solutions. The final goal is to contribute to a sustainable, decarbonised and fully integrated EU energy system, and to the EU's Hydrogen Strategy, playing an important role in the implementation of its roadmap towards climate neutrality.

In order to prepare the implementation strategy of the Programme, the Clean Hydrogen JU prepared a Strategy Map[56] to identify this large number of (often high-level) objectives to more specific ones. This facilitated the identification of the necessary actions over the lifetime of the JU, necessary to meet its objectives. The Strategy Map links the resources of the JU and the actions taken (operational objectives / indicators) towards concrete outcomes (specific objectives / indicators) and directly to one (or more) of the general objectives and intended impacts of the Clean Hydrogen JU, which would contribute in turn to one or more high-level objectives of the Union. Figure 1 below presents the JU's strategy map, linking actions with expected outcomes and intended impacts.

It needs to be emphasised that the Strategy Map does not aim to replace the legal objectives of the JU, as reflected in the SBA and the Horizon Europe Regulation, but helps to restructure and further specify them, in order to be able to better define the implementation strategy for the Programme and set up relevant indicators for its monitoring framework, while avoiding overlaps among the objectives and making more obvious the interlinkages between them.

Figure 1 Strategy Map of the Clean Hydrogen Joint Undertaking



Considering the different levels of objectives and the high level of ambition associated with the hydrogen sector, a gradual implementation was deemed more appropriate. Therefore, the Programme is mainly implemented through open and competitive annual Calls for Proposals[57],

[55] "clean" meaning "renewable" in agreement with the definition of the Hydrogen Strategy, the only definition available at the time of adopting the SBA

[56] See Section 7 of the Clean Hydrogen JU SRIA.

[57] In 2023, the Clean Hydrogen Joint Undertaking will also carry out a number of operational activities via calls for tenders, see section 2.2.4 of this document for additional information.

providing financial support mainly in the form of grants to participants. The planned research and innovation actions for 2025 are described in Section 2.2.3. The topics of each Call are determined on an annual basis through extensive consultation between the three members of the JU[58] and with the support of the Programme Office. In addition, the advisory bodies[59] of the JU are also consulted on the Call topics throughout the drafting process. The progress of the Programme, as observed via the monitoring framework of the JU and the European Commission's Biennial Monitoring Report on partnerships in Horizon Europe[60], are a useful input in these discussions, indicating whether more action is needed in certain area.

Moreover, the Clean Hydrogen JU undertakes in parallel a number of complementary activities, aiming to support the market uptake of hydrogen applications and reinforce the EU scientific and industrial ecosystem. In addition, these activities will address the specific tasks assigned in the SBA to the Joint Undertaking, its Governing Board and its Executive Director, in addition to the indirect actions implemented through grants. These activities are described in Section 2.2.4.

1.3.2. Planned research and innovation actions

The key component in the implementation of the Programme is the annual Call for Proposals, covering a number of the research and innovation actions described in the SRIA. The selection of the actions and the description of the topics comes from a joint effort and intensive interaction between the JU members, namely Hydrogen Europe, Hydrogen Europe Research and the European Commission. They represent a set of prioritised actions, consistent with the objectives of the Clean Hydrogen JU, and are divided primarily into the Pillars identified in the SRIA:

- Pillar 1: Renewable Hydrogen Production
- Pillar 2: Hydrogen storage and distribution
- Pillar 3: Hydrogen end uses
    - Pillar 3.1: Transport applications
    - Pillar 3.2: Clean heat and power

In addition to working within each of these pillars, future mass deployment requires support and coordination action. They are thus complemented by four additional horizontal and cross-cutting activities, necessary as follows:

- Horizontal Activity 1: Cross-cutting activities
- Horizontal Activity 2: Hydrogen Valleys
- Horizontal Activity 3: Hydrogen Supply Chains
- Horizontal Activity 4: Strategic Research Challenges

In the SRIA, for each Pillar and Horizontal Activity, specific objectives are described,

[58] The three members of the JU are the European Commission, Hydrogen Europe and Hydrogen Europe Research.
[59] The advisory bodies of the JU are the States Representatives Group and the Stakeholders Group. In line with the Single Basic Act a formal consultation on the full AWP2025 took place with the SRG whilst the focus of the SG consultation is on potential synergies with adjacent your sectors and/or initiatives.
[60] https://ec.europa.eu/research-and-innovation/en/knowledge-publications-tools-and-data/interactive-reports/performance-european-partnerships-2022

accompanied by a number of actions[61] aiming to contribute towards their achievement. These actions comprise of long-term, breakthrough-oriented research, applied research and technology development, demonstrations and supporting actions, including strategic studies, pre-normative actions and technology assessment.

The emphasis given to different actions in different pillars reflects the industry and research members' assessment of the state of the technological maturity of the applications and their estimated importance to achieve critical objectives of the Clean Hydrogen JU.

The main scientific priorities and challenges for the different pillars and activities are as follows in the SRIA:

Scientific priorities and challenges: Renewable Hydrogen production

Most of the hydrogen that is currently being produced in the EU and worldwide is produced from fossil fuels – either by steam reforming of natural gas or gasification of coal. Renewable hydrogen needs to become cost-competitive, and its technologies need to be scaled up in a fashion similar to renewable technologies during the last decade. For transport, this would require a cost around 5 €/kg at the pump to achieve cost parity with diesel fuel[62]. For industrial applications, renewable hydrogen costs must reach levels between 2-3 €/kg as a feedstock[63,] in order to achieve parity with fossil-based inputs, once the cost of carbon is included in the feedstock cost.

To reach these costs, further improvements are required especially in cost reduction and efficiency increase for a variety of renewable hydrogen production routes, the main technology being electrolysis, supported by other routes exploiting direct sunlight such as thermal dissociation of water using concentrated solar energy or through photocatalysis, biomass/biogas or other biological routes.

Water electrolysis will be the main technology supported, covering high technology readiness level (TRL) types - Alkaline Electrolysis (AEL), Proton Exchange Membrane Electrolysis (PEMEL), Solid Oxide Electrolysis (SOEL) - and less mature types - Anion Exchange Membrane Electrolysis (AEMEL) and Proton Conducting Ceramic Electrolysis (PCCEL). The topic of pyrolysis and carbon black production is outside the scope of the Clean Hydrogen JU and should be covered through the synergies with Processes 4 Planet Partnership (P4P).

Scientific priorities and challenges: Hydrogen storage and distribution

As explicitly mentioned in the EU Hydrogen Strategy, it is essential that hydrogen becomes an intrinsic part of an integrated energy system. In order for this to happen, hydrogen will have to be used between daily and/or seasonal storage providing buffering functions thereby enhancing security of supply in the medium term. The strategy also calls for an EU-wide logistical infrastructure that needs to be developed to transport hydrogen from areas with large renewable potential to demand centres across Europe.

For distances compatible with the European territory, compressed and liquefied hydrogen solutions, and especially compressed hydrogen pipelines, offer lower costs than chemical carriers do. The repurposing of existing natural gas pipelines for hydrogen use is expected to significantly lower the delivery cost, making the pipeline option even more competitive in the

[61] The actions proposed for all the pillars are based on the final draft of the Strategic Research and Innovation Agenda, final draft October 2020, Hydrogen Europe and Hydrogen Europe Research (SRIA-HE/HER). These should be considered indicative, especially considering the dynamic and fast-growing field of research and development in hydrogen technologies, which may very likely shift the priorities over the next few years.
[62] See Figure 15 in SRIA-HE/HER
[63] Green Hydrogen Cost Reduction: Scaling up electrolysers to meet the 1.5°C climate Goal, IRENA 2020

future. By contrast, chemical carriers become more competitive the longer the delivery distance (due to their lower transport costs) and thus can more easily be traded in the global hydrogen markets.

In line with the above, a pluralistic approach with respect to the technologies that will be investigated and supported is envisaged, to have a complete set of technologies that can serve as building blocks of the EU-wide logistical infrastructure.

Scientific priorities and challenges: Hydrogen end uses - transport

Transport is a key area of economic growth in our society, responsible for around 30% of EU total CO_2 emissions. The European Green Deal has set the ambition for at least 90% reduction in transport emissions by 2050 to be consistent with climate neutrality. Hence, there is a need to urgently take measures to decarbonise the transport sector. Regulatory aspects will define the speed of adoption of new zero emissions transport means. The 'Fit for 55' package proposes a number of policy measures that promote the use of hydrogen as a low carbon fuel in the transport sector.

The technology developments so far are not sufficient to meet the ambitious emission reductions in transport. The required solutions can be based on the transfer of technical knowledge already gained in fuel cell (FC) light duty vehicles (LDV) and FC buses, while cost reductions and higher efficiencies can be achieved by scaling and by process integration, improving the competitiveness of these technologies with a roll down effect, e.g. by platform approaches of FC modules across sectors.

A number of technology routes still need further improvements, especially in the context of reducing costs and increasing durability, in order to make them competitive with incumbent technologies. These should be further validated and integrated in the different transport modes in synergies with the end-use partnerships of Horizon Europe (such as Clean Aviation JU, EU-Rail JU, Zero-Waterborne partnership, 2ZERO partnership) and include:

- Improvement of main technology building blocks that can be applied across a range of different transport applications, notably fuel cell stacks and hydrogen tanks;
- Adapting fuel cell systems from other vehicles (urban buses / cars) for long distance coaches and heavy-duty vehicles;
- Producing components for rail freight and shunting locomotive applications;
- Adapting FC components to waterborne transport, and developing next generations based on learnings from first demonstrations;
- Developing tanks and FC technologies specifically adapted for aviation.

It should be also stressed that, especially in the case of hydrogen-based transportation, the competitiveness of hydrogen technologies is dependent on research and innovation breakthroughs, on production volumes of vehicles and components and on the price and availability of hydrogen as a fuel. Therefore, actions aimed at stimulating a broad rollout of FC vehicles around Europe are equally important to research and innovation actions, in particular for heavy-duty sectors, in order to drive the Total Cost of Ownership (TCO) of the FC vehicles down. This is particularly true, for example, for the road heavy-duty transport segment where the TCO is extremely relevant for final users and ultimately for the market uptake. Monitoring of the FC trucks TCO and comparison with battery-powered trucks electrified trucks and others decarbonisation technologies will be needed. Addressing all of these aspects simultaneously is necessary to allow for hydrogen transport applications to enter mass market. This should be also performed in synergies with the Connecting Europe Facility, CEF Programme for implementation of related Hydrogen Refuelling Stations (HRS) network and in line with the Alternative Fuel Infrastructure Regulation (AFIR).

Scientific priorities and challenges: Hydrogen end uses - clean heat and power

Hydrogen offers a unique chance to decarbonise the power generation and heating sectors reliably and independently from weather or seasonal conditions.

The overall goal of this pillar is to support European supply chain actors to develop a portfolio of solutions providing clean, renewable and flexible heat and power generation for all end users' needs and across all system sizes; from domestic systems all the way to large-scale power generation plants. Preferential support will be for solutions running on 100% hydrogen. However, to develop solutions for a transitional period, support may be also offered to solutions running on a hydrogen mixture in the gas grid (up to 20%) during this transition phase[64].

For gas turbines, in order to enable a smooth transition and assure backward compatibility with conventional fuels during the transition, support for actions running with different hydrogen admixtures are likely to be required to facilitate the development process and to achieve the final goal of 100% hydrogen turbines.

Scientific priorities and challenges: Cross-Cutting activities

Mass-market commercialisation of hydrogen-based technologies presents a number of systemic (or horizontal) challenges that need to be addressed to effectively kick-start a hydrogen ecosystem of significant scale throughout the EU in the coming decade.

Cross-cutting activities are structured around three focus areas: (i) Sustainability; (ii) Education and public awareness; and (iii) Safety, pre-normative research and regulations, codes and standards.

As hydrogen-based technologies become a market value proposition, strengthening the focus on environmental and sustainability aspects (such as water resources for electrolysis, critical raw materials use along hydrogen value chains and pollutant emissions) is required in the framework of the transition to a circular economy. Furthermore, continuous education and training are fundamental to safeguard existing expertise and to prepare a well-educated workforce needed for a competitive hydrogen market, while underpinning the jobs and value creation in a knowledge-based society in Europe. Public awareness activities are essential for increasing social acceptance and trust in hydrogen-based technologies throughout Europe but in particular, for bridging the potential lack of knowledge or mistrust of key stakeholders directly involved in the first phases of mass deployment in Europe. Moreover, for a safe deployment of clean hydrogen technologies in Europe, safety-related aspects are of paramount relevance. As the technologies will shift from the industrial domain to the public domain, strengthening hydrogen safety is one of the priorities of the Clean Hydrogen JU Programme. Besides, a suitable regulatory framework for hydrogen-based technologies is necessary for an EU-wide deployment of clean hydrogen technologies. To this end, pre-normative research activities and desk research activities are fundamental for supporting regulations, codes and standards (RCS) development.

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[64] According to the "Hydrogen strategy for a climate-neutral Europe", the blending of hydrogen in the natural gas network at a limited percentage may enable decentralised renewable hydrogen production in local networks in a transitional phase.

Scientific priorities and challenges: Hydrogen Valleys

Since 2014, the predecessor FCH 2 JU has pursued the concept of hydrogen territories, which have evolved into the most recent concept of Hydrogen Valleys with the new Clean Hydrogen JU. Hydrogen Valleys are hydrogen ecosystems that cover a specific geography ranging from local or regional focus (e.g. industrial cluster, ports, airports, etc.) to specific national or international regions (e.g. cross border hydrogen corridors). Hydrogen Valleys showcase the versatility of hydrogen by supplying ideally several sectors in their geography such as mobility, industry and energy end uses. They are ecosystems or clusters where various final applications share a common hydrogen supply infrastructure. Across their geographic scope, Hydrogen Valleys cover multiple steps in the hydrogen value chain, ranging from hydrogen production (and often even dedicated renewables production) to the subsequent storage of hydrogen and distribution to off-takers via various modes of transport. Whilst most of the projects are in the EU, over the past years, Hydrogen Valleys have gone global, with new projects emerging worldwide. Mission Innovation on Clean Hydrogen has set a target of deploying 100 large-scale Hydrogen Valleys worldwide by 2030[65].

The concept aims to demonstrate how all the different parts of the hydrogen value chain fit together in an integrated system approach. This concept has gained momentum and is now one of the main priorities of the industry and the European Commission (EC) for scaling-up hydrogen deployments and creating interconnected hydrogen ecosystems across Europe.

A Hydrogen Valley should not only demonstrate how hydrogen technologies work in synergy, but it should also offer a competitive solution and work complementary with (or reuse of) other elements such as renewable production, gas infrastructure, electricity and thermal grid, energy storage solutions, etc.

The REPowerEU Plan acknowledges the need to develop Hydrogen Valleys based on local renewables, demonstrating ecosystems that contribute to a faster sustainable energy transition via renewable hydrogen across the EU. The Commission is therefore allocating an additional EUR 200 million for doubling the number of Hydrogen Valleys in the EU by 2025, while contributing to the wider goal of consuming 10 million tonnes of domestic renewable hydrogen by 2030. A key objective will be to progressively set up hydrogen local ecosystems which will accelerate the development of an EU hydrogen economy, interconnecting them step by step, and building on local renewable energy resources including mixing them to produce renewable hydrogen. In that respect, Hydrogen Valleys could have various dimensions and various sets of end use applications.

Scientific priorities and challenges: Hydrogen Supply Chains

Hydrogen technologies and systems have been identified by the European Commission as an emerging and strategic value chain for Europe.[66] A strong and sustainable European supply chain of hydrogen technologies will avoid that the manufacturing capacity becomes a limiting factor to technology uptake, improve the competitiveness and innovation of industries, support the decarbonisation of the economy and reduce dependence on fossil fuels, critical raw materials (CRM) and components imports. Following this, the European Clean Hydrogen Alliance[67] was set up in July 2020 to support the large-scale deployment of clean hydrogen technologies by 2030. The Alliance brings together renewable and low-carbon hydrogen production, demand in industry, mobility and other sectors, and hydrogen transmission and

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[65] http://mission-innovation.net/wp-content/uploads/2022/09/Clean-Hydrogen-Mission-Action-Plan-Sept-22.pdf
[66] Strengthening Strategic Value Chains for a future-ready EU Industry, EC, 2019.
[67] https://single-market-economy.ec.europa.eu/industry/strategy/industrial-alliances/european-clean-hydrogen-alliance_en

distribution. Its members come from industry, public authorities, civil society, and other stakeholders.

The SRIA foresees a set of actions aiming at strengthening the overall supply chain of hydrogen technologies, from processing the raw materials into specialised materials (e.g. electro-catalysts), production of components and sub-system to system integration. The supply chain is complemented by the wider view of the value chain approach vis-à-vis creation of jobs, added value to economy and industry competitiveness.

Scientific priorities and challenges: Strategic Research Challenges

To ensure a continuous generation of early-stage research knowledge, the above actions will be supplemented by multidisciplinary investigations, gathering expertise at different technology scale (materials, component, cell, stack and system). All the generated knowledge needs also to be combined in such a way to allow further comprehensive interpretations. The usual 3-year focused research projects do not really appear to be the optimum option to ensure a continuum in early-stage research knowledge. The proposed approach considers gathering, with a long-term vision and covering the whole Clean Hydrogen JU activities, the needed capabilities and expertise from European Research and Technology Organisations (RTOs) while preparing the next generation of products (lower cost and better performance), beyond 2030.

Based on the early-stage research actions mentioned in the different previous roadmaps, the following strategic research challenges appear the most relevant:

- Low or free platinum group metal (PGM) catalysts (including bioinspired catalysts), reducing critical (raw) materials use in electrolysers and fuel cells, and safe and sustainable use of all material, including developing of perfluorosulfonic acid (PFAS)-free ionomers and membranes;
- Advanced materials for hydrogen storage (e.g. carbon fibres, H_2 carriers);
- Advanced understanding of the performance / durability mechanisms of electrolysers and fuel cells.

1.3.3. Other activities

Although the financial support to research and innovation actions is the main tool of the JU to achieve its objectives, it is not sufficient. A number of additional support activities are necessary to fulfil its objectives in relation, for example, to developing synergies with other partnerships and programmes, strengthening scientific excellence and its links to innovation and increasing public awareness.

For this reason, the SBA[68] includes a number of tasks that the JU, its Governing Board and its Executive Director (supported by the Programme Office) should carry out, which were then translated into specific activities in the SRIA.

Activities related to Synergies

The overall principle is that the JU activities shall be implemented in synergy with other Union programmes while aiming for maximal administrative simplification.

In line with the SBA, the JU will develop close cooperation and ensure coordination with other European partnerships, including by dedicating, where appropriate, a part of the joint

[68] See Articles 5(2), 17 (2), 19(4), 74, 82 and 83 of the SBA.

undertaking's budget to joint or complementary calls.

Moreover, it will seek and maximise synergies with and, where appropriate, possibilities for further funding from relevant activities and programmes at Union, national and regional level, in particular with those supporting the deployment and uptake of innovative solutions, training, education and regional development, such as Cohesion Policy Funds, or preparing for support from deployment funds like the Innovation Fund, or the National Recovery and Resilience Plans.

Activities related to Regulations, Codes and Standards

The Clean Hydrogen JU will contribute to supporting the implementation of hydrogen-specific regulatory and enabling frameworks by a strategic and coordinated approach to RCS issues within the Programme, which will mostly be implemented through Pre-Normative Research (PNR) activities. To this end, PNR activities will encompass research activities and desk research activities in view of supporting RCS developments.

Moreover, an RCS Strategy Coordination (RCS SC) Task Force composed of the Commission (incl. links with the European Clean Hydrogen Alliance and its plan on standardisation), Hydrogen Europe and Hydrogen Europe Research, and the Clean Hydrogen JU Programme Office (PO) will be set up to better coordinate these activities. Altogether, the RCS SC Task Force will contribute to coordinating and establishing an approach to enhance European participation and contribution in international and European RCS bodies while contributing to lay down a regulatory friction-less hydrogen market in Europe and beyond if possible. According to the SBA, the JU should also support the Commission in its work in the Clean Energy Ministerial (CEM) and International Partnership on hydrogen and fuel cells in the economy (IPHE) both entities working on standardisation.

Activities related to European Hydrogen Safety

Independently of the research and innovation actions addressing hydrogen safety issues, the Clean Hydrogen JU will retain and further reinforce the European Hydrogen Safety Panel (EHSP), aiming to support the development and deployment of inherently safer hydrogen systems and infrastructure.

The mission of the EHSP in the Programme is twofold:

- To assist the Clean Hydrogen JU at both programme and project levels, in assuring that hydrogen safety is adequately addressed and managed;
- To promote and disseminate a high-level hydrogen safety knowledge and culture within and beyond the Programme.

Activities related to European Hydrogen Sustainability and Circularity

The research and innovation actions under the Cross-cutting and the Hydrogen Supply Chain scientific priorities will play a key role in providing the methodological foundation to strengthen the sustainability and circularity of these technologies and their industrial value chains in Europe. Nevertheless, the transition towards a fully-fledged sustainable and circular hydrogen economy requires an integrated approach beyond these activities.

To this end, the Clean Hydrogen JU will set up a European Hydrogen Sustainability and Circularity Panel (EHS&CP) at the Programme level which will act as a focal point or "advisor" to the Programme in these matters in an independent, coordinated and consolidated way. This Panel started working in March 2024.

The EHS&CP will assist the Clean Hydrogen JU in assuring that sustainability and circularity aspects are adequately addressed and managed at both programme and project levels, encompassing environmental, social and economic aspects as a whole. Moreover, it will promote and disseminate knowledge and a more sustainable and circular culture within and beyond the Programme.

Activities related to knowledge management

The main goals of the Clean Hydrogen JU knowledge activities will be to support the collection and diffusion of high-quality new knowledge and support evidence-based implementation of Union policies.

It will monitor progress towards the achievement of the objectives of the Clean Hydrogen JU and its technology key performance indicators (KPIs), while strengthening the knowledge capacity of hydrogen value chain actors through data collection and knowledge collection.

Moreover, it will contribute to developing a more effective science-policy interface, fostering open science by ensuring better use of results and to addressing policy needs, as well as to promoting faster exploitation, dissemination and uptake of results.

Activities related to SMEs

The Clean Hydrogen JU will continue to rely on the innovativeness of SMEs. To do this, it will need to deal with two of the largest obstacles that SMEs must overcome, the need to raise financing, especially in the early stages of growth, and to kick-start sales and thereby gain valuable field experience.

In order to address the specific limitations and risks of SMEs, the Clean Hydrogen JU will continue to explore ways to open access to the necessary manufacturing and process capabilities through partnership schemes and education initiatives. It will help raise awareness of projects' results within the finance community, while at the same time trying to address the private sector funding and financing challenge that acts as a market barrier for deployment of hydrogen technologies and wider hydrogen integrated solutions.

Activities related to international cooperation

The Clean Hydrogen JU will build on the actions undertaken by its predecessor and expand them accordingly, in order to support the European Commission in the implementation of its international cooperation agenda in research and innovation.

Its activities will include strengthening the links with the major deployment programmes globally, continue providing technical support to the European Commission on its international activities in relation to hydrogen research and innovation, most notably in relation to the International Partnership for Hydrogen and fuel cells in the Economy (IPHE), the Clean Energy Ministerial Hydrogen Initiative, Mission Innovation 2.0 and Hydrogen Energy Ministerial. Similarly, the Clean Hydrogen JU Programme Office will continue to support the Joint Research Centre (JRC) and Directorate-General (DG) R&I by contributing to the Commission activities for the International Energy Agency (IEA) Hydrogen Technology Collaboration Programme (HTCP) where the Clean Hydrogen JU is participating in Task 41 on Analysis and Modelling of Hydrogen Technologies and Task 42 on Underground Hydrogen Storage.

Activities related to Communication

The JU will continue to undertake a number of communication activities with the objective to promote the development of the hydrogen technologies sector, build public awareness and acceptance of the hydrogen technologies and ensure communication towards and between stakeholders.

Among them, it will convene an annual European Clean Hydrogen partnership forum including Annual Programme Review and within the Hydrogen Week premises. The forum will include an independent scientific advisory workshop, aiming to gather independent opinions and advice of the wider scientific community on the Strategic Research and Innovation Agenda, work programmes and developments in adjacent sectors.

2. Work Programme 2025

2.1. Executive summary 2025 and message from the Executive Director

2.1.1. Message from the Executive Director

Dear Readers,

As we unveil the **Annual Work Plan (AWP) for 2025**, I am proud to reflect on the pivotal role the Clean Hydrogen Partnership continues to play in advancing hydrogen innovation across Europe. This fourth AWP represents a bold and forward-looking roadmap, addressing critical challenges in research and innovation while reinforcing the strategic priorities that underpin our shared vision for a sustainable hydrogen future.

With an indicative total budget of **€184.5 million** for the next call for proposals, we are restating our commitment to groundbreaking projects that will drive progress across renewable hydrogen production, storage and distribution, transport, and heat and power , in addition to cross-cutting topics. Moreover, in 2025, our efforts will continue supporting the **REPowerEU Plan**, which aims to double the number of Hydrogen Valleys in the EU by 2025. Hydrogen Valley projects can receive up to €80 million, illustrating their strategic importance in building a robust hydrogen value chain and fostering industrial synergies across Europe.

This year will also see advancements in strategic studies, knowledge management, and capacity building, all of which are crucial for scaling the hydrogen sector. The launch of the **Clean Hydrogen Knowledge Hub** and the continued development of the **Hydrogen Valleys Platform** under the activities of the **Hydrogen Valley Facility** will enhance our ability to consolidate data, share best practices, and provide tools that drive innovation and efficiency.

Importantly, our work in 2025 underscores the power of collaboration. **Synergies** with other European partnerships, Member States, and international bodies remain at the heart of our approach. Whether through cooperation on various topics such as regulatory frameworks, sustainability strategies, or educational initiatives, we are uniting stakeholders to create an integrated ecosystem for hydrogen technologies.

As we move forward, I invite all partners - current and future- to **join us in making 2025 a transformative year for hydrogen innovation.** Together, we can ensure that the Clean Hydrogen Partnership continues to deliver on its mission, strengthening Europe's leadership in decarbonised hydrogen technologies and driving the transition toward a sustainable energy future.

Let us seize the opportunities ahead with ambition, dedication, and collaboration.

Valerie Bouillon-Delporte,

Executive Director

Clean Hydrogen Partnership

2.1.2. Executive Summary

The fourth Annual Work Programme has been prepared in response to the challenges and R&I activities that still remain to be addressed within the context of the SRIA of the Clean Hydrogen Partnerhsip. It is also accordingly in alignment with the strategy for the implementation of the Programme, as described in Section 1.3.1.

In 2025, one Call for Proposals for an indicative total budget of EUR 184.5 million is foreseen. This includes EUR 80 million to support exclusively Hydrogen Valleys topics to support the REPowerEU Plan ambitions for doubling the number of Hydrogen Valleys in the EU by 2025. The budget of the Call also includes additional EUR 20 million from United Kingdom (UK) appropriations which are available to support projects in the reserve lists and will be allocated according to the Governing Board strategic priorities.

The Call addresses key challenges as identified by the stakeholders in the Clean Hydrogen JU. These challenges encompass different areas of research and innovation with direct and quantified impact towards the achievement of the objectives of the Clean Hydrogen JU in general and to each of the Pillars in particular. A total of 19 topics will be part of the call for proposals, including 7 for Renewable Hydrogen Production, 3 for Hydrogen Storage and distribution, 3 for transport and 1 for heat and power. In addition, 3 topics will support Cross-cutting issues. This call also includes 2 Hydrogen Valleys topics. They will be grouped into 11 Research and Innovation Actions (RIA), 7 Innovation Actions (IA), and 1 Coordination and Support Actions (CSA). Two of the Innovation Actions, on Hydrogen Valleys, are considered of strategic importance and are selected as flagship projects. Synergies with other European partnerships and programmes as well as with Member States and regional programmes are at the core of a number of topics.

The Call for Proposals will be subject to independent evaluation and will follow the Horizon Europe rules on calls for proposals. Upon selection, the Partners (the ‘consortium’) will sign a Grant Agreement with the JU. As in the previous JU Call, the Call 2025 will be implemented using lump sum grants. With this approach the JU aligns with other parts of Horizon Europe and bring simplification and efficiency gains across the overall grant management cycle.

In the same year, the Clean Hydrogen JU intends to also publish up to three Calls for Tenders, covering subjects of strategic nature for the JU, for an indicative amount of EUR 1.5 million These include an assessment of the legal and administrative processes relevant to fuel cell and hydrogen technologies across the EU and some associated countries, support to European ports to develop and mature plans for the use of hydrogen and support the implementation of the requirements included in the Alternative Fuels Infrastructure Regulation including the obligation of operators of having publicly accessible (hydrogen) refuelling stations. The exact scope of these studies will be further elaborated while preparing the tender specifications to avoid duplication with planned activities in these areas.

The Clean Hydrogen JU will continue to contribute towards the implementation of EU Policies through different means. For instance, the Clean Hydrogen JU will continue to support DG CLIMA on a number of initiatives aiming at bringing the JU family of projects closer to the Innovation Fund programme. As requested, we will continue to provide input to the activities of the Hydrogen Bank. The JU is also ready to continue supporting DG GROW and cooperate with the European Clean Hydrogen Alliance (ECH2A) activities, to ensure synergies. Building on the cooperation that started in 2023, the JU will continue collaborating and supporting DG GROW to reach the ambitions of the EU Net-Zero Industry Act on the area of hydrogen in general and concerning skills in particular. On the maritime sector, the collaboration with European Commission services and Zero Emission Waterborne Transport (ZEWT) on fostering the development of alternative powertrains and supply of zero emissions fuels will continue. The Clean Hydrogen JU will continue following and contributing as necessary to the Strategic Energy Technology Plan (SET-Plan) activities, in particular to the Implementation Working Group (IWG) on “Renewable Fuels and Bioenergy” where the Clean Hydrogen JU is participating in the Core Group and the recently established IWG on “Green Hydrogen

A new Framework Agreement between Clean Hydrogen JU and the JRC was signed in the spirit of the previous Framework Contract. The annual Rolling Plan 2025 was agreed in 2024 and will be implemented in 2025. It consists of the annual activities and their related deliverables provided by JRC, which include the support to the regulations, codes and standards strategy and its implementation, its contribution to the Programme monitoring and assessment, as well as the JRC contribution to the assessment of sustainability of hydrogen and fuel cells.

In terms of knowledge management, the JU will continue with the annual data collection exercise from its projects and the publication of the Annual Programme Review Report, planned to be published end of 2025. In 2025, the JU will continue supporting the European Hydrogen Observatory and related contract. In addition, the activities of the Clean Hydrogen Knowledge Hub will begin. The Knowledge Hub will be a single platform that will not only address many of the aspects regarding access and handling of the data, but also encompass information and data from the available tools/platforms into an integrated new system. Moreover, the Hydrogen Valley platform (H2V), will be funded by the JU within the context of the Hydrogen Valleys Facility contract activities. Also in 2025, the first deliverables of the Knowledge Hub project, i.e. the Project Repository and the internal Knowledge Hub analytical tool/platform are expected. After their completion, the Knowledge Hub will be expanded with additional tools and functions, link with other platforms supported by the JU to allow the exchange of data, while also launching a public portal towards the summer of 2025.

Building already on experiences (and success stories) of the JU’s predecessors as well as in the first years of the Clean Hydrogen Partnership, synergies have become a central piece of the 2021-2027 multi-annual financial framework. In 2025, the JU will continue with a structured cooperation with relevant European partnerships, EU agencies and other EU funding programmes, including those managed nationally or regionally by Managing Authorities.

In 2025, the Regulations, Codes and Standards Strategy Coordination (RCS SC) Task Force will continue to contribute to coordinating and establishing an approach to enhance European participation and contribution in international and European RCS bodies while contributing to lay down a regulatory friction-less hydrogen market in Europe and beyond if possible.

Similarly, the European Hydrogen Safety Panel will continue its activities, performing safety plan reviews, updating its guidance documents, providing guidance in developing areas (e.g. heavy transport), performing public outreach and continuing with its data collection and assessment activities. In addition, the JU will continue supporting the activities of the European Hydrogen Sustainability and Circularity Panel which already started in 2024.

The Clean Hydrogen JU will continue supporting the European Commission in its international cooperation activities. It will continue its work in relation to the harmonisation of the regulatory and policy frameworks, as well as safety and education. Moreover, as needed, it will continue its involvement in some working groups of the IEA Hydrogen Technology Collaboration Program. Finally, it will continue supporting the Hydrogen Valleys platform, while contributing also towards the other activities of Clean Hydrogen Mission under MI2.0. International collaboration.

As part of the knowledge management activities, but also in the context of the Project Management workflow, the Programme Office will continue its activities in dissemination and exploitation of project results. It will continue participating in the Innovation Radar, while also promoting other tools supporting further exploitation and dissemination.

Communication and outreach activities in 2025 will have three main goals. Firstly, to position the Clean Hydrogen JU as the main EU tool for the funding of hydrogen research and technology demonstration in Europe. Secondly, to establish Clean Hydrogen's reputation as a centre of knowledge on hydrogen technologies at EU level and thirdly to increase awareness, acceptance, and uptake of clean hydrogen. In 2025, the JU will also organise a number of events with both online and physical presence including European Clean Hydrogen Partnership Forum. In continuation of the previous years, the JU will actively involve and consult with its two advisory bodies, the States Representatives Group (SRG) and the Stakeholders Group (SG) on the different activities expected for 2025.

In all its activities, the Clean Hydrogen JU shall fully comply with the requirements of Regulation (EU, Euratom) 2018/1046 (the Financial Regulation). In compliance with its Article 71, the Joint Undertaking will respect the principle of sound financial management. It shall also comply with the provisions of the Financial Rules adopted in 2019.

As in previous years, an assessment of corporate processes and procedures will be done, and where relevant they will be further streamlined, using the opportunities offered by new corporate tools (for financial, HR and procurement processes) in combination with back office arrangements services as well as own continuous improvement actions.

The Clean Hydrogen JU is the lead JU for the back office arrangement on Information and Communications Technology (BOA ICT), with the Innovative Health Initiative Joint Undertaking (IHI JU) as co-lead. For other areas of shared services (namely, for back office arrangements, Accounting, HR, Procurement and Facility Management) the Clean Hydrogen JU is a beneficiary or a contributor.

Furthermore, the Clean Hydrogen JU will closely monitor the implementation of its budget and its Staff Establishment Plan.

2.2. Operational activities of Clean Hydrogen JU for 2025

2.2.1. Objectives, Indicators and Risks

2.2.1.1. Objectives

The operational activities of the Clean Hydrogen JU contribute towards achieving the legal objectives of the JU, as reflected through its implementation strategy of the Programme and its Strategy Map, presented in Section 1.3.1. The links between the specific operational activities planned for 2024 with the Strategy Map are presented in Annex 0.

2.2.1.2. Key Performance Indicators

The Clean Hydrogen JU has established a monitoring framework to track the progress towards its objectives as set out in the SBA and the Horizon Europe Regulation, as well as its contribution towards the priorities of the Union and the SRIA[69].

The JU will monitor a number of Key Performance Indicators as described in Section 7 of its SRIA. These indicators can be grouped in the following categories:

- Horizon Europe KPIs[70], defined in the Horizon Europe Regulation as Key Impact Pathways and applicable for the whole Horizon Europe Programme;
- Common JU Indicators, as defined in the monitoring framework[71] developed by the Expert Group set up to support the strategic coordination process of the European R&I partnerships through a more strategic monitoring for European Partnerships, including the preparation of the Biennial Monitoring Report[72];
- Clean Hydrogen JU KPIs, defined by the Clean Hydrogen JU[73] for the purpose of monitoring the progress towards the objectives of the Strategy Map and its relevant targets;
- Technology KPIs, defined by the Clean Hydrogen JU[74] to monitor technology progress and innovation of its projects towards the R&I priorities defined in the SRIA.

The third category of these KPIs, the ones specific for the Clean Hydrogen JU present in Table 1 below, are the ones that are used to evaluate the performance of the JU as an entity and provide quantifiable means to measure any associated risks towards the achievement of its objectives.

[69] Articles 5.2(h), 17.2(a), 19.4(f)/(g)/(o), 36, 74(a) and 171 of the SBA.
[70] HE Regulation Art 50(1) & SBA Art 171(2)(a-c-d-e)
[71] A robust and harmonised framework for reporting and monitoring European Partnerships in Horizon Europe, 2021, RTD, https://op.europa.eu/en/publication-detail/-/publication/6b63295f-d305-11eb-ac72-01aa75ed71a1
[72] https://research-and-innovation.ec.europa.eu/document/04974c33-68e6-4f20-a818-a46e4ecfaa09_en
[73] Annex I of the SRIA
[74] Annexes II-VI of the SRIA.

Table 1 Clean Hydrogen JU KPIs, monitoring the progress towards the objectives of the Strategy Map[75]

KPI Name		Unit of measurement	Baseline	Actual 2023[a]	Target 2023	Target 2025	Target 2027	Ambition 2030	Status
Resources (input), processes and activities									
1. Supporting climate neutral and sustainable solutions	1a. Hydrogen end-use solutions in hard to abate sectors	% of JU budget	2.5[b]	21	15	30	40		On track
	1b. Circular and sustainable solutions	% of JU budget	< 1[b]	6	5	10	15		On track
2. Early research projects		% of budget	10[b]	13	10	10	10		On track
3. Demonstration projects		# of projects	43[b]	19	20	40	60		On track
4. Education and training		# of projects	4[b]	3	2	4	6		On track
5. Monitoring technology progress		*Qualitative indicator*	N/A	AAR23[c]	N/A	N/A	N/A		On track
6. Supporting EC in H2 market uptake		*Qualitative indicator*	N/A	AAR23[c]	N/A	N/A	N/A		On track
Outcomes									
7. Environmental impact and sustainability	7a. Reduction in the use and increase in the recycling rate of Critical Raw Materials (CRM)	% of CRM relevant KPIs reached	0	N/A[d]	N/A	75[e]	75	100	N/A[d]
	7b. Improvement in the quality of Life Cycle Assessments (LCA)	Quality of LCA submitted by projects (rating in %)	60[b]	N/A[d]	N/A	65	70	75	N/A[d]

[75] The reported KPIs and their values/baselines/targets may differ in some cases compared to the past, following certain updates in the methodology and data sources, including the first SRIA amendment in June 2024.

KPI Name		Unit of measurement	Baseline	Actual 2023[a]	Target 2023	Target 2025	Target 2027	Ambition 2030	Status
Resources (input), processes and activities									
8. Capital cost of hydrogen applications	8a. Capital cost of electrolysers	% reduction across electrolyser technologies	100	N/A[d]	N/A	65	55	45	N/A[d]
	8b. Capital cost of heavy-duty road applications	Cost of FC module CAPEX in €/kilowatt	1,500	N/A[d]	N/A	420	290	100	N/A[d]
9. Research and Innovation Synergies		# of projects	5[b]	12	5	10	20		On track
10. Public perception of hydrogen		*Qualitative indicator*	N/A	AAR23[c], project HYPOP[f]	N/A	N/A	N/A		On track
11. Total persons trained		# of persons in thousands	5[b]	N/A[d]	N/A	110	160	240	N/A[d]
12. Patents and publications		# of patents / publications	12[b]/ 289	21/ 224	17/ 100	25/ 400	25/ 450		On track[g]
13. Promoting cross-sectoral solutions		% of budget	15[b]	14	10	15	25		On track
Impacts* **(KPIs reporting progress of hydrogen sector at EU level, to which the JU is contributing)**									
14. Expected avoided emissions		Million tonnes of CO2-eq/year	0.085	0.18[h]	N/A	N/A	N/A	223	Off track[i]
15. Deployment of electrolysers		Gigawatt	0.077	0.222[h]	4	6	10	40	Off track[i]
16. Market uptake of clean hydrogen		Mt of clean hydrogen consumed	0.008	0.022[h]	0.7	1	2	10	Off track[i]
17. Total cost of producing renewable hydrogen		€/kg	8	6.76[h]	6.5	5.5	4.5	3	On track
18. Size of private hydrogen sector	18a. Activity in terms of companies	# of companies	300	1,121[h]	1,000	1,500	2,000	-	On track
	18b. Activity in terms of projects in the pipeline (ongoing or under construction)	# of Projects	50	125[h]	200	500	800	-	Off track[j]
	18c. Electrolyser manufacturing capacity	GW/year	1	4.4[h]	5	17.5	30	-	Off track[k]

* The set of KPIs under "impact" report the progress of the hydrogen sector at EU level, to which the JU is contributing. Targets for KPI-14 to KPI-17 are based on the relevant ambition set in EU's Hydrogen Strategy. Targets for KPI-18a and KPI-18b are based on current trends and expectations for the sector, while KPI-18c reflects the 2025 target mentioned in the Joint Declaration signed between the European Commission and the European electrolysers manufacturers in May 2022. For this set of KPIs, the status refers to Europe as a whole and not on the individual performance of the JU, helping to identify where more effort should also be placed by the JU in the coming years.

[a] The latest values available on October 2024 are reported. For KPIs (#1-4, 9, 13) these reflect the signed grants of Call 2023. For the KPIs on project results (#7, 8 and 11) there is nothing to report yet, as the first grants where only signed in 2023. For KPI 12 the latest data by the end of 2023 are reported, as reported in the latest Annual Activity Report of the JU (AAR 23). All KPIs on impacts (14-18) come from the latest available data on the European Hydrogen Observatory. For the qualitative KPIs (#5-6, 10), these are described in AAR23. The methodology for the calculation of all KPIs is described in detailed in the corresponding methodology document published on the JU website.

[b] Baseline refers to the achievement over the lifetime of the predecessor partnership (FCH 2 JU).

[c] More information about this KPI can be found in Section 5.5 of Clean Hydrogen JU's Annual Activity Report 2023 (published July 2024).

[d] First relevant project was signed only in first half of 2023, more are expected to be signed by end of 2023. Results will become available gradually as the projects advance, mostly towards the end of the projects.

[e] Target for 2025 measured against SRIA 2024 targets, while targets for 2027 and 2030 measured against SRIA 2030 targets.

[f] https://www.clean-hydrogen.europa.eu/projects-repository/hypop_en

[g] Reported figures concern 2023 coming from Annual Activity Report 2023. Current main source of data is eGrants, but it is considered incomplete, especially in relation to patents. The JU is currently working with JRC to improve the data collection methodology concerning this series.

[h] Calculated from the European Hydrogen Observatory, using values only for EU27 countries; data extracted on October 2024. KPI-14 was calculated using the methodology proposed by the Observatory contractors. KPI-15 is extracted from the hydrogen production data, while KPI-16 from the hydrogen demand data. KPI-17 comes from cost of hydrogen production data, KPI-18a from the market directory (not counting associations, public entities, universities and research institutes), KPI-18b from the hydrogen production and consumption projects – but only for clean hydrogen -, while KPI18c from the electrolyser manufacturing capacity data.

[i] KPIs 15-16 are off track, and thus KPI 14 which is directly linked to them, as despite the ambitiousness of the Hydrogen Strategy hydrogen technologies require more time and research to be ready for commercialisation and scaling up. Nevertheless, the significant funding planned via the European Hydrogen Bank and other European, regional and national instruments may be able to turn this around in the coming years. This can be further supported by the activities of the Clean Hydrogen JU, which although may have a limited direct impact to these deployment figures due to its small budget compared to the ambition, it can play an important role in increasing the technology readiness of the hydrogen solutions, allowing their faster market uptake.

[j] Please note that the Observatory only tracks clean hydrogen projects. Therefore, this KPI is off track when referring only to clean hydrogen projects. Nevertheless, delays in hydrogen projects are significant globally, as reported in all major reports, e.g. the IEA's Global Hydrogen Review 2024 and Hydrogen Council's Hydrogen Insights 2024.

[k] This number concerns operational capacity by May 2024, with additional 1.0 GW/year being operational in UK and Norway.

2.2.1.3. Risk Assessment

An annual risk assessment exercise was conducted in October 2024 in the form of all staff workshop, for the purpose of identifying, analysing and responding to key risks (including fraud risks) across all of the areas of responsibility of the JU.

The risk identification in the JU started with the assessment of the relevance of the risks and related action plans identified in the previous risk-assessment exercises and continued with the identification of any new relevant risks.

During the risks assessment exercise in 2024, the following guiding questions were asked:

- Are the risks and action plans identified in the previous year's exercise and presented in the AWP 2024 still relevant?
- Are there any significant risks to the achievement of JUs' objectives that emerged during the course of the year 2024?
- Are there any new fraud-related risks which are not covered by controls in place?
- Are there any significant changes in the external/internal environment that can have a significant impact on our organization in 2024 and beyond?

Establishing clear and comprehensive action plans in response to identified risks enables the JU to prioritize allocation of the JU's resources and tasks to adequately and timely address those most significant risks.

Following the EC methodology for risk measurements in terms of impact and likelihood[76], high and medium risks, together with the action plans are presented below:

[76] Ref. to Risk Management in the Commission, Implementation Guide, Version updated in September 2022

Risk Abbreviation	Risk Identified	Action Plan
Insufficient Manpower	Risk of not meeting H2020 and Horizon Europe objectives due to insufficient manpower, as the Programme Office is running two framework programmes simultaneously, H2020 and Horizon Europe with increased 50% of the budget and additional budget from the RePowerEU (approx. one half to be committed in the first two years), with only two additional FTEs for 2022 - 2027. Additional interconnected risks could result from high staff turnover. Back-office arrangements are helping to harmonize the working processes but have revealed that they do not represent a solution for the headcount issue. External Service Provider for the operations and communication activities are hired but, in the area, restricted by the PTA engagement contract.	The JU will continue to use service contracts for support activities in the operations and communication activities, while increased coordination will be explored through synergies with other joint undertakings on administrative activities. The JU will continue to implement simplification models (i.e. lump sum). The JU will continue to analyse and monitor tasks allocated among staff members to measure the staff workload and take appropriate measures. The JU will continue to explore best ways to shorten recruitment time for staff by using other JUs reserve list. The JU will, on an ad-hoc basis continue to publish vacancy posts to get a reserve list at disposal to prevent the gap between the arrival and departure of a staff member. The JU will continue to discuss with the Governing Board (GB) on the adequacy of the current staff establishment plan supported with a real workload analysis for the entire organization. The Governing Board should be continuously informed on the manpower situation and should be informed and provide guidance accordingly.
Synergies	Risk of missing opportunities for synergies with other partnerships and other EC programmes or Member States (MS)/regional funds for hydrogen technologies due to lack of strategic guidance and consequently JU proper involvement in programming activities.	The JU shall, based on the results of the Internal Audit Service (IAS) audit on operational synergies, develop and implement an overall synergies' strategy including a systemic approach to the three levels of synergies listed in the Single Basic Act (SBA) (i.e. with other partnerships, other programmes and at national/regional level), under the orientation and guidance of its GB, with input from the JU's advisory bodies, and taking into account the experience gained so far. The JU will consider the different approaches suggested by the IAS to develop an overall synergies' strategy. In the meantime, the Programme Office will continue to plan, implement and report on already identified synergies. The JU will continue to report to the Governing Board and will continue to seek strategical guidance and orientation.

Risk Abbreviation	Risk Identified	Action Plan
Membership Data	Risk that in-kind contributions in projects are not timely and fully recognised, due to lack of clear identification and timely update of private members membership (of Hydrogen Europe and Hydrogen Europe Research) status within JU projects. In addition, there is a risk that beneficiaries (non-members) could be indirectly contributing to JU administrative expenses, which could result in non-compliance of the JU financing rules. This can result in a potentially high negative impact on the JU reputation.	The JU will continue to work on a process to ensure eligibility criteria and their continuous monitoring throughout lifetime of the projects. The JU will continue an active dialogue with the private members and with the Commission central services to further develop the information technology (IT) tools for sufficient data accuracy. In addition, the JU will continue reminding to the stakeholders the provision of the JU Financial Rules, in particular article 32.
Projects Execution	Risk that program objectives will not be achieved fully and timely due to delays in project execution attributed to COVID-19, geopolitical instability, inflation situation and due to hydrogen market changes. There is a negative impact on duration of the projects, including FIDs ("Final Investment Decision") for demonstration projects as regards co-funding, and consequently on budget execution and programme reaching its objectives. Due to war in Ukraine and Middle East, there is an increased disruption in value chain and a general economic impact of the war (increase prices and scarcity of raw materials and energy resources).	The JU will continue to closely monitor the planned activities and budget. The JU will monitor any delays in the project, restructuring of the projects, if necessary, granting project extension via the amendment process. The JU will maximise the use of the carry overs through reallocation of fund sources of projects. The JU will quarterly report to the Governing Board on budget execution.

The JU will report on the status of the completion of the action plans as identified above in its annual activity report for the year 2025.

The risk assessment process is iterative rather than a one-time exercise. Changes can occur due to factors over which the organization has no control (e.g. COVID-19, international conflicts); factors that the organization can control, such as revision of strategic priorities or operational changes; and adjustments in key personnel (leadership changes). The JU is vigilant for these types of changes and recognize that any significant change may result in the need for a new or updated risk assessment related to areas that are affected by the changes.

2.2.2. Scientific priorities, challenges and expected impacts

Throughout its duration, the Clean Hydrogen JU will provide financial support mainly in the form of grants to participants following open and competitive calls for proposals. The awarded Grants are the main instrument of the Clean Hydrogen JU to implement the actions that are needed to reach the SRIA objectives.

In line with the structure of the SRIA, topics in the Call for Proposals are clustered according to Pillars (scientific priorities). Topics under a specific pillar contribute mainly to the objectives of that particular Pillar. Sometimes a topic can contribute to the objectives of several pillars.

In line with the approach of Horizon Europe, the topics in this Call for Proposals have been written following an impact driven approach and in line with the standard structure proposed under Horizon Europe. In this regard, each of the topics include a section on expected outcomes and another one on the scope.

To maximise the impacts that can be achieved by each of the topics, the ‘expected outcome' section for all topics includes:

- The outcomes that are expected to be reached as a consequence of the achievements of a particular project;
- The SRIA objectives that for a specific Pillar are addressed by each of the topics. This is complemented by the inclusion of Programme KPIs[77] that each of the topics (and successful proposals) should reach.

The above structure is aligned with the monitoring strategy of the Clean Hydrogen JU. It will allow a streamlined approach to monitor how the Grants that will be supported contribute to the achievements of the Clean Hydrogen JU goals.

In 2025 the Call for proposals will contribute to the objectives of the Clean Hydrogen JU as described below - more detailed information how each of the topics contribute to achieving the objectives of each Pillar is included in the Annexes.

Scientific priority – Renewable Hydrogen production

Hydrogen will be an integral part of REPowerEU Plan. A target of 10 million tonnes of domestic renewable hydrogen production has been set, to replace natural gas, coal and oil in hard-to-decarbonise industries and transport sectors. To seize this opportunity and keep European electrolyser industry at the forefront and to support the achievement of the EU performance and cost targets it is necessary to translate our scientific excellence into technological industrial leadership.

Contributing to the objectives for 2025, the Clean Hydrogen Joint Undertaking (JU) will

[77] Detailed information on the objectives and KPIs available in the Clean Hydrogen JU Strategic Research and Innovation Agenda 2021 – 2027

continue its support for cutting-edge research and innovation in hydrogen technologies. In 2025, particular focus will be given to improving the **lifetime** and **cost-efficiency** of both **low-temperature** and **high-temperature electrolysers** through the introduction of **advanced and innovative materials** and components in both the **stacks** and the **balance of plant** (BoP). These efforts will aim to enhance overall performance and reduce operational costs in hydrogen production.

Further, the 2025 Call will support activities focused on the **scale-up and optimization of manufacturing processes** for electrolyser materials, cells, and stacks. This will ensure that the sector can meet growing demand while maintaining efficiency and quality standards.

In addition to standard electrolysis advancements, **innovative co-electrolysis systems** will be supported, aiming for seamless integration with downstream processes. This will allow for the efficient production of multiple products from electrolysis, improving both resource use and process efficiency.

Recognizing the importance of efficient coupling of electrolysis with renewable energy, support will be provided for demonstration (innovation action) projects that optimize the integration of electrolysis with **variable renewable electricity** and/or **heat** sources, ensuring enhanced operational flexibility and reduced environmental impact.

In addition, the Call 2025 will support the demonstration of **novel processes for hydrogen and solid carbon production** using **renewable gases** and **biogenic waste**. With this approach hydrogen and solid carbon from renewable gases/biogenic wastes can be embedded into a circular and life cycle thinking approach for the co-production of green carbon, chemicals, fertilisers and/or decarbonised materials.

Lastly, the Call 2025 will explore the potential of **natural hydrogen** in Europe by supporting a topic aimed at better understanding the mechanisms related to natural hydrogen generation as well as the development of methods to assess the resource potential in Europe.

Scientific priority - Hydrogen Storage and distribution

According to the same REPowerEU ambitions published in May 2022, about 10 million tonnes of renewable hydrogen should also already be distributed throughout Europe in 2030. It is therefore essential that hydrogen becomes an intrinsic part of an integrated energy system. For this to happen, hydrogen will have to be used between daily and/or seasonal storage. In addition, an EU-wide logistical infrastructure is still to be developed (to transport hydrogen from areas with large renewable potential to demand points across Europe). Significant work is therefore still needed to have a complete set of technologies that can serve as building blocks for such EU-wide logistical infrastructure.

In 2025, the Clean Hydrogen Joint Undertaking will expand its support for innovations in **hydrogen storage, transport, and distribution**. Key focus areas will include the development of advanced technologies that enable efficient and scalable hydrogen infrastructure.

One major area of support will be the **development of mined and lined rock caverns for hydrogen storage**. These caverns will provide a **cost-effective and safe solution** for large-scale hydrogen storage, crucial for managing supply and demand fluctuations and ensuring stable hydrogen distribution.

Additionally, the JU will invest in research aimed at developing **high-capacity and cost-effective compression solutions** for hydrogen. These innovations will help reduce the cost of compressing hydrogen for transport and storage, addressing a critical challenge in the hydrogen supply chain.

Further emphasis will be placed on demonstrating **modular and scalable ammonia cracking technologies**. These technologies will facilitate the efficient conversion of ammonia back into hydrogen, enabling its use as a **transport medium** and expanding the possibilities for hydrogen storage and transport over long distances.

Scientific priority - Hydrogen end uses - transport

In 2025, the Clean Hydrogen Joint Undertaking will enhance its focus on **hydrogen-powered transport** by supporting key research and innovation activities aimed at advancing fuel cell technologies and expanding their applications in various sectors.

One area of support will be the **development and demonstration of configurable fuel cell powertrains for non-road mobile machinery**. This initiative aims to enable **adaptable, efficient, and scalable fuel cell solutions** tailored to machinery used in sectors such as agriculture and port environments where hydrogen-powered alternatives can significantly reduce emissions and improve operational flexibility.

The Call 2025 will also focus on advancing **scalable and innovative processes for producing Proton Exchange Membrane (PEM) fuel cell membrane electrode assemblies (MEAs)**. This research will aim to lower production costs and increase the efficiency of Proton Exchange Membrane Fuel Cells (PEMFC), which are crucial for expanding hydrogen applications in transportation.

Finally, the JU will support the ***development*** **of a reliable, efficient, scalable, and low-cost 1 MW-scale fuel cell system for the maritime sector**. Support in this area will contribute to the decarbonization of shipping, demonstrating hydrogen's potential as a **clean and sustainable fuel** for large-scale maritime applications.

Scientific priority - Hydrogen end uses - clean heat and power

In 2025, the Clean Hydrogen Joint Undertaking will continue to support the transition to cleaner energy systems by investing in the **demonstration of stationary fuel cells in renewable energy communities**. This initiative aims to showcase how **fuel cell technologies** can be integrated into local energy networks, providing **reliable, efficient, and clean power** to homes and businesses.

By enabling the use of stationary fuel cells in renewable energy communities, this action will help **optimize energy self-sufficiency**, reduce reliance on fossil fuels, and enhance the resilience of community-level energy systems. The goal is to demonstrate the practical and scalable deployment of hydrogen technologies in everyday energy use, contributing to a **more sustainable and decentralised energy future**.

Scientific priority - Cross-Cutting activities

In 2025, the Clean Hydrogen Joint Undertaking will support several **cross-cutting initiatives** designed to enhance sustainability, safety, and knowledge dissemination across the hydrogen value chain. These efforts aim to address key challenges that impact multiple areas of hydrogen technologies, from materials recycling to environmental safety and regulatory processes.

One of the focus areas will be **simultaneous ionomer and iridium recycling**, a critical step towards improving the sustainability of hydrogen production technologies by reducing the dependency on scarce and expensive materials. This will support the development of advanced recycling methods that enable the recovery and reuse of these valuable resources from electrolyser and fuel cell components.

In addition, research will be conducted to improve the understanding of **PFAS emissions** from electrolysers and/or fuel cells during product use. This will help assess potential environmental impacts and ensure that hydrogen technologies align with strict environmental standards, promoting safer and cleaner applications.

To further support the hydrogen sector's growth, the JU will provide funding for **developing and implementing training programs** aimed at **civil servants, safety officials, and permitting staff**. These programs will focus on improving safety assessments and streamlining licensing procedures across Europe, ensuring that hydrogen technologies are deployed in a safe, efficient, and compliant manner, specially for hydrogen valleys.

Scientific priority - Hydrogen Valleys

The REPowerEU Plan strives to have Hydrogen Valleys established in all Member States and to double the number of Hydrogen Valleys across Europe by 2025. To support this ambition, in 2025 the Clean Hydrogen JU will continue supporting several flagship[78] Hydrogen Valleys of different scales.

[78] For definition of flagship see section 5.3 of SRIA

Table 2 Correspondence of topics into the different scientific priorities

	Topic identifier	Topic Title	Type
Renewable Hydrogen	HORIZON-JU-CLEANH2-2025-01-01	Improvements in lifetime and cost of low temperature electrolysers by introducing advanced materials and components in stacks and balance of plant	RIA
	HORIZON-JU-CLEANH2-2025-01-02	Improved lifetime and cost of high-temperature electrolysers by introducing innovative materials and components in stacks and BoP	RIA
	HORIZON-JU-CLEANH2-2025-01-03	Scale-up and Optimisation of manufacturing processes for electrolyser materials, cells, or stacks	RIA
	HORIZON-JU-CLEANH2-2025-01-04	Efficient electrolysis coupling with variable renewable electricity and/or heat integration	IA
	HORIZON-JU-CLEANH2-2025-01-05	Innovative co-electrolysis systems and integration with downstream processes	RIA
	HORIZON-JU-CLEANH2-2025-01-06	Innovative hydrogen and solid carbon production from renewable gases/biogenic waste processes	IA
	HORIZON-JU-CLEANH2-2025-01-07	Towards exploration and evaluation of European natural hydrogen potential	RIA
Hydrogen storage and distribution	HORIZON-JU-CLEANH2-2025-02-01	Development of mined, lined rock cavern for gaseous hydrogen storage	RIA
	HORIZON-JU-CLEANH2-2025-02-02	Development of cost effective and high-capacity compression solutions for hydrogen	RIA
	HORIZON-JU-CLEANH2-2025-02-03	Demonstration of scalable ammonia cracking technology	IA
End uses: transport applications	HORIZON-JU-CLEANH2-2025-03-01	Configurable Fuel Cell Powertrain for Non-Road Mobile Machinery	RIA
	HORIZON-JU-CLEANH2-2025-03-02	Scalable innovative processes for the production of PEMFC MEAs	RIA
	HORIZON-JU-CLEANH2-2025-03-03	Reliable, efficient, scalable and lower cost 1 MW-scale PEMFC system for maritime applications	RIA
End uses: heat & power	HORIZON-JU-CLEANH2-2025-04-01	Demonstration of stationary fuel cells in renewable energy communities	IA
Cross-cutting Issues	HORIZON-JU-CLEANH2-2025-05-01	Simultaneous ionomer and Iridium recycling	RIA
Cross-cutting Issues	HORIZON-JU-CLEANH2-2025-05-02	Understanding emissions of PFAS from electrolysers and/or fuel cells under product use	RIA
	HORIZON-JU-CLEANH2-2025-05-03	Knowledge transfer and training of civil servants, safety officials, and permitting staff	CSA
Hydrogen Valleys	HORIZON-JU-CLEANH2-2025-06-01	Large-scale Hydrogen Valley	IA (flagship)
	HORIZON-JU-CLEANH2-2025-06-02	Small-scale Hydrogen Valley	IA (flagship)

2.2.3. Call for Proposals

2.2.3.1. Overview of the Call

The AWP 2025 includes one Call for Proposals as follows:

Call Identifier	Budget (EUR million)	Publication[79]	Deadline
HORIZON-JU-CLEANH2-2025	184.5	15 January 2025	23 April 2025

The Call for Proposals has an indicative total budget of EUR 184.5 million. This includes a part of the RePowerEU as well as of the UK appropriations as follows:

- The European Commission (EC) in its communication "REPowerEU Plan[80]" announced an additional investment of EUR 200 million available[81] for the Clean Hydrogen JU for doubling the number of Hydrogen Valleys in the EU by 2025.

  In that respect, the budget of this Call of EUR 184.5 million includes an amount of EUR 80 million from the RePowerEU Plan to support exclusively Hydrogen Valleys as follows:

  - at least one large-scale Hydrogen Valley and one small-scale Hydrogen Valley from the Call 2025 ranking list[82] will be selected for funding provided they meet the required thresholds;
  - additional Hydrogen Valleys proposals from the Call 2025 ranking list[83] will be further selected for funding in order to optimise the use of this available budget

- The budget of this Call of EUR 184.5 million includes additional EUR 20 million from United Kingdom (UK) appropriations which are available to support projects in the reserve lists and will be allocated according to the Governing Board strategic priorities.

Topic descriptions are detailed starting from the next page.

The general call conditions are detailed in section 2.2.3.2.

Common elements applicable to all topics have also been included in section 2.2.3.2 (some of which, when relevant, are also reflected in the topic scope).

In addition, specific conditions have been included in the description of each topic.

79 The Executive Director may decide to open the call up to one month prior to or after the envisaged date of publication.
80 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2022%3A230%3AFIN&qid=1653033742483
81 Allocated as follows: 60 MEUR Call 2023, 60 MEUR Call 2024 and 80 MEUR Call 2025.
82 The two topics on Hydrogen Valleys will have a combined ranking list for the available budget of 80 MEUR
83 The two topics on Hydrogen Valleys will have a combined ranking list for the available budget of 80 MEUR

RENEWABLE HYDROGEN PRODUCTION

HORIZON-JU-CLEANH2-2025-01-01: Improvements in lifetime and cost of low temperature electrolysers by introducing advanced materials and components in stacks and balance of plant

Specific conditions	
Expected EU contribution per project	The JU estimates that an EU contribution of maximum EUR 4.00 million would allow these outcomes to be addressed appropriately.
Indicative budget	The total indicative budget for the topic is EUR 4.00 million.
Type of Action	Research and Innovation Action
Technology Readiness Level	Activities are expected to start at TRL 3-4 and achieve TRL 5-6 by the end of the project - see General Annex B.
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G. The following exceptions apply: Eligible costs will take the form of a lump sum as defined in the Decision of 7 July 2021 authorising the use of lump sum contributions under the Horizon Europe Programme – the Framework Programme for Research and Innovation (2021-2027) – and in actions under the Research and Training Programme of the European Atomic Energy Community (2021-2025)[84].

Expected Outcomes

According to IEA's Global Hydrogen Review 2023[85], the global hydrogen production in 2022 was dominated by the use of fossil fuels while low-emission hydrogen production was less than 0.7% of the global production. A large number of low-emission hydrogen production projects are under development with projected annual production of up to 38 Mt by 2030. Among these, electrolysers projects dominate and aim at reaching 70% of low-emission hydrogen production. Particularly, Europe announced to account almost 30% of such electrolytic hydrogen projects by 2030 and is focused on projects boosting the supply of low-carbon and renewable hydrogen.

Given hydrogen's potential as a clean energy vector and chemical feedstock, and its applicability across various sectors including transportation, industry, and integration of renewables in the power grid, optimising the efficiency and longevity of electrolysers is of paramount importance. This necessity gives rise to the significance of this topic, aimed at developing advanced materials and/or components for the stack and BoP (Balance of Plant), by understanding and mitigating the degradation mechanisms of low temperature electrolyser components, while at the same time further improving their performance and reducing their reliance on critical raw materials (CRM). By focusing on the development and integration of advanced materials in stack, and BoP components that don't induce degradation or reliability

[84] This decision is available on the Funding and Tenders Portal, in the reference documents section for Horizon Europe, under 'Simplified costs decisions' or through this link: https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/guidance/lsdecision_he_en.pdf

[85] IEA (2023), Global Hydrogen Review 2023, IEA, Paris https://www.iea.org/reports/global-hydrogen-review-2023, Licence: CC BY 4.0

issues or even mitigate degradation, proposals are expected to make a substantial contribution to prolong the lifetime of low temperature electrolysers and demonstrate cost reduction.

Project results are expected to contribute to the following outcomes:

- Development of advanced cell, stack, and BoP components, including functional and structural materials exhibiting an improved performance and engineered to counteract degradation mechanisms;
- Increasing the lifetime of electrolysers;
- Innovations that reduce the need for CRM and/or Platinum Group Metals (PGM);
- Improved circularity of materials and components;
- Increase understanding of relevant degradation mechanisms of materials and/or components and demonstrating effective mitigation using developed materials and/or components.

The topic is expected to contribute to the following objectives of the Clean Hydrogen Joint Undertaking Strategic Research and Innovation Agenda (SRIA):

- Reduce the OPEX (operational expenditures) of low-temperature electrolysers by prolonging the lifetime, reducing the efficiency loss over time, and/or reduce the maintenance costs.
- Reduce the CAPEX (capital expenditures) of low-temperature electrolysers, for example, by using less CRM and/or PGM for materials and components.
- Improving dynamic operation and efficiency, with high durability and reliability, especially when operating dynamically and integrated with renewables.

The project results are expected to contribute to the 2030 Key Performance Indicators (KPI) of the SRIA:

- Alkaline Electrolysis (AEL):
  - Degradation: 0.10 %/1000 h
  - Performance: 1.0 A/cm^2 at 48 kWh/kg efficiency (system level)
  - CAPEX: 800 €/(kg/d)
  - OPEX: 35 €/(kg/d)/y
  - Critical raw materials as catalyst: 0 mg/W
- Proton Exchange Membrane Electrolysis (PEMEL):
  - Degradation: 0.12 %/1000 h
  - Performance: 3.0 A/cm^2 at 48 kWh/kg efficiency (system level)
  - CAPEX: 1000 €/(kg/d)
  - OPEX: 21 €/(kg/d)/y
  - Critical raw materials as catalyst :0.25 mg/W
- Anion Exchange Membrane Electrolysis (AEMEL):
  - Degradation: 0.5 %/1000 h
  - Performance: 1.5 A/cm^2 at 48 kWh/kg efficiency (system level)
  - CAPEX: 600 €/(kg/d)
  - OPEX: 21 €/(kg/d)/y
  - Critical raw materials as catalyst :0 mg/W

In addition, at system level the following SRIA KPIs are relevant:

- Hot idle ramp time:
  - AEL: 10 seconds
  - PEMEL: 1 second
  - AEMEL: 5 seconds
- Cold start ramp time:
  - AEL: 300 seconds
  - PEMEL: 10 seconds
  - AEMEL: 150 seconds

Scope

The scope of the topic is to address the lifetime, performance and cost of low temperature electrolysers at system level by developing, designing and testing advanced functional and structural materials and/or components for the cell, stack, and BoP.

The topic seeks to enhance the performance and durability of low temperature electrolysers by addressing not only the inherent degradation of the cell/stack itself but also the degradation that might occur on the stack due to interactions with BoP components. For instance, issues such as corrosion and leaching out of ions from piping that can contaminate the feed water, or ripple effects and electrical failures from power converters that can significantly shorten the stack's operational life.

The main objective is to develop advanced cell and stack materials and BoP components that don't induce degradation or reliability issues or even mitigate degradation and improve overall system durability.

The proposals should address the following elements:

- Investigate and further develop advanced materials for cell, stack, and BoP components to further increase performance and extend the lifetime of low temperature electrolysers;
- Optimise BoP components and architectures to minimise their impact on stack degradation and improve overall system performances and lifetime; also taking care of footprint of those elements in the view of designing future GW size plants;
- Validate novel solutions in relevant testing conditions to demonstrate their effectiveness in improving the lifetime compared to the baseline. The baseline should match state-of-the-art at the start of the project and be substantiated in the proposal. Additionally, modelling activities may be employed to support these validations;
- Demonstrate the improved lifetime at system level using an industrially relevant stack of > 20 kW by testing under relevant conditions for a minimum of 2000 hours. Validation should be compatible with system level. It is expected that proposals explain their approach towards this. An example could be the use of a hardware-in-the-loop approach to simulate the operation of system components that are not part of the targeted development;
- In line with the TRL level aimed at the end of the project, the targeted level of hydrogen purity and outlet pressure should be indicated and taken into account when performing cost-calculations;
- Describe how the dynamic conditions arising from connection to the renewable grid will be addressed and justify the chosen approach (for example simulation of

fluctuating power input from renewable energy);

- Sustainability, circularity and recycling aspects for the chosen materials and their manufacturing processes and perform techno-economic and life cycle assessments for the chosen developments.

The expected TRL step at the end of the project should increase from TRL 3 to 5 or from TRL 4 to 6 depending on the chosen technology. Proposals should be aware of the current maturity level of the different technologies and should define their initial and final TRLs accordingly. In general, the technologies have a different maturity level and thus it may be expected that for PEMEL and AEL materials and component innovation would correspond with a TRL 4 to 6 step, whereas for AEMEL this could correspond to a TRL 3 to 5 step. Proposals are also expected to reach the 2030 SRIA targets as mentioned above. The following activities are within the scope of this project and the proposal should meet at least three of the following points and should include the two first points:

- Investigate and further develop advanced cell components such as, but not limited to, electrodes (with minimised loading of CRM/PGM), membranes/electrolyte separators, functional additives (e.g. radical scavengers), joints and sealings, coatings, stack components such as bipolar plates and associated manufacturing processes that can realise CAPEX reduction and lifetime improvements at stack level under realistic operating conditions;
- Investigate and further develop advanced BoP components that prolong the lifetime of electrolysers, for example but not limited to: innovative H2 compressors, power electronics that reduce (the effect of) ripples, minimise corrosion and leaching out of ions from the BoP parts such as piping and pumps by using alternative materials and/or coatings, and/or minimise the effect of impurities in the water feed for example by ion exchange;
- Understand through experiments the different mechanisms affecting the performance of cell components such as the examples mentioned above during stack operation, and how the proposed development minimises the degradation along extended operation under realistic conditions. Modelling activities can be used to support these findings;
- Develop protocols for accelerated ageing and degradation monitoring that specifically target ageing mechanisms complementing the existing EU-harmonised testing protocols for low temperature electrolysis;
- Understand and minimise the impact of dynamic operation and grid integration, such as start/stop events and load fluctuations, under realistic operating conditions;
- Develop a lifetime model with a predictive value based on data acquired by testing at lab scale and stack scale.

Proposals are expected to build further on the findings and targets of previous projects and find synergies with running projects in which the improvement of the lifetime at stack level of low-temperature electrolysers was within the scope. It is encouraged to find synergies with the ELECTROLIFE[86] project, supported by the JU, that focuses on comprehensive understanding of electrolyser degradation mechanisms through testing and modelling. It is also encouraged to have an electrolyser (stack) manufacturer in the consortium for this topic.

[86] https://cordis.europa.eu/project/id/101137802

Proposals are also expected to build on previous projects (ANIONE[87], CHANNEL[88], ELECTROHYPEM[89], NEPTUNE[90], NEWELY[91], NEXPEL[92], NOVEL[93], PRETZEL[94]) and find synergy with existing projects (HyScale[95], HERAQCLES[96], AEMELIA[97], ENDURE[98], EXSOTHyC[99], SEAL-HYDROGEN[100]) in which the development of novel materials is/was in scope. In addition, synergy and learnings can be found with previous projects on the coupling of low temperature electrolysis with renewables such as DEMO4GRID[101], ELY4OFF[102], ELYGRID[103], ELYntegration[104].

Proposals should address the manufacturability of the components and materials to be developed. It is expected to provide a well-documented assessment of the scalability of manufacturing processes and procedures, as well as the sustainability and circularity of the selected materials and their production methods.

For activities developing test protocols and procedures for the performance and durability assessment of electrolysers and fuel cell components proposals should foresee a collaboration mechanism with JRC[105] (see section 2.2.4.3 "Collaboration with JRC"), in order to support EU-wide harmonisation. Test activities should adopt the already published EU harmonised testing protocols[106] to benchmark performance and quantify progress at programme level.

For additional elements applicable to all topics please refer to section 2.2.3.2.

87 https://cordis.europa.eu/project/id/875024
88 https://cordis.europa.eu/project/id/875088
89 https://cordis.europa.eu/project/id/300081
90 https://cordis.europa.eu/project/id/779540
91 https://cordis.europa.eu/project/id/875118
92 https://cordis.europa.eu/project/id/245262
93 https://cordis.europa.eu/project/id/303484
94 https://cordis.europa.eu/project/id/779478
95 https://cordis.europa.eu/project/id/101112055
96 https://cordis.europa.eu/project/id/101111784
97 https://cordis.europa.eu/project/id/101137912
98 https://cordis.europa.eu/project/id/101137925
99 https://cordis.europa.eu/project/id/101137604
100 https://cordis.europa.eu/project/id/101137915
101 https://cordis.europa.eu/project/id/736351
102 https://cordis.europa.eu/project/id/700359/es
103 https://cordis.europa.eu/project/id/278824
104 https://cordis.europa.eu/project/id/671458
105 https://www.clean-hydrogen.europa.eu/knowledge-management/collaboration-jrc-0_en
106 https://www.clean-hydrogen.europa.eu/knowledge-management/collaboration-jrc-0/clean-hydrogen-ju-jrc-deliverables_en

HORIZON-JU-CLEANH2-2025-01-02: Improved lifetime and cost of high-temperature electrolysers by introducing innovative materials and components in stacks and BoP

Specific conditions	
Expected EU contribution per project	The JU estimates that an EU contribution of maximum EUR 4.00 million would allow these outcomes to be addressed appropriately.
Indicative budget	The total indicative budget for the topic is EUR 8.00 million.
Type of Action	Research and Innovation Action
Technology Readiness Level	Activities are expected to start at TRL 3 and achieve TRL 5 (SOEL) and TRL 4 (PCCEL) by the end of the project - see General Annex B.
Procedure	The procedure is described in General Annex F. The following exceptions apply: To ensure a balanced portfolio covering complementary approaches, grants will be awarded to applications not only in order of ranking but at least also to one additional project that is/are complementary, provided that the applications attain all thresholds.
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G. The following exceptions apply: Eligible costs will take the form of a lump sum as defined in the Decision of 7 July 2021 authorising the use of lump sum contributions under the Horizon Europe Programme – the Framework Programme for Research and Innovation (2021-2027) – and in actions under the Research and Training Programme of the European Atomic Energy Community (2021-2025)[107].

Expected Outcomes

Water/steam electrolysis, when coupled with renewables bears the potential of enabling the decarbonisation of hard-to-abate industrial sectors via the introduction of renewable hydrogen. Steam electrolysis technologies such as solid oxide electrolysers (SOELs) and proton conducting ceramic electrolysers (PCCEL) operate at high temperatures and therefore yield high efficiencies.

However, the cost of hydrogen production via electrolysis remains higher than those of other routes, such as steam methane reforming. Therefore, it is paramount that the lifetime and energy densities are maximised and the system integration with BoP components is improved to bring both the CAPEX and the OPEX down, thus resulting in more affordable renewable hydrogen costs for the end-users.

The degradation mechanisms, from which high temperature electrolysers suffer, are mainly tied to the material in their stack such as the electrolyte, electrodes, interconnects, and seals, depending on operation temperature, pressure and thermal cycling; but they can also be related to their surroundings including balance of plant (BoP) components, for instance, and

[107] This decision is available on the Funding and Tenders Portal, in the reference documents section for Horizon Europe, under 'Simplified costs decisions' or through this link: https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/guidance/lsdecision_he_en.pdf

load variation and fluctuation upon connection with the external grid.

Therefore, project results are expected to contribute to the following expected outcomes:

- Improvements to already conceptualised novel materials including electrocatalysts, electrodes, metallic interconnects, coatings, and seals enabling increased lifetime to the ensemble of both single cells and stacks;
- Use of advanced manufacturing techniques to tackle issues with interfaces within the cell structure to minimise polarisation;
- Promote circularity of materials and components, by working on upstream (during manufacturing) and downstream (end of life) recycling, to integrate recycled materials, such as Ni, Co, Ce, La, and others, into the components, addressing the concerns with critical raw materials utilisation and hence strengthening the European hydrogen value chain on high-temperature electrolysers;
- Improvements to eventual multi-stack configuration to minimise the degradation mechanisms through optimising the control of the different stacks and the interactions between them, as well as BoP architecture;
- Introduction of accelerated stress test protocols on both single cell and stack levels to assure quality and lifetime of cells, stacks, and ultimately systems, including BoP;
- Balance of plant configuration that demonstrates satisfying performances at the system level. This includes new stack insulation strategies and materials, hot box systems, improved power electronics, innovative valorisation strategy of waste heat (e.g., for efficient compression or gas purification), and innovative design for multi-stack configuration. This innovative balance of plant configuration will enable to optimise the efficiency of the system's lifetime and reliability;
- Paving the way towards European leadership for renewable hydrogen production from high-temperature electrolysis, with enhanced heat integration.

Within this scenario, project results are expected to contribute to the following objectives and 2030 KPIs of the Clean Hydrogen JU SRIA for SOEL and PCCEL, as follows:

SOEL:

- To reach current densities over 1.2 A/cm2 at thermoneutral voltage;
- To demonstrate average degradation rates lower than 0.5%/1,000 h or equivalent to 6.4 mV/1,000 h per cell, on thermoneutral voltage;
- To operate steadily with an electrical demand of < 37 kWh/kg of H2 and a heat demand of < 8 kWh/kg of H2 at nominal capacity at a system level.

PCCEL:

- To reach current densities over 1.0 A/cm2 at thermoneutral voltage;
- To demonstrate average degradation[108] rates lower than 0.8%/1,000 h or equivalent to 10.3 mV/1,000 h per cell, on thermoneutral voltage;
- To operate steadily with an electrical demand of < 40 kWh/kg of H2 and a heat demand of < 10 kWh/kg of H2 at nominal capacity at a system level.

[108] Degradation under thermo-neutral conditions (@UTN) in per cent loss of production rate (hydrogen power output) at constant efficiency. Note this is a different definition from that of low temperature electrolysis, reflecting the difference in technology. Testing time should be a minimum of 2,000 hours.

Scope

The scope of this topic is centred around minimising the effects of degradation to consequently extend the lifetime of high temperature steam electrolysers (HTSE) such as solid oxide electrolysers (SOEL) and proton-conducting ceramic electrolysers (PCCEL). HTSE technology has the potential to achieve a low cost of hydrogen production because of its higher energy efficiency due to the operation at high temperature.

However, because of the latter, degradation mechanisms such as electrocatalyst agglomeration and migration, delamination of electrodes from electrolyte layers, interconnects oxidation, thermal cycling failure and structure cracking for instance of sealings are common sources of lifetime degradation and further reasons for the replacement of components or even full stacks. In addition to that, instability in load due to renewables intermittency or grid fluctuations are also sources of degradation and need to be addressed accordingly.

Moreover, the link between materials improvements and design (of cells, stacks, modules, systems, and balance of plant) should be demonstrated. Electrolysers are supposed to target lifetimes of over 40,000 hours, albeit undergoing long-term calendar tests (> 10,000 hours) is rather impractical, and thereby this sets the scene for accelerated-stress tests (AS-T) and modelling techniques that can predict the lifetime achieved by potential new technologies.

Considering the above-given background, the project should address the following issues:

- Materials and advanced manufacturing techniques improvements aiming to address the deactivation of electrocatalysts within the fuel electrode, microstructure sintering and interdiffusion between species within the oxygen electrode, degradation of sealing due to long-term high temperature operation, chromium oxidation in interconnect stainless steels and growth of poorly conducting oxide layers between the metallic interconnect plates and the electrodes;
- Development of circularity by working on upstream and downstream recycling processes, targeting to minimise the utilisation of raw critical materials. In particular, design strategies that allow for facile re-utilisation of half-cell materials, utilisation of manufacturing scrap in the process, as well as the development of materials originating from downstream recycling within the stack;
- Optimisation of load variation and fluctuation including the electrolysers' integration with renewable energy sources;
- Optimisation of BoP components and architectures to minimise their impact on stack degradation and improve overall system performances (e.g. steam generator, power quality from the power electronics components towards the electrolyser plant under Renewable Energy conditions, valorisation of stack heat for hydrogen compression, optimisation of gas purification concept, efficient multi-stack design etc.);
- Introduction of techniques to understand long-term degradation, such as accelerated-stress tests, and modelling;

Those developments should be validated at the scale of stacks steadily producing a minimum of 20 kW nominal power, within a long-term operation of above 2,000 h. Validation should be compatible with system levels. In this context, innovative BoP components (e.g. power electronics, compressor, gas purification system) may be tested together with the stacks if relevant to validate the innovative system integration. The use of a hardware-in-the-loop approach to simulate the operation of system components that are not part of the targeted development may also be considered.

It is encouraged to find synergies with the ELECTROLIFE[109] project that focuses on a comprehensive understanding of electrolyser degradation mechanisms through testing and modelling. Furthermore, the project proposals should be able to demonstrate how they would go beyond the intentions of the EU-funded projects ELECTRA[110], GAMER[111], Hy-SPIRE[112], and WINNER[113] when it comes to PCCEL materials and stacks, SElySOs[114] regarding the understanding of degradation mechanisms, NOAH2[115] as a benchmark for stacks, LOWCOST-IC[116] when it comes to lowering costs of components, NewSOC[117] on advanced manufacturing, AD ASTRA[118] for accelerated stress tests, REACTT[119] for monitoring and diagnostics of solid oxide electrolysers and PROMETEO[120] that focused on the coupling of solid oxide electrolysers with intermittent renewable sources. To have an electrolyser stack manufacturer involved in the consortium for this topic is encouraged.

Proposals are expected to be able to demonstrate that there is at least an experimental proof-of-concept validated in the laboratory (Technology Readiness Level (TRL) 3) to be addressed, and detail how the project will achieve the maturity of TRL5 for SOEL technologies and TRL4 for PCCEL by the end of its execution and validate the technology in a relevant environment.

For activities developing test protocols and procedures for the performance and durability assessment of electrolysers and fuel cell components proposals should foresee a collaboration mechanism with the Joint Research Centre (JRC)[121] (see section 2.2.4.3 "Collaboration with JRC"), in order to support EU-wide harmonisation. Test activities should adopt the already published EU harmonised testing protocols[122] to benchmark performance and quantify progress at programme level.

For additional elements applicable to all topics please refer to section 2.2.3.2.

[109] https://cordis.europa.eu/project/id/101137802
[110] https://cordis.europa.eu/project/id/621244
[111] https://cordis.europa.eu/project/id/779486
[112] https://cordis.europa.eu/project/id/101137866
[113] https://cordis.europa.eu/project/id/101007165
[114] https://cordis.europa.eu/project/id/671481
[115] https://cordis.europa.eu/project/id/101137600
[116] https://cordis.europa.eu/project/id/826323
[117] https://cordis.europa.eu/project/id/874577
[118] https://cordis.europa.eu/project/id/825027
[119] https://cordis.europa.eu/project/id/101007175
[120] https://cordis.europa.eu/project/id/101007194
[121] https://www.clean-hydrogen.europa.eu/knowledge-management/collaboration-jrc-0_en
[122] https://www.clean-hydrogen.europa.eu/knowledge-management/collaboration-jrc-0/clean-hydrogen-ju-jrc-deliverables_en

HORIZON-JU-CLEANH2-2025-01-03: Scale-up and Optimisation of manufacturing processes for electrolyser materials, cells, or stacks

Specific conditions	
Expected EU contribution per project	The JU estimates that an EU contribution of maximum EUR 4.00 million would allow these outcomes to be addressed appropriately.
Indicative budget	The total indicative budget for the topic is EUR 8.00 million.
Type of Action	Research and Innovation Action
Technology Readiness Level	Activities are expected to start at TRL4 and achieve TRL5-6 by the end of the project - see General Annex B.
Manufacturing Readiness Level	Activities are expected to start at MRL4 and achieve MRL 5 by the end of the project - see Call management and general conditions section.
Procedure	The procedure is described in General Annex F. The following exceptions apply: To ensure a balanced portfolio covering complementary approaches, grants will be awarded to applications not only in order of ranking but at least also to one additional project that is/are complementary, provided that the applications attain all thresholds.
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G. The following exceptions apply: Eligible costs will take the form of a lump sum as defined in the Decision of 7 July 2021 authorising the use of lump sum contributions under the Horizon Europe Programme – the Framework Programme for Research and Innovation (2021-2027) – and in actions under the Research and Training Programme of the European Atomic Energy Community (2021-2025)[123].

Expected Outcomes

Clean hydrogen is expected to play a critical role in Europe's decarbonisation objectives and electrolysers, which produce hydrogen from water and electricity, are a key enabler for Europe to meet its net-zero targets. Given this, it is vital to increase the amount of electrolysis capacity produced annually through scale-up of material, components, and stack manufacture.

Providing sufficient electrolyser capacity to meet the needs of the energy transition requires a rapid and efficient scale up of stacks (and component) production capacity. This will require electrolyser components and material manufacturers to transition to large-scale production featuring increased automation, or novel technologies. Optimisation and upscaling of manufacturing processes is required to increase production yields and improve cost-effectiveness. At the same time, new materials, components, and stack designs for improved efficiencies and reduced environmental impact must be produced in sufficient quantities to

[123] This decision is available on the Funding and Tenders Portal, in the reference documents section for Horizon Europe, under 'Simplified costs decisions' or through this link: https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/guidance/lsdecision_he_en.pdf

meet the growing needs of clean hydrogen production facilities.

Project results are expected to contribute to all of the following outcomes:

- Maintain European leadership in electrolyser production and strengthen the European value chain through the ability to deliver high-quality stacks;
- Employ sustainable-by-design and/or design for recycling methods to improve circularity;
- Minimise the life-cycle impact of materials, component, or electrolyser manufacture through waste (e.g scrap or consumables);
- Increase production rates whilst reducing manufacturing costs for materials, components or stacks through manufacturing process development, considering learnings from other industrial sectors such as fuel cells, batteries, etc;
- Contribute to CAPEX reductions of water electrolysis systems through economies of scale and reduced waste;
- Contribute to creating a viable business case for clean hydrogen production and use, through delivery of more affordable, higher-quality systems with improved lifetimes;
- Improve the cost-effectiveness, efficiency, reliability, quantity and quality of clean hydrogen production through improved manufacturing processes and scale-up of material, component, or stack production or the component or stack active area;
- Contribute to the creation of high-value manufacturing and supply chain jobs;

Project results are expected to contribute to the following objectives and 2030 KPIs of the Clean Hydrogen JU SRIA:

- Technologies should have efficiencies at nominal capacity comparable to those in the 2030 SRIA:
    - AEL 48kWh/kg
    - PEMEL 48kWh/kg
    - SOEL 37kWh/kg
    - AEMEL 48kWh/kg

Technologies not mentioned in the 2030 SRIA should provide similar, suitable KPIs in line with current state of the art.

- Capital Cost 2030 KPIs for the relevant technologies:
    - AEL 800 €/(kg/d)
    - PEMEL 1000 €/(kg/d)
    - SOEL 800 €/(kg/d)
    - AEMEL 600 €/(kg/d)
- Demonstration of a Takt time for material, component, and stack production, which will enable Europe to meet its hydrogen production markets;
- Contribute to the achievement of manufacturing KPIs including:
    - Manufacturing part yields of >98%, defined as 1-rejected parts / produced parts;

- Manufacturing material yield >80%, defined as (material used in stacks*yield)/amount of material;
- FAT failure rates linked to stacks of <10%, defined as (Number of FAT failures / Total number of FAT events).

Technologies not mentioned in the 2030 SRIA should provide suitable KPIs in line with current state of the art.

Scope

The scope of this topic is the development and demonstration of manufacturing processes which are suitable for scale-up and which can contribute to meeting predicted annual clean hydrogen production requirements. Considering manufacturing scale-up of new materials, the proposal should provide sufficient information to show that these materials have been proven to work at an appropriate scale.

Proposals should consider and build on relevant existing work in this area and results from projects related to the manufacturing and scaling- up of electrolysis systems including projects funded by the Clean Hydrogen JU such as AMPS[124], DJEWELS[125], HERAQCLES[126], MULTIPLHY[127], NEPTUNE[128], OUTFOX[129], PilotSOEL[130], REFHYNE[131] and SUSTAINCELL[132], clean-tech manufacturing projects supported by the Innovation Fund such as TopSOEC[133], HyNCREASE[134] and GIGA-SCALES[135], national funded projects such as ELYAS[136], and Open Innovation Test Beds projects supported by Horizon Europe such as H2Shift[137] and CLEANHYPRO[138]. In addition synergies with the Made in Europe partnership[139] and the Zero-Defect Manufacturing Platform[140] should be explored. Successful projects are also expected to review the state of the art during their implementation and to identify additional synergies with these and other ongoing relevant projects.

Proposals should develop solutions to address material and manufacturing bottlenecks including component supply, manufacturing processes, and end-of-line testing. Technologies to be developed should lead to increased manufacturing throughput and/or yield. Research and Development (R&D) activities should be included, for example, design for manufacture, additive manufacture, improved handling methods, automation and in-line quality control. The developed technologies may be capable of processing several types of material or be used for the manufacture of more than one type of electrolyser system.

Proposals should include relevant baseline information relating to techno-economics and the environmental / life cycle impacts of the current state of the art for the processes being

[124] https://cordis.europa.eu/project/id/101111882
[125] https://cordis.europa.eu/project/id/826089
[126] https://cordis.europa.eu/project/id/101111784
[127] https://cordis.europa.eu/project/id/875123
[128] https://cordis.europa.eu/project/id/779540
[129] https://cordis.europa.eu/project/id/101101439
[130] https://cordis.europa.eu/project/id/101112026
[131] https://cordis.europa.eu/project/id/779579
[132] https://cordis.europa.eu/project/id/101101479
[133] https://climate.ec.europa.eu/news-your-voice/news/topsoec-fuelling-europes-renewable-hydrogen-ambitions-energy-efficient-electrolyser-components-2024-09-30_en
[134] https://ec.europa.eu/assets/cinea/project_fiches/innovation_fund/101132982.pdf
[135] https://cinea.ec.europa.eu/featured-projects/giga-scales-smarter-membranes-lower-cost-hydrogen-production_en
[136] https://www.bosch-hydrogen-energy.com/about-us/collaboration-funding/elyas/
[137] https://cordis.europa.eu/project/id/101137953
[138] https://cordis.europa.eu/project/id/101091777
[139] https://www.effra.eu/made-in-europe-state-play/
[140] https://www.zdmp.eu/

considered. They should also provide a quantified description of the expected improvements.

Proposals should include validation of the developed technologies in an industrial environment on an OEM-relevant stack, i.e. TRL5/6 and MRL5 depending on the electrolyser technology and on the current TRL/MRL of the process. Proposals should state the capacity of their demonstrator and justify the way in which the equipment and stack size used for validation demonstrates manufacturing capacity sufficient for production of sufficient electrolyser manufacturing capacity to allow Europe to meet its hydrogen production targets using high-quality components.

Validation consists of demonstration of increased throughput or yield of the material, component, or stack without reduction in quality. For example, in-line inspection may increase the number of flaws detected so a link could be made between defect type/severity and its impact on quality to determine critical defect types.

The project outputs should include validation of increased manufacturing capability in a relevant environment and include life-cycle analysis, waste management/recycling potential and a techno-economic report describing the expected throughputs, yields, defect rate and costs when implemented in a manufacturing facility.

The inclusion of consortium partner(s) relevant to the electrolyser stack manufacturing value chain is considered beneficial.

The following aspects are to be addressed in the scope of the project:

- Further develop and optimise industrially relevant, scalable manufacturing processes to increase production rate while reducing cost for materials, components or stacks, or a combination of these. Examples of potential innovations include:
    - Design for manufacture techniques applied to material, components, or stacks for high volume manufacture;
    - Increased automation to improve throughput, tighten tolerances and reduce scrap;
    - Streamlined manufacturing processes to remove non-value-added steps and reduce waste;
    - Use of Artificial Intelligence (AI) / machine learning for scalability of processes;
- Develop quality control tools (preferably in-line) to increase production yield and decrease scrap rates. Increased detection of defects should be considered and for example, machine learning could be used to link defects to material, component, or stack quality and avoid increased scrap. Development of statistical sample-testing methods could also be considered;
- Apply Design for Sustainability principles to improve the environmental and end-of-life impact of electrolyser manufacture to maximise the potential of recycling processes to recover CRMs and other materials and investigation of material or component recycling when considering rejected items and dismantled stacks. Recycling development is out of scope of this topic;
- Provide an industrially relevant baseline and relevant KPIs for each technology and describe the quantified expected improvements;
- Validate novel processing solutions in an industrially relevant environment and demonstrate operation and reliable scalability with respect to cost, performance and durability KPIs. Quantify expected scrap and recall rates to reflect the true cost to the

end-user.

This topic is focused on manufacturing technologies and concepts that will facilitate production scale-up rather than on new materials. It is particularly relevant to original equipment manufacturers (OEMs), component suppliers and integrators, although support from research and technology organisations (RTOs) developing innovative manufacturing technologies is welcome. Projects and processes should be relevant to electrolyser-manufacturing OEMs and should consider future demand when considering novel manufacturing processes.

Proposals should include manufacturing scale-up of materials and components in the supply chain as well as of electrolysers; proposers should clearly explain the importance of the components, materials, or stacks which are the focus of their project in terms of increased electrolyser production and deployment.

Scale-up can include:

- Production of an increased number of stacks, components or materials;
- The development of manufacturing processes for stacks with larger active areas at the cell level;
- Development of processes with higher throughputs due to reduced scrap or increased recycling potential.

The above improvements will enable manufacturers to deliver sufficient hardware for large-scale deployment as well as to benefit from economies of scale, improving the competitiveness of clean hydrogen.

It is expected that this topic will support complementary projects in order to cover low-temperature electrolysis and high-temperature electrolysis.

For additional elements applicable to all topics please refer to section 2.2.3.2.

HORIZON-JU-CLEANH2-2025-01-04: Efficient electrolysis coupling with variable renewable electricity and/or heat integration

Specific conditions	
Expected EU contribution per project	The JU estimates that an EU contribution of maximum EUR 6.00 million would allow these outcomes to be addressed appropriately.
Indicative budget	The total indicative budget for the topic is EUR 6.00 million.
Type of Action	Innovation Action
Technology Readiness Level	Activities are expected to achieve TRL 7 by the end of the project - see General Annex B.
Admissibility conditions	The conditions are described in General Annex A. The following exceptions apply: The page limit of the application is 70 pages.
Eligibility	The conditions are described in General Annex B. The following additional eligibility criteria apply: At least one partner in the consortium must be a member of either Hydrogen Europe or Hydrogen Europe Research. The maximum Clean Hydrogen JU contribution that may be requested is EUR 6.00 million – proposals requesting Clean Hydrogen JU contributions above this amount will not be evaluated.
Procedure	STEP Seals will be awarded to proposals exceeding all of the evaluation thresholds set out in this work programme.
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G. The following exceptions apply: Eligible costs will take the form of a lump sum as defined in the Decision of 7 July 2021 authorising the use of lump sum contributions under the Horizon Europe Programme – the Framework Programme for Research and Innovation (2021-2027) – and in actions under the Research and Training Programme of the European Atomic Energy Community (2021-2025)[141]. Purchases of equipment, infrastructure or other assets used for the action must be declared as depreciation costs. However, for the following equipment, infrastructure or other assets purchased specifically for the action (or developed as part of the action tasks): hydrogen production plant (e.g electrolyser), its Balance of Plant (BoP), and any other hydrogen related equipment essential for the implementation of the project (e.g. hydrogen storage), costs may exceptionally be declared as full capitalised costs.

[141] This decision is available on the Funding and Tenders Portal, in the reference documents section for Horizon Europe, under 'Simplified costs decisions' or through this link: https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/guidance/lsdecision_he_en.pdf

Expected Outcomes

Renewable hydrogen production via electrolysis offers a clean alternative for various industrial and mobility applications. To reach the REPowerEU domestic hydrogen production target of 10 million tonnes of renewable hydrogen by 2030, many large-scale electrolysis production projects will be commissioned between 2025 and 2027 with the massive support of subsidies at EU (e.g. through IPCEI[142] and Innovation Fund) or national level. Additional large-scale renewable hydrogen projects will be supported by the European Hydrogen Bank. However, considerable effort is needed to achieve these targets due to the many technical, regulatory and economical challenges to be tackled. These challenges include the integration of electrolysis plants into energy systems (concerning electricity, heating and gas networks, both on- and off-power grid, on- and offshore) fed with variable renewable energy (VRE), and the integrated management of heat (both inside the electrolysis plant and in relation to external infrastructures and uses).

When operated flexibly, electrolysers can support grid stability. Increasing levels of renewable electricity penetration to the target defined in the REPowerEU plan brings a range of challenges, some of which could be addressed by hydrogen produced via electrolysis:

- To reduce the need for grid improvements and grid management operations (variable renewable energy curtailment) through dynamic electrolyser operation and cross-sectoral flexibility (connecting power, gas and heat networks), especially in regions with strong current (or planned) variable renewable energy surplus;
- To boost off-grid renewable electricity generation in offshore installations and areas adjacent to underground storage, islands, and remote areas;
- To provide a range of energy storage (including seasonal) and grid services to help match supply and demand, while reducing curtailment, dependencies on fossil fuels and electricity prices;
- To increase the penetration of renewable energy into the energy system (in on- and/or off-grid systems);
- To reduce the need for curtailment of renewable electricity generation at times of excess production.

The EU regulations (Renewable Energy Directive III, Delegated Acts) have laid the foundations of defining renewable hydrogen (Renewable Fuels of Non-Biological Origin – RFNBO) for different hydrogen production contexts (e.g. direct or indirect interconnection of hydrogen production via electrolysis to (additional) sources of variable renewable energy).

Enhanced thermal management can improve overall energy efficiency and offers another optimisation pathway for the economically viable production of renewable hydrogen. This can appear through the valorisation of heat from the electrolysis plant itself, through the integration of heat from renewable sources or heat from industrial processes. Such heat can be valorised in the electrolysis plant itself, or through external stakeholders. In all cases, enhanced and integrated thermal management can contribute to lower the levelised cost of green hydrogen.

Projects should address efficient electrolysis coupling with variable renewable electricity or heat integration or both.

Project results should contribute to all the following expected outcomes:

For all projects:

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[142] Important Projects of Common European Interest

- Enhanced electrolysis capacity to produce renewable hydrogen (in line with EU regulations);
- Reduction of the levelised cost of hydrogen, including business models for generating additional income;
- Improved overall integration of electrolysis with the energy system.

For projects on coupling with variable renewable electricity:

- Fostering the use of electrolysis plants to balance the electrical network;
- Coupling of multi-MW electrolysis plants to variable renewable energy generation (both on- and off-grid, directly or indirectly coupled);
- Improved and diversified business models for electrolysis plants thanks to the provision of remunerated electrical grid services (at transmission and distribution system level).

For projects addressing heat integration:

- Fostering synergies between electrolysis plants and external heat stakeholders (producers and consumers);
- Improving thermal management within electrolysis plants;
- Improved and diversified business models for electrolysis plants through integrated thermal management and/or integration into heating supply networks.

Project results are expected to contribute to the following objectives of the Clean Hydrogen JU SRIA:

- Improve dynamic operation and efficiency of systems, with high durability and reliability, especially when operating dynamically, with the following KPIs of the Clean Hydrogen JU SRIA by 2030:
    - Hot idle ramp time at electrolyser system level:
        - Alkaline Electrolysis: 10s;
        - Proton Exchange Membrane Electrolysis: 1s;
        - Solid Oxide Electrolysis: 180s;
        - Anion Exchange Membrane Electrolysis: 5s;
    - Stability in constant power sections: 2.5%;
- Demonstrate the value of electrolysers for the power system through their ability to provide flexibility and allow higher integration of renewables;
- Operate efficiently (at system level including balance of plant) and safely (including with reduced gas crossover when relevant) under variable load with adequate flexibility to be coupled with variable renewable energy;
- MW scale direct coupling to renewable generation (both on- and off-grid) including offshore hydrogen production, aiming at identifying the best system configuration to reach competitiveness;
- Consider innovative system designs and improved balance of plant components to reduce parasitic losses and reduce cost (e.g. purpose-built rectifiers, integrated cooling

systems, electrical heaters and heat-exchangers), when relevant in optimised electrical integration with renewables;

- Explore the options for utilising by-product oxygen and waste heat.

Scope

Several previous and current projects supported by the Clean Hydrogen Partnerhsip such as REMOTE[143], HYBALANCE[144], HAEOLUS[145], ELY4OFF[146], DEMO4GRID[147], H2FUTURE[148], HOPE[149] and EPHYRA[150] as well as supported by national funded projects such as such as Energiepark Mainz[151], have explored different coupling configurations and system optimisations for the integration of hydrogen production with renewable electricity generation and the provision of grid services. Yet further progresses are needed to demonstrate the full potential of this integration. These should increase the capacity of electrolysis plant operators to produce RFNBO respecting the EU Delegated Acts on Renewable Hydrogen requirements on time correlation, while enhancing their business model through the provision of higher levels of remunerated flexibility services to the electrical grid and potentially through heat integration. These progresses should also address improving electrolysis whole system efficiency and robustness towards load variation and power fluctuation. Improvements in the economics of electrolytic hydrogen production may be achieved by valorisation of dissipated heat from electrolysis and/or by integration of renewable or process heat when coupling the electrolyser to a RES or in an industrial plant, as explored in several European projects (such as as GrinHy[152], GrInHy2.0[153], MULTIPLHY[154], SOPHIA[155], REFLEX[156], GAMER[157]).

This topic is open for all technologies of water and steam electrolysis and for synergies with projects funded under topics supported by the Clean Hydrogen JU: HORIZON-JTI-CLEANH2-2024-01-04[158], HORIZON-JTI-CLEANH2-2025-01-01 and HORIZON-JTI-CLEANH2-2025-01-02.

The following activities are within the scope of this topic:

- Improve storage (hydrogen, demineralised water, heat, power) and plant control strategies to increase overall plant response reactivity while smoothening ramp-up and -down. This may be supported by a connection to a gas network (incl. salt cavern), or other energy storage (gaseous or electrochemical);

143 https://cordis.europa.eu/project/id/779541
144 https://cordis.europa.eu/project/id/671384
145 https://cordis.europa.eu/project/id/779469
146 https://cordis.europa.eu/project/id/700359
147 https://cordis.europa.eu/project/id/736351
148 https://cordis.europa.eu/project/id/735503
149 https://cordis.europa.eu/project/id/101111899
150 https://cordis.europa.eu/project/id/101112220
151 https://www.energiepark-mainz.de/en/

152 https://cordis.europa.eu/project/id/700300
153 https://cordis.europa.eu/project/id/826350
154 https://cordis.europa.eu/project/id/875123
155 https://cordis.europa.eu/project/id/621173

156 https://cordis.europa.eu/project/id/779577
157 https://cordis.europa.eu/project/id/779486
158 https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/horizon-jti-cleanh2-2024-01-04?keywords=HORIZON-JTI-CLEANH2-2024-01

- Demonstrate innovative power electronics (e.g. transformer and rectifier, direct DC/DC coupling) and control strategies to maximise flexibility of operation;
- Develop ad-hoc Balance of Plant components for heat integration;
- Optimise heat re-use within the electrolysis plant and/or the integration of the plant with its environment (e.g. heat networks, industry);
- Improve interaction with the electricity grid to perform grid services on command from the grid (e.g., utilising unexpected power production peaks from renewables, thanks to planning and optimisation tools that could benefit of utilising advanced methodologies such as predictive approach and real-time optimisation). Such tools should optimise the renewable coupling and/or heat integration, including on the basis of economic aspects;
- Utilise emerging digital technologies to integrate electrolysers into a highly flexible and resilient energy system, in synergy with calls from Horizon Europe Cluster 5 and Clean Energy Transition partnership;
- Minimise power consumption in stand-by operation and ensure safe operation at high turn-down operation of the electrolyser;
- Provide improved plant designs of >50MW sites with design-inherent increased operating flexibility, providing higher levels of services to the electrical grid (e.g. capacity to absorb black outs from other sites) while better valorising heat, with concrete business cases on at least one plant with a commissioning date before 2030.

Projects should demonstrate developments for at least 6 months on plants in operation at least at the MW scale. Applicants may work on existing electrolyser installations where only the BoP would need to be adapted/modified or on electrolyser installations under development.

It is expected to have an electrolyser manufacturer in the consortium for this topic. In addition, it is encouraged to include a balance of plant manufacturer. Cooperation with renewable hydrogen production plant operators is also encouraged.

The costs for the construction and commissioning phase of the hydrogen production technology/ies maybe funded while costs related to the operation of the hydrogen production plant (e.g., electricity for electrolysers) will not be funded.

Proposals are expected to demonstrate the contribution to EU competitiveness and industrial leadership of the activities to be funded including but not limited to the origin of the equipment and components as well infrastructure purchased and built during the project. These aspects will be evaluated and monitored during the project implementation.

It is expected that Guarantees of origin (GOs) will be used to prove the renewable character of the hydrogen that is produced. In this respect consortium may seek out the issuance and subsequent cancellation of GOs from the relevant Member State issuing body and if that is not yet available the consortium may proceed with the issuance and cancellation of non-governmental certificates (e.g CertifHy[159]).

For activities developing test protocols and procedures for the performance and durability assessment of electrolysers and fuel cell components proposals should foresee a collaboration mechanism with JRC[160] (see section 2.2.4.3 "Collaboration with JRC"), in order to support EU-wide harmonisation. Test activities should adopt the already published EU

[159] https://www.certifhy.eu
[160] https://www.clean-hydrogen.europa.eu/knowledge-management/collaboration-jrc-0_en

harmonised testing protocols[161] to benchmark performance and quantify progress at programme level.

Proposals should provide a preliminary draft on 'hydrogen safety planning and management' at the project level, which will be further updated during project implementation.

For additional elements applicable to all topics please refer to section 2.2.3.2.

HORIZON-JU-CLEANH2-2025-01-05: Innovative co-electrolysis systems and integration with downstream processes

Specific conditions	
Expected EU contribution per project	The JU estimates that an EU contribution of maximum EUR 4.00 million would allow these outcomes to be addressed appropriately.
Indicative budget	The total indicative budget for the topic is EUR 4.00 million.
Type of Action	Research and Innovation Action
Technology Readiness Level	Activities are expected to start at TRL 3 and achieve TRL 5 by the end of the project - see General Annex B.
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G. The following exceptions apply: Eligible costs will take the form of a lump sum as defined in the Decision of 7 July 2021 authorising the use of lump sum contributions under the Horizon Europe Programme – the Framework Programme for Research and Innovation (2021-2027) – and in actions under the Research and Training Programme of the European Atomic Energy Community (2021-2025)[162].

Expected Outcomes

Co-electrolysis technology has a relevant impact on hydrocarbon synthetic production processes (e.g. Fisher-Tropsch, ethylene and methanol routes), which is gaining continuous interest for the production of e-fuels (e.g. Sustainable Aviation Fuel (SAF), e-diesel, e-methane, etc) and other chemicals relevant for the chemical industry. With co-electrolysis carbon dioxide and steam are converted into syngas which is subsequently utilised in the downstream chemical processes to produce synthetic fuels or molecules of interest thereby enhancing overall energy efficiency. The primary benefit of the co-electrolysis lies in the ability to produce high-quality syngas in a single step, eliminating the need for extra H2/CO2 conversion processes.

Previous EU funded projects (Eco[163], HELMETH[164], SOPHIA[165], ELECTRA[166], SElySOs[167],

[161] https://www.clean-hydrogen.europa.eu/knowledge-management/collaboration-jrc-0/clean-hydrogen-ju-jrc-deliverables_en
[162] This decision is available on the Funding and Tenders Portal, in the reference documents section for Horizon Europe, under 'Simplified costs decisions' or through this link: https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/guidance/lsdecision_he_en.pdf
[163] https://cordis.europa.eu/project/id/699892
[164] https://cordis.europa.eu/project/id/621210
[165] https://cordis.europa.eu/project/id/621173
[166] https://cordis.europa.eu/project/id/621244
[167] https://cordis.europa.eu/project/id/671481

eCOCO2[168], SUN2CHEM[169]) have already assessed the feasibility of co-electrolysis and laid the groundwork for further improvements. However, heat integration between co-electrolysis systems and downstream processes can improve the overall efficiency of production with lower OPEX and flexible operation towards synthetic chemicals production, an aspect which has not been covered by those projects.

Project results are expected to contribute to the following expected outcomes:

- Efficiency improvement via an optimised system integrating co-electrolyser and downstream reactor, enhancing the efficiency of the power to final chemical process by reducing heat losses and recovering heat produced in the synthesis phase;
- Optimised resource utilisation via integration with downstream processes, enabling the efficient utilisation of resources, such as waste heat or by-products, leading to overall process optimisation and reduced resource wastage;
- Durability Improvement via an optimised operational strategy to prevent coke formation in the cells, stacks, stack modules and co-electrolyser system;
- Cost reduction by optimising the production process and minimising energy consumption with integrated systems helping in reducing production and Total Cost of Ownership (TCO) costs, making the overall process more economically viable;
- Environmental benefits via an integrated system contributing to reducing the environmental, economic and social impacts of synthetic chemical production, resulting in high reduction potential of greenhouse gas emissions, promoting circularity of materials and components, and, in general, improving the overall environmental impact of the process (in particular when associated with a reduction of the critical raw materials content);
- Product diversification via integration with downstream processes, facilitating the production of a wider range of products and enabling diversification and opening up new market opportunities.

Overall, the expected outcomes of integrating innovative co-electrolysis systems with downstream processes encompass improvements in efficiency, cost-effectiveness, environmental sustainability, technological advancement, and market competitiveness.

Project results are expected to contribute to the following objectives of the Clean Hydrogen JU SRIA:

- Improve cell design/materials for an increased lifetime and high performance, and increase cell/stack robustness through improved thermal and process-flow management;
- Develop new stack and balance of plant (BoP) designs;
- Consider innovative system designs and improved balance of plant components to reduce cost;

Furthermore, project results are expected to contribute to the following KPIs, targeted at co-electrolyser scale, specific for three high temperature co-electrolysis technologies: Oxide and Proton conductive Solid Oxide electrolysers (SOEL, PCCEL) and Molten Carbonate Electrolyser (MCE):

[168] https://cordis.europa.eu/project/id/838077
[169] https://cordis.europa.eu/project/id/884444

- Oxide conductive Solid Oxide electrolysers (SOEL):
  - Power to syngas efficiency: 0.9 kWe/ kWLHV
  - Degradation in operating conditions: 0.8 %/1000h @1A/cm²
  - Unit cost: 500 €/kW
- Proton Conductive Ceramic electrolysers (PCCEL):
  - Power to syngas efficiency: 0.9 kWe/ kWLHV
  - Degradation in operating conditions: 0.8 %/1000h @0.75A/cm²
  - Unit cost: 500 €/kW
- Molten Carbonate electrolysers (MCE):
  - Power to syngas efficiency: 0.93 kWe/ kWLHV
  - Degradation in operating conditions: 0.5 %/1000h @0.5A/cm²
  - Unit cost: 500 €/kW

KPIs are defined for the main high temperature co-electrolysis techniques, derived from the SRIA and from results of previous EU funded projects.

Scope

Proposals should aim to accelerate the development of the co-electrolysis technology and its integration into real chemical synthesis process by proving the concept and the overall efficiency of the coupling between the co-electrolyser and the downstream process, mainly the catalytic reactor for the chemical synthesis. They should also contribute to resolving additional technological challenges on low-TRL level (cell/stack/stack module technology) to improve the stack operations for direct downstream process integration (downstream gas purity and composition, pressurised conditions) and the core technology impacting more drastically the lifetime (hence OPEX cost contribution) compared to steam electrolysis.

The project should cover the following elements:

- Adapt core technology and cell design to increase the robustness in the identified operating conditions and gas composition;
- Screening at cell or short-stack level different catalysts and operational parameters to achieve the required H2/CO ratio for further downstream processing including pressure, temperature, reactant purity. Investigation should encompass not only performances but also prevention of coke formation in the stack, stack module, system and afterwards;
- Assessing the optimal operating conditions of the co-electrolyser and of the downstream process at the scale of a short stack over durations above 3000h, with the aim of ensuring an optimised coupling of the two technologies, considering:
  - heat recovery from the fuel synthesis process in the co-electrolysis unit (steam generation, gas preheating, etc.);
  - the most effective strategy for cleaning up produced syngas, if necessary;
- Design integrated co-electrolyser and downstream reactor with ad hoc BoP to increase global efficiency and promote syngas production stability, supported by simulation tools and experimental validation. The study should analyse the effects of transient and off-design operation of the system, encompassing both startup and shutdown

processes. Technological and economical impacts of recirculation of separated streams such as water (steam) and carbon dioxide have to be considered;

- Demonstrating the coupling at a relevant scale (size of the co-electrolyser >15 kW) between the co-electrolyser and the downstream reactor and evaluate its performance and durability over 2000 h minimum;
- Conducting a techno-economic and life cycle impacts analysis and a preliminary study of safety aspects of the integrated system.

Costs related to downstream process unit design and development will not be funded and the coupling should be performed in a location where such a reactor is available at the adequate size for a good matching with the co-electrolyser. An electrolyser manufacturer should be involved in the consortium for this topic. Participation of industrial partners in the integration downstream and valorisation of the co-electrolysis product is expected.

For activities developing test protocols and procedures for the performance and durability assessment of electrolysers and fuel cell components proposals should foresee a collaboration mechanism with JRC[170] (see section 2.2.4.3 "Collaboration with JRC"), in order to support EU-wide harmonisation. Test activities should adopt the already published EU harmonised testing protocols[171] to benchmark performance and quantify progress at programme level.

For additional elements applicable to all topics please refer to section 2.2.3.2

[170] https://www.clean-hydrogen.europa.eu/knowledge-management/collaboration-jrc-0_en
[171] https://www.clean-hydrogen.europa.eu/knowledge-management/collaboration-jrc-0/clean-hydrogen-ju-jrc-deliverables_en

HORIZON-JU-CLEANH2-2025-01-06: Innovative hydrogen and solid carbon production from renewable gases/biogenic waste processes

Specific conditions	
Expected EU contribution per project	The JU estimates that an EU contribution of maximum EUR 8.00 million would allow these outcomes to be addressed appropriately.
Indicative budget	The total indicative budget for the topic is EUR 8.00 million.
Type of Action	Innovation Action
Technology Readiness Level	Activities are expected to achieve TRL 7 by the end of the project - see General Annex B.
Admissibility conditions	The conditions are described in General Annex A. The following exceptions apply: The page limit of the application is 70 pages.
Eligibility	The conditions are described in General Annex B. The following additional eligibility criteria apply: At least one partner in the consortium must be a member of either Hydrogen Europe or Hydrogen Europe Research. The maximum Clean Hydrogen JU contribution that may be requested is EUR 8.00 million – proposals requesting Clean Hydrogen JU contributions above this amount will not be evaluated.
Proceudre	STEP Seals will be awarded to proposals exceeding all of the evaluation thresholds set out in this work programme.
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G. The following exceptions apply: Eligible costs will take the form of a lump sum as defined in the Decision of 7 July 2021 authorising the use of lump sum contributions under the Horizon Europe Programme – the Framework Programme for Research and Innovation (2021-2027) – and in actions under the Research and Training Programme of the European Atomic Energy Community (2021-2025)[172]. Purchases of equipment, infrastructure or other assets used for the action must be declared as depreciation costs. However, for the following equipment, infrastructure or other assets purchased specifically for the action (or developed as part of the action tasks): reactor and all units and subunits to allow a proper and independent functioning of the hydrogen production plant, costs may exceptionally be declared as full capitalised costs.

<u>*Expected Outcomes*</u>

There is an increasing interest in implementing a circular economy in the context of

[172] This decision is available on the Funding and Tenders Portal, in the reference documents section for Horizon Europe, under 'Simplified costs decisions' or through this link: https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/guidance/lsdecision_he_en.pdf

decarbonisation as a path to achieving a sustainable, productive system. Such a goal requires developing and implementing a great variety of new processes and innovation into subprocesses, including gas separation, purification, new reactors and catalyst, when needed. The transformation of renewable gases (such as biogas and biomethane), or solid biogenic wastes (as per Directive 2008/98/EC), as well as advanced feedstocks (as per Annex IX of Renewable Energy Directive 2018/2001) into hydrogen and carbon, is one of those processes aiming at the utilisation of renewable resources to produce valuable products and decarbonise hard-to-abate industrial processes. The process to convert bio-feedstocks into hydrogen is also compatible with the regulatory targets into Fit-to-55 packages, within the Red transport, RefuelEU Aviation, and FuelEU Maritime GHG reduction targets. Decarbonisation costs (replacement of fossil-based hydrogen) by (Bio)Methane splitting and Biowaste-to-energy have been estimated below 180 €/tonCO2[173]. Biogenic or waste C-feedstock input material in the process ending into carbon production implies a net carbon removal (negative GHG emissions).

Developing processes to convert these renewable sources into hydrogen and carbon will contribute to the evolution of the hydrogen economy, complementing other hydrogen production methods, complying with strategic lines of the European Commission, as is the case of the European Innovatin Council (EIC)[174]. Hydrogen and solid carbon from renewable gases/biogenic wastes are embedded into a circular and life cycle thinking approach for the co-production of green carbon, chemicals, fertilisers and/or decarbonised materials, and avoiding or minimising the use of toxic and critical raw materials. It contributes to the capture cross sectorial coupling and system integration opportunities (i.e. energy systems, industrial symbiosis contributing to net-zero industrial districts, bio-wastes supply chains), complementing the advanced thermochemical processes for biomass upgrade to biocrude and green hydrogen. The energy to decompose hydrocarbons is thermodynamically much lower than the one needed to split water, showing a potential to reduce energy requirements for the production of hydrogen. A process with a high rate of complete decomposition into solid carbon reduces the need for conventional CO_2 capture, which is required for fossil/biomass steam reforming/gasification technologies for low-emission, and it can provide a reliable source of carbon as raw material for other industrial sectors, improving circularity of the whole chain. The transformation of bio-based gases into hydrogen will provide a decarbonised fuel, avoiding implementing CO_2 capture stages in industrial or energy processes. In addition, stress on current CO_2 sequestration sites will be reduced, potentially producing harmful greenhouse gas (GHG) emissions.

Renewable gases (bio-methane or any hydrocarbon produced by renewable sources such as bio-lifiquied petroleum gas (bio-LPG), synthetic natural gas and others) in Europe can play an important role in achieving the REPowerEU objectives as an endogenic resource with the potential to significantly reduce imports of natural gas or other hydrocarbons, both for the power sector and as a raw material for other industrial processes. Developing technologies to transform biogenic wastes/biogas/biomethane/renewable gases into hydrogen and high-value solid carbon will advance such resources' circularity and sector coupling potential. Depending on its properties, solid carbon may have various economic uses. For example, graphitic carbon is a critical raw material in the EU[175] , with an expected demand in Europe of 3.7 Mton/y in 2050 for the development of a clean economy, including graphite electrodes, and fuel cells, with a strong dependence on non-EU countries. Other applications of solid carbon could target

173 https://hydrogeneurope.eu/wp-content/uploads/2024/06/2024_H2E_CleanH2ProductionPathwaysReport.pdf
174 https://eic.ec.europa.eu/calls-proposals/eic-pathfinder-challenge-novel-routesgreen-hydrogen-production_en
175 "European Commission, Critical materials for strategic technologies and sectors in the EU - a foresight study, 2020"

agriculture, energy production, animal farming, the building sector, decontamination, water treatment and many other industrial uses.

This topic is expected to contribute to the following outcomes:

- Development of advanced breakthrough technologies for the low-emission transformation of renewable sources, e.g., biogas, biomethane, solid wastes, biochars, and advanced feedstocks into hydrogen and solid carbon;
- Strengthening the European technological capacity regarding the production of hydrogen and carbon, key pillars of a sustainable future, in the context of contributing to the CO_2 emission reduction targets, and advancing to even potential negative emissions;
- Increasing applications of e.g. biogas/biomethane, solid wastes, and advanced feedstocks applications, promoting its circular approach, and facilitating its sector coupling with the chemical, steel or material industries, among others;
- Enhancing energy security by promoting European renewable/clean hydrogen production and reducing the dependency on foreign energy, as well as raw material, carbon imports;
- Reducing geopolitical risks relating to the development of clean technologies, including hydrogen technologies, in the EU.

The expected long-term outcomes of the technology in the proposals should include energy consumption lower than water electrolysis considering both heat and electricity, and energy consumption lower than 15 kWh/kgH_2. The capital cost per nominal daily production should be 1 k€/(kg/day) with a system operational cost close to 1.3 €/kgH_2[176], leading to a levelized cost of hydrogen close to 3 €/kgH_2 by 2030.

Greenhouse gases emissions from technologies to convert renewable gases/biogas/waste to hydrogen and carbon is potentially negative, as in practice constitutes a carbon removal. As an outcome of the project, a clear confirmation of this feature should be quantified and confirmed.

Moreover, the role of waste/advanced feedstocks/biogas/biomethane in hydrogen and carbon production as raw material input for the chemical, steel, or other industries would be of paramount importance for the substitution/reduction of fossil hydrocarbons use in the industrial sector, as well as a supply chain for solid biogenic carbon, as a critical raw material for the development of a Net-Zero economy, as well as a complementary path for hydrogen production.

There are significant initiatives worldwide (USA, Canada, Europe,…) to advance in the technology of renewable gases/waste splitting into solid carbon and hydrogen announcing plants with capacities up to tons of H2 per day by high temperature electric heating plasma, plasmalysis, thermal pulsed methane pyrolysis, or microwaves, showing that the technology is within the parameters of an innovation action, as a previous step to be available for hydrogen valleys or full scale demonstration.

Scope

Methods to achieve such transformation are very diverse. They may be included in a family of processes of different nature comprising alternative energy transfer methods based on renewables (e.g., microwave, thermal and non-thermal plasma, induction, shockwave,

[176]Annex to GB decision no. CleanHydrogen-GB-2022-02, Table 7

radiation heating, direct thermal heating by several methods as Concentrated Solar Platform or molecular oxidation), and reactor designs (e.g., bubble column, plug, fluidised-bed, packed-bed, pulse tube, tubular, fluid wall, honeycomb monolith, moving carbon-bed, rotary kiln and others). These also involve combining these methods and the use or absence of catalysts, including innovative separation devices for enhanced purification and efficiency.

Proposals are expected to show feasible significant advances (up to TRL 7) respect to previous Horizon Europe projects ColdPSark[177] and Storming[178] with a significant amount of carbon material production (for instance, > 50% of the initial carbon in the material input). Current running projects are in the right track and show the potential of the technology by the announced development up to TRL5 of non-thermal plasma, thermal catalytic, and microwave heated biomethane splitting into hydrogen and solid carbon. Such carbon material may be characterised to evaluate valuable applications, such as carbon black for the tyre industry, active carbon materials for batteries, electrodes and supercapacitors, metallurgic coke, agricultural application of carbonaceous materials, soil recovery, input material for high quality carbon products, as graphene or graphite, or any other of interest; that should be included into the evaluation of the technical, economic and societal impact of the proposal outcome.

The presence of impurities in the inlet gas stream, for instance, in the biomethane or biogas input to the process, should play a role and thus are expected to be addressed in the proposal, discussing the need for upgrading through advanced techniques for separation, methanation or any other subprocess. Furthermore, a project should address the processing of suitable gas products, including separating and purifying hydrogen from undesirable by-products. Other technological issues, such as coke deposition, carbon-hydrogen separation, hydrogen-selectivity, catalyst deactivation and lifetime, catalyst regeneration, or quality of the products and their applications, are expected to be investigated and the practical solutions implemented at a large scale. The project should demonstrate a functional process producing 30 kgH_2/h (approx. 1 MWH_2 based on Low Heating Value (LHV)) with a purity acceptable for a direct application (99.97 % according to ISO 14687), or acceptable to H_2 network and industries (a purity above 98% for ISO/FDIS 14687 – Grade A) and report significant testing time as to show operational availability and stability for industrial implementation (for instance, 3,000 h). If needed to derisk technology scale up, proposals are allowed to build intermediate steps (for instance, a facility around 100 kWH_2 under industrial relevant conditions) within the program to reach the TRL7 target.

Proposals should consider different feedstocks and routes to identify the most relevant ones from a technical and economical point of view as well as a techno-economic analysis of the technology at scale. Furthermore, proposals should also address sustainability and circularity aspects through a life cycle assessment (compatible with current efforts on carbon footprint analysis, for instance well-to-wheels as defined by Renewable Energy Directive (REDII)) of the proposed technology, which should demonstrate a significant reduction of CO_2 emissions (and negative in certain circumstances) for both hydrogen and carbon products ($kgCO_2/kgH_2$, $kgCO_2/kgC$) at large scale, including a cost analysis to see the impact of higher hydrogen purity requirements. Different feedstocks and methods may be included in the sustainability analysis. In addition, a critical raw material assessment should be considered if relevant. The integration with other processes should be showcased, particularly for hard-to-abate sectors. are outside the scope of this topic

Proposals are encouraged to explore synergies with projects within the metrology research

[177] https://cordis.europa.eu/project/id/101069931
[178] https://cordis.europa.eu/project/id/101069690

programme run under the EURAMET research programme, in particular projects DECARB[179] and MetCCUS[180]. These projects support(ed) the development of a new infrastructure for purity assessment and for measurement of "low" emissions levels for hydrogen and carbon dioxide.

As relevant, synergies should also be explored with the activities and projects supported by the Circular Bio-based Europe Joint Undertaking.

Proposals are expected to demonstrate the contribution to EU competitiveness and industrial leadership of the activities to be funded including but not limited to the origin of the equipment and components as well infrastructure purchased and built during the project. These aspects will be evaluated and monitored during the project implementation.

It is expected that Guarantees of origin (GOs) will be used to prove the renewable character of the hydrogen that is produced. In this respect consortium may seek out the issuance and subsequent cancellation of GOs from the relevant Member State issuing body and if that is not yet available the consortium may proceed with the issuance and cancellation of non-governmental certificates (e.g CertifHy[181]).

Proposals should provide a preliminary draft on 'hydrogen safety planning and management' at the project level, which will be further updated during project implementation.

For additional elements applicable to all topics please refer to section 2.2.3.2.

HORIZON-JU-CLEANH2-2025-01-07: Towards exploration and evaluation of European natural hydrogen potential

Specific conditions	
Expected EU contribution per project	The JU estimates that an EU contribution of maximum EUR 2.00 million would allow these outcomes to be addressed appropriately.
Indicative budget	The total indicative budget for the topic is EUR 2.00 million.
Type of Action	Research and Innovation Action
Technology Readiness Level	Activities are expected to start at TRL 2 and achieve TRL 4 by the end of the project - see General Annex B.
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G. The following exceptions apply: Eligible costs will take the form of a lump sum as defined in the Decision of 7 July 2021 authorising the use of lump sum contributions under the Horizon Europe Programme – the Framework Programme for Research and Innovation (2021-2027) – and in actions under the Research and Training Programme of the European Atomic Energy Community (2021-2025)[182].

[179] Metrology for decarbonising the gas grid (Decarb) https://www.euramet.org/european-metrology-networks/energy-gases/activities-impact/projects/project-details/project/metrology-for-decarbonising-the-gas-grid
[180] Metrology for CCUS (MetCCUS) https://www.euramet.org/european-metrology-networks/energy-gases/activities-impact/projects/project-details/project/metrology-support-for-carbon-capture-utilisation-and-storage
[181] https://www.certifhy.eu
[182] This decision is available on the Funding and Tenders Portal, in the reference documents section for Horizon Europe, under 'Simplified costs decisions' or through this link: https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/guidance/lsdecision_he_en.pdf

Expected Outcomes

Although natural hydrogen is produced via various physical phenomena taking place in the Earth's subsurface, notably fluid-rock interactions, the discoveries have all been accidental, limited in investigation, and only harnessed in Mali. As such, natural hydrogen is a potential new source of clean hydrogen which can play a significant role in Europe to meet the objectives set out in the Fit-for-55 Package and REPowerEU plan.

In the future, the potential of natural hydrogen accumulations in the subsurface should be determined and exploited in Europe in a safe and sustainable way to complement other routes of hydrogen production. Indeed, natural hydrogen may contribute to limiting greenhouse gas emissions, raw materials, water resources, and land use as compared to other types of hydrogen production, hereby strengthening the EU energy independency while accelerating the implementation of the hydrogen energy economy and thus the net-zero energy transition. Nevertheless, current needs are to develop methods and workflows to efficiently explore this resource, increase public support, and evaluate economically viable industrial solutions.

Project results are expected to contribute to the following outcomes:

- Strengthened European leadership in the exploration of natural hydrogen to identify and evaluate reserves and seek industrial production;
- Improved understanding of the occurrence and the resource potential of natural hydrogen in Europe, to define prospective areas for exploration and production (E&P);
- Identification of enablers and barriers in terms of regulation, social acceptability, market, and financial incentives to stimulate the E&P of natural hydrogen for European countries.

Scope

Natural hydrogen is a resource that has recently come under the spotlight for its potential to accelerate the shift to a net-zero economy within the next decades. However, its production is critically challenged by the relatively limited understanding of the processes and geological conditions of its generation, the lack of well-proven workflows and the development of standard methods for its exploration. Efficient detection methods are required to identify promising areas prone to regional exploration, while analytical and numerical workflows are needed to quantify the potential of a geological formation to hold adequate volumes of natural hydrogen for production at an industrial scale. This requires knowledge improvement of the subsurface processes controlling the generation, migration and trapping of hydrogen in economically relevant quantities.

This topic aims to support both the development of new methods, technologies, and workflows that will enable the development of E&P of natural hydrogen in Europe. It will bridge the gap between Research and Innovation (R&I), regulatory framework, and economic investments to boost the energy transition.

Proposals in this call should aim at better understanding the mechanisms related to natural hydrogen generation and accumulation in the subsurface, developing specific tools and methods to assess the resource potential, demonstrating its environmentally and economically viable exploitation, and informing adequate regulation and policies in Europe for large-scale deployment.

Proposals should address most of the following elements:

- Development of techniques, tools, and methods to better characterise and understand processes controlling the formation, migration, and accumulation of hydrogen in the subsurface as well as natural emissions to the surface, and to establish a set of criteria to confidently identify prospective areas. Proposals should include at least one case study area (two if the budget allows it) to test remote sensing and hydrogen sensors, gather geophysical data from active or passive seismic, gather geochemical data, possibly logging tool (tools which are run into the well after drilling and which, with specific development would help to characterize hydrogen in the well) in order to calibrate methods with minimal environmental impact;

- Guidelines for systematically identifying potential natural hydrogen sources in Europe by determining the combination of key parameters and conditions necessary to its generation;
- Analogue experiments to simulate *in situ* conditions (temperatures, pressures, rock mineralogy and chemistry, geofluid compositions) controlling the generation of natural hydrogen and its kinetic (in mol/kg/s);
- Numerical models to predict the dynamics of large hydrogen systems, from the source (generation, migration, and alteration), trapping in reservoirs if appropriate, to emission/leakage at the surface. It should allow the determination of a "Hydrogen Window" *i.e.* both chemical and physical subsurface conditions to generate natural hydrogen, applicable on specific or general conditions. Ultimately, the numerical models should allow quantifying the possible volume (in tonnes) and production rate (in tonnes/year) of selected sites of natural hydrogen in Europe in the coming years and characterizing its potential renewable aspect;
- Characterisation of purification requirements of selected expected gas compositions, identification of possible technologies, and test of their performances at laboratory scale.
- Life Cycle Assessment to determine the environmental performance of exploring, extracting, and producing natural hydrogen at this early stage of knowledge and at relevant specifications (*i.e.* including purification and other post-production treatments) notably in terms of (i) Greenhouse gas emissions range (in kg CO_2 eq. per kg H_2 produced) including possible associated gases and fugitive leakages, (ii) critical raw materials use, (iii) water resources consumption, and (iv) land use;
- A check (based on the LCA results) whether natural hydrogen can be classified as Renewable Fuels of Non-Biological Origin (RFNBO) established under the Renewable Energy Directive (RED II). This would allow framing natural hydrogen into EU certifications which will ensure a commercialisation of the natural hydrogen to clients willing to decarbonise their activities. Elements to establish the right taxonomy of natural hydrogen to be certified under EU certification schemes should be provided;
- A conceptual study to assess the levelized cost range of hydrogen production (in € per kg H_2 produced) taking into account, key parameters such as drilling design, operational costs, periodic work-over, abandonment costs, purification requirement, expected volume and well deliverability. A parametric model integrating the outputs of the conceptual study will allow the economic assessment of prospects on a case-by-case basis.
- At the same time, a bottleneck is to access these reserves in a safe and cost-efficient manner. Thus, research on identifying challenges related to well construction, drilling dynamics, and how to address them, will provide tools and methods to advance exploration and production of natural hydrogen, and mitigate leakages from prospection to exploitation;

In addition, proposals may address the following:

- Identification, description, and evaluation of the specific geological formations, processes, and settings that can potentially produce natural hydrogen in economically viable quantities in Europe;
- The social acceptability of these projects is also key to operate. Protocols are needed to improve public perception and acceptance including communication strategies dedicated to specific stakeholders with emphasis on the local benefits provided by the resources, and on the activities and their related safety risk mitigation;
- Mitigate the risks related to the safety of handling hydrogen in such quantities and opposition by the public, to accelerate the transition towards low-carbon energy solutions.

As relevant, proposals are encouraged to involve European and national geological research institutes.

For additional elements applicable to all topics please refer to section 2.2.3.2.

HYDROGEN STORAGE AND DISTRIBUTION

HORIZON-JU-CLEANH2-2025-02-01: Development of mined, lined rock cavern for gaseous hydrogen storage

Specific conditions	
Expected EU contribution per project	The JU estimates that an EU contribution of maximum EUR 5.00 million would allow these outcomes to be addressed appropriately.
Indicative budget	The total indicative budget for the topic is EUR 5.00 million.
Type of Action	Research and Innovation Action
Technology Readiness Level	Activities are expected to start at TRL 3 and achieve TRL 5 by the end of the project - see General Annex B.
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G. The following exceptions apply: Eligible costs will take the form of a lump sum as defined in the Decision of 7 July 2021 authorising the use of lump sum contributions under the Horizon Europe Programme – the Framework Programme for Research and Innovation (2021-2027) – and in actions under the Research and Training Programme of the European Atomic Energy Community (2021-2025)[183]. Beneficiaries must, up to 4 years after the end of the action, inform the granting authority if the results could reasonably be expected to contribute to European or international standards.

Expected Outcomes

Clean hydrogen is recognised as an energy carrier that will play a major role in the decarbonisation of European energy systems, as it can substitute fossil fuels in hard-to-abate sectors. Several governments and institutions have announced ambitious plans for developing a hydrogen economy. The European Union has notably set a 2030 target of 40 GW of electrolysers producing 10 million tonnes of renewable hydrogen to be added to 10 million tonnes of imported clean hydrogen.

These substantial quantities of hydrogen will require aboveground and underground storage capacities. Notably, underground hydrogen storage will provide a means for fulfilling these large-scale storage needs as it presents advantages in terms of environmental protection, energy security, safety, and economically, in terms of CAPEX (for high storage capacity) and OPEX. Underground storage CAPEX is highly dependent on targeted capacities, operating envelopes (namely required flowrates), available geology, needs for purification, and on storage technologies. However, an estimation of the orders of magnitude for costs is as follows:

- According to the Clean Hydrogen Partnership project HYSTORIES[184] (2022), storage solutions based on porous reservoirs have an estimated cost of about 20€/kg (+/- 50%)

[183] This decision is available on the Funding and Tenders Portal, in the reference documents section for Horizon Europe, under 'Simplified costs decisions' or through this link: https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/guidance/lsdecision_he_en.pdf

[184] https://cordis.europa.eu/project/id/101007176

and are only valid for very large quantities, whilst SRIA KPIs (2022) present a target value of 5€/kg in 2030 for porous reservoirs (storage capacity not provided; 120 bar compression);

- Salt caverns technology costs are estimated at approximately 35€/kg (+/- 50%) and are applicable for moderate to large quantities, whilst SRIA KPIs (2022) present a target value of 30€/kg in 2030 for salt caverns (storage capacity > 3000 tons);
- Storing hydrogen in mined, lined rock caverns is more difficult to assess as the methodology is not fully understood yet. Initial assessments estimate costs between 250€/kg (large quantities, in very good rock conditions) and 500€/kg (large quantities, in good rock conditions). However, costs could be both higher or lower, depending on conditions. Nonetheless, these costs remain attractive when compared to costs for surface storage techniques while also addressing concerns that are present for such techniques (e.g. safety, security, etc.).

Whether these storage capacities will be scattered or centralised remains an open question, but many analysts consider that a variety of storage unit sizes will be required including large and centralised storage.

Salt caverns or porous geological traps offer possibilities for massive hydrogen storage needs as a more cost-effective large-scale hydrogen storage solution. However, applications are limited to locations with suitable geology. In the EU, the number of such locations is limited. Thus, for regions without suitable geology, mined, lined rock caverns may be considered as a suitable technological solution for gas and liquid storage.

The design and safe operation of European hydrogen storage in mined, lined rock caverns requires the development of shared, dedicated standards and guidelines. Amongst the challenges are the choice of a hydrogen-compatible liner material (e.g. steel), the behavior of this material in cycle fatigue[185] situations, the selection of optimised concrete or other materials to cushion the liner against the rock mass and protect it from the effects of the environmental degradation (e.g. corrosion), and other potential impacts, and an understanding of how varying geological lithologies will interact with the cyclical pressure differences. Steel is likely to be chosen for the liner based on lessons learned from manufacturing, installation, and operation processes. However, other materials may also be explored and compared to steel.

Understanding the impact of constructing new caverns as opposed to utilising previously constructed caverns on environment, safety, energy security, and economics is also a topic of interest.

Project results are expected to contribute to all the following expected outcomes:

- Generate knowledge on the mechanical behaviour of a complex liner (concrete, steel, etc.) in combination with the geomechanical behaviour of the surrounding rock for a mined, lined rock cavern subject to cycling conditions and natural hazards (e.g., earthquakes);
- Provide design principles and operation envelopes to be used by decision makers when assessing CAPEX and OPEX of mined, lined rock caverns in various conditions (rock mass quality, commercial needs, accessibility, security considerations, etc.);
- Make hydrogen storage systems that are fit for purpose and that can reduce the cost and improve the efficiency of hydrogen supply across Europe available to industry;

[185] Understood as material fatigue under a range of operational demands

- Facilitate international collaborations to generate and apply knowledge that can improve underground hydrogen storage operations that contribute to hydrogen sustainability and reduce associated costs;
- Contribute to maintaining European leadership for large-scale hydrogen storage solutions, with particular focus on assessing the opportunities to understand what makes a previously built cavern best suited for purpose, as well as to understand the dynamics of building mined, lined rock caverns in a diverse set of potential geological lithologies (e.g. gneiss, granite, carbonates, sandstones, basalts). Furthermore, identify and define which geological, geotechnical, and hydrological parameters are best suited for large-scale underground hydrogen storage;
- Provide replication tools of the methodologies developed and demonstrated in the project in sites in other European regions with different subsurface (and operational) characteristics, ensuring an exhaustive coverage of the different European sites' specifics;
- Motivate technical and economic revitalisation of areas with abandoned and/or underutilised cavern infrastructure (e.g. tunnels, natural gas caverns, mines, etc.) in Europe.

Project results are expected to contribute to the following objectives (KPIs of the Clean Hydrogen JU SRIA are not applicable as such):

- Undertake research activities on underground storage to validate the performance in different geologies, to identify better and more cost-effective materials and to encourage improved designs;
- Support the development of Regulations Codes and Standards (RCS) for hydrogen technologies and applications, focusing on standards for assessing the life span of a mined, lined rock cavern for hydrogen storage;
- Organise safety, Pre-Normative Research (PNR) and RCS workshops.

Scope

The primary challenge to the integrity of a mined, lined rock cavern used for hydrogen storage is the cyclical fatigue, within which hydrogen embrittlement can play a role.

Cyclic strains are induced by the loading/unloading of gas in combination with the confining pressure exerted by the surrounding geological and hydrological environment. These strains can be significant enough to cause plastic deformation of the liner. Additionally, the operational cycling conditions leads to liner (e.g. steel, concrete, etc.) fatigue in addition to having an impact on the surrounding rock mass itself. This fatigue is known as "low-cycle fatigue" (large strain, limited number of cycles).

Proposals should address the technical challenges stemming from combining large strains, fatigue conditions, and hydrogen service on the liner, the surrounding concrete, and the encompassing rock masses. Therefore, industrial development of this concept for hydrogen storage requires studies, tests and a combination of laboratory and field demonstrations.

This topic focuses exclusively on gaseous hydrogen – liquid hydrogen is not considered because of its extremely low temperature requirements.

To overcome the gaps mentioned above, proposals should address the following:

- Generate knowledge of steel behaviour when subject to cycling conditions in hydrogen environment under a range of operational demands. This may include simulations based on rupture mechanics, fracture propagation, plasticity theory, etc. This should also include validation by testing;

- Generate knowledge on the corrosion of steel over time including the potential for crevice corrosion and pitting that could result in failure. Damage resulting from H_2 embrittlement, or impurities within the H_2 of the steel liner may also be considered. This includes knowledge generation on hydrogen quality after storage and withdrawal from the mined, lined rock cavern. This may include hydrogen analysis under simulated cavern conditions in the laboratory using material from the lined rock cavern in the test reactor or by testing gas samples from a field demonstration;
- Generate knowledge on appropriate concrete compositions for cycle fatigue under a range of operational demands, as well as to best protect the integrity of both the steel liner and the surrounding rock mass. Alternative binders to Ordinary Portland Cement should be considered, to improve the environmental footprint while creating a concrete with higher durability. This may include simulations on fracture propagation, porosity/permeability analyses, as well as laboratory and/or field testing;
- Design the concrete buffer slurry ensuring that it is designed to be space filling in such a way that it does not introduce stress/strain concentrations. It will likely require high pumpability, alongside good self-compacting properties with high gravitational stability. The use of expanding agents in the concrete mix may be considered through testing, to improve space filling properties and potentially pre-stress the steel liner;
- Generate knowledge on how variations in geological conditions (e.g. lithology, depth, stress, temperature, etc.) impact both the short- and long-term performance of the storage site. This may include complex numerical simulations of the full storage system, taking into account fracture generation and propagation, fatigue, etc., as well as analogue modeling in the laboratory and/or field testing in a variety of representative geological conditions;
- Provide guidelines for the selection of steel grades (including welds) for hydrogen services in mined, lined rock caverns. This may include simulations and testing. Challenges associated with welds including potential damage due to the presence of residual stresses and heterogenous microstructures may be considered;
- Develop recommendations for a standardised design for new mined, lined rock caverns, and best practices for converting existing caverns for hydrogen storage. This design should include underground and aboveground installations dedicated to the storage activity (hydrogen treatment, compression, piping, metering). Connecting lines between the cavern and the aboveground installations should also be covered. Additionally, it is important to consider the impact of natural hazards (e.g. earthquakes) on the entire system (e.g. steel liner, concrete, rock mass, etc.);
- Understanding potential monitoring methods, including the storage site and surrounding rock mass, should be considered. Ideally, any field testing carried out would include various potential monitoring methods to understand advantages and disadvantages of each approach. Monitoring methods should be able to able to indicate potential failure, as well as other changes within the mined, lined rock cavern storage system (i.e. steel liner, concrete, rock mass, etc.);
- Ascertain the design through a comprehensive set of simulations. A physical proof of concept (POC) should also be proposed. The parameters for the POC should be ascertained through a combination of numerical modelling, and laboratory testing. The

proposal for a POC may be either or a combination of 1) an above ground test that could be utilised to explore the impact of cycling hydrogen within a storage container on the various non-subsurface components (e.g., steel, concrete) and/or 2) a series of tests designed to understand the impact of different geological conditions. Other POC approaches can be proposed provided they significantly improve the level of confidence in the concept;

- Define construction methods for a mined, lined rock cavern;
- Define cavern acceptance test procedure of the mined, lined rock cavern with a focus on how geological uncertainty may impact this;
- Provide a comprehensive risk analysis covering construction, operation, and geomechanical risks taking into account an understanding of the economic, environmental, energy security, and safety considerations;
- Define guidelines/protocols to support Storage System Operators (SSOs) in the identification and management of risk associated to the storage of hydrogen in mined, lined rock caverns. The guidelines should also propose a fast-track procedure which will allow the SSOs to have a preliminary qualitative assessment of the hydrogen storage feasibility, considering the main relevant factors, as well as assist SSOs in the identification of the optimum storage sites including preferential geological/hydrological conditions; These guidelines should be seen as replication tools of the methodologies developed and demonstrated in the project in sites in other European regions with different subsurface (and operational) characteristics, ensuring an exhaustive coverage of the different European sites' specifics;
- Develop techno-economic analyses considering the application of this large-scale solution in a number of different use-case studies including dynamic simulations. Possibilities include, but are not limited to: 1) on-grid applications where mined, lined rock caverns support the EU hydrogen grids in transporting and managing the daily intermittent (e.g., solar, wind) hydrogen production, 2) off-grid applications, where the storage solution is directly connected to an end-user (e.g., industrial use cases, maritime transportation, etc.) and its hydrogen demand, 3) hybrid solutions wherein temporary hydrogen storage may be beneficial, but that use by the grid may also be beneficial (e.g., integrated renewable energy systems).

Building on the results of previous activities, proposals should, as relevant, provide recommendations and dissemination for updated and/or developing new standards at EU and international levels. Projects are encouraged to involve the relevant standardization bodies, for example through liaison organisations[186]. In addition, the outcomes of, but not only, project MefHySto[187], supported by the under the EURAMET research programme, maybe of relevance.

For additional elements applicable to all topics please refer to section 2.2.3.2.

[186] https://www.cencenelec.eu/media/Guides/CEN-CLC/cenclcguide25.pdf

[187] Metrology for Advanced Hydrogen Storage Solutions, https://www.euramet.org/european-metrology-networks/energy-gases/activities-impact/projects/project-details/project/metrology-for-advanced-hydrogen-storage-solutions This project has developed standards-based solutions to support the development of advanced hydrogen storage technologies.

HORIZON-JU-CLEANH2-2025-02-02: Development of cost effective and high-capacity compression solutions for hydrogen

Specific conditions	
Expected EU contribution per project	The JU estimates that an EU contribution of maximum EUR 5.00 million would allow these outcomes to be addressed appropriately.
Indicative budget	The total indicative budget for the topic is EUR 5.00 million.
Type of Action	Research and Innovation Action
Technology Readiness Level	Activities are expected to achieve TRL 5 by the end of the project - see General Annex B.
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G. The following exceptions apply: Eligible costs will take the form of a lump sum as defined in the Decision of 7 July 2021 authorising the use of lump sum contributions under the Horizon Europe Programme – the Framework Programme for Research and Innovation (2021-2027) – and in actions under the Research and Training Programme of the European Atomic Energy Community (2021-2025)[188].

<u>*Expected Outcomes*</u>

Cost-effective and high-capacity hydrogen compression in a wide pressure range is an important component for enabling fossil-price parity of green hydrogen for Power-to-X (PtX) and transport fuel onwards 2030. This calls for substantially reduced CAPEX and OPEX costs and improved efficiency and reliability for hydrogen compression compared to state-of-the-art, through pursuing new innovations and designs. This requires pioneering new design solutions to address the unique challenges of hydrogen compression, such as material degradation and leak tightness under high-pressure conditions and ensuring structural integrity to prevent component failures.

Innovations might include exploring novel design for currently used materials or the development of new materials resistant to hydrogen embrittlement and high-temperature hydrogen attack, and advanced leak detection and mitigation systems. Furthermore, innovations could include disruptive and breakthrough enhancements with a strong emphasis on solutions that can withstand varied operational stresses.

Previous EU-funded projects[189] e.g electrochemical compression (PHAEDRUS[190]), thermochemical compression (COSMHYC[191], COSMHYC XL[192] & COSMHYC DEMO[193]), hydraulic boosters (H2Ref[194] & H2Ref Demo[195]), are helping to progress hydrogen compression towards achieving the Clean Hydrogen JU SRIA 2024 targets. However, for

[188] This decision is available on the Funding and Tenders Portal, in the reference documents section for Horizon Europe, under 'Simplified costs decisions' or through this link: https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/guidance/lsdecision_he_en.pdf
[189] Alternative technologies have already been investigated in the frame of previous of all these EU funded projects
[190] https://cordis.europa.eu/project/id/303418
[191] https://cordis.europa.eu/project/id/736122
[192] https://cordis.europa.eu/project/id/826182
[193] https://cordis.europa.eu/project/id/101007173
[194] https://cordis.europa.eu/project/id/671463
[195] https://cordis.europa.eu/project/id/101101517

hydrogen compression to contribute to enabling fossil-price parity a further stretch towards the SRIA 2030 targets is required.

Market segments such as Power-to-X (PtX) and transport fuel at the same time requires much higher compression capacities in a wide pressure range as a mean to reduce costs, compared to what is currently cost-feasible for state-of-the-art.

Project results are expected to contribute to all of the following expected outcomes:

- Development of innovative scalable hydrogen compression solutions;
- Enhancing European leadership on hydrogen infrastructure solution based on compression technologies;
- Accelerating the deployment, uptake and diffusion of European innovative compression technologies, through wide and early engagement with end-users, SMEs, start-ups, and regulatory & standardisation bodies;
- Lowering the costs of production of green hydrogen, thus accelerating the expansion of a hydrogen-based infrastructure (for which hydrogen compression is a key element*).*

Project results are expected to contribute to the following objectives and KPIs of the Clean Hydrogen JU SRIA:

- Inlet pressure: 30 bar or lower;
- Outlet pressure: up to 900 bar or higher;
- Minimum capacity: 150kg/hour or higher (30 bar inlet and 900 bar outlet);
- Electrical energy consumption including auxiliaries (steady inlet 30bar to steady outlet 900 bar): 3 kWh/kg;
- Mean Time Between Maintenance (MTBM) at 95% confidence level: 8,000 hours; If relevant consider the SRIA 2030 Mean Time Between Failure (MTBF) of 60,000 hours
- OPEX (maintenance): 0,2 €/kg with a roadmap to the SRIA 2030 target of 0,03 €/kg;
- CAPEX (30-900 bar 150kg/hour): 3,500€/kW (438 €/kg/day at 3kWh/kg and 150kg/hour).

Scope

This topic aims at addressing the two-folded challenge of reducing hydrogen compression costs whilst at the same time leaping a substantial capacity increase and in a wide pressure range.

Proposals should develop highly disruptive compression technologies or achieve breakthrough on conventional compression technologies – or a combination of both novel and conventional technologies.

Proposals should develop a flexible hydrogen compression solution that is adaptable across a wide range of applications in order to capture aggregated market volume and resultant reduced costs. This should at least cover PtX applications in the range of 30-200bar (off-take from electrolysers/pipelines and supply for industrial gas applications) and 200-900bar for supply to Medium and Heavy-Duty (MHD) vehicle Hydrogen Refuelling Stations (HRS), compressors for pipeline feeding of H2 in the range of 30-200bar, as well as high pressure trailer filling facilities (500+bar).

To effectively integrate compression technologies into the required pressure range, it is also crucial to develop the required materials technology to address the unique challenges posed by the intake of hydrogen by the system components, potentially leading to degradation through mechanisms such as hydrogen embrittlement and high-temperature hydrogen attack. These challenges are exacerbated at high pressures. Developing a comprehensive understanding of how compressors deteriorate under real-world operating conditions is essential for achieving reliability and economic targets.

Proposals should cover the following elements:

- Development and operation of a full-scale hydrogen compressor prototype, in a relevant environment, for achieving TRL5 (e.g. test centre with simulated or real supply and off-take that resembles relevant PtX and MHD HRS applications being targeted);
- The compressor solution should feature a design that allows for flexible adaption to accommodate different pressure and capacity ranges in order to maximise potential following commercial market volume;
- Compatibility of the hydrogen compression solution with liquid hydrogen supply in the case of MHD HRS applications should be considered – e.g. capturing gaseous hydrogen outlet from conventional liquid supply setups.

The compression solution should prove the ability to achieve the capacity and targets relevant for the market applications being targeted by the proposal. Targets outlined for this topic use the HRS application as baseline, where at least 150 kg/h (3,6 tons/day) capacity in the pressure range of 30-900 bar, and 5000 kg/h for pipelines transport. This will be required to enable use in HRSs with sufficient capacities for fast fuelling of MHD vehicles. The pressure range and capacity would also support various PtX market segments such as electrolyser/pipeline off-take, industrial gas use and high-pressure trailer filling facilities. Proposals may also choose to target achieving of compressor direct filling.

Proposals should include development activities targeting compressor designs with high capacity (2.5 tons/day), e.g. through higher compression ratios, increased operation speed or other relevant means.

Proposals may however choose to target an outlet pressure lower than 900 bar e.g. if focusing on specific market applications where solutions are missing or too costly.

Despite increasing of capacity likely will stretch the physical design parameters, energy efficiency and reliability is to be improved at the same time. This may be done by e.g. exploring use of new or novel materials and/or coatings with reduced friction and longer lifetime and/or reducing wear and increasing efficiency by means of cooling, or by developing non-mechanical hydrogen compression solutions.

Proposals should include thorough testing of a full-scale (or reduced-scale for early-stage technologies) compression prototype in an operational environment that is adequate for achieving TRL5 (or higher) and validate reaching of targets. Operation in a test centre should resemble real conditions for supply/off-take in PtX market segments and MHD HRSs including relevant start/stop conditions and fluctuating inlet/outlet pressures, potentially using new monitoring and sensor techniques. Whereas 8,000 hours of MTBM may not realistically be achieved during the test period of a project, the potential for achieving the target should be substantiated as part of the test efforts. Proposals may also consider the SRIA 2030 Mean Time Between Failure (MTBF) target of 60,000 hours if this can be quantified as part of the project at the targeted TRL level.

Proposals should substantiate that an OPEX level of 0,2 €/kg can be achieved for the compression solution and should develop a roadmap towards reaching of the SRIA 2030 target of 0,03 €/kg beyond the project.

Requirements or guidelines from European and International hydrogen standardisation bodies relevant for hydrogen compression should be considered for the activities to be undertaken. In addition, proposals may include a technical simulation-based analysis of the integration of the developed flexible hydrogen compression into the future hydrogen infrastructure (e.g. gas grid and caverns) if relevant for the market applications being addressed.

Whereas proposals are to achieve minimum TRL5 only, efforts should also be included on planning and preparing following activities that can further advance the compression solution eventually to a market ready product. Consortium behind a proposal should include stakeholders capable of and with plans for a further advancement and market introduction.

Proposals are encouraged to explore synergies with projects within the metrology research programme run under the EURAMET research programme, in particular projects DECARB[196] and Met4H2 [197]. These projects are working on development of leak detection measurement standards and method, what may be required to evaluate any hydrogen impurities the compression step may introduce.

For additional elements applicable to all topics please refer to section 2.2.3.2.

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[196] Metrology for decarbonising the gas grid (Decarb) https://www.euramet.org/european-metrology-networks/energy-gases/activities-impact/projects/project-details/project/metrology-for-decarbonising-the-gas-grid

[197] Metrology for the hydrogen supply chain (Met4H2) https://www.euramet.org/european-metrology-networks/energy-gases/activities-impact/projects/project-details/project/metrology-for-the-hydrogen-supply-chain

HORIZON-JU-CLEANH2-2025-02-03: Demonstration of scalable ammonia cracking technology

Specific conditions	
Expected EU contribution per project	The JU estimates that an EU contribution of maximum EUR 6.00 million would allow these outcomes to be addressed appropriately.
Indicative budget	The total indicative budget for the topic is EUR 6.00 million.
Type of Action	Innovation Action
Technology Readiness Level	Activities are expected to start at TRL 5 and achieve TRL 7 by the end of the project - see General Annex B.
Admissibility conditions	The conditions are described in General Annex A. The following exceptions apply: The page limit of the application is 70 pages.
Eligibility	The conditions are described in General Annex B. The following additional eligibility criteria apply: At least one partner in the consortium must be a member of either Hydrogen Europe or Hydrogen Europe Research. The maximum Clean Hydrogen JU contribution that may be requested is EUR 6.00 million – proposals requesting Clean Hydrogen JU contributions above this amount will not be evaluated.
Procedure	STEP Seals will be awarded to proposals exceeding all of the evaluation thresholds set out in this work programme.
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G. The following exceptions apply: Eligible costs will take the form of a lump sum as defined in the Decision of 7 July 2021 authorising the use of lump sum contributions under the Horizon Europe Programme – the Framework Programme for Research and Innovation (2021-2027) – and in actions under the Research and Training Programme of the European Atomic Energy Community (2021-2025)[198]. Purchases of equipment, infrastructure or other assets used for the action must be declared as depreciation costs. However, for the following equipment, infrastructure or other assets purchased specifically for the action (or developed as part of the action tasks): ammonia cracking system including its BoP, costs may exceptionally be declared as full capitalised costs.

<u>*Expected outcomes*</u>

Ammonia is an essential global commodity. Today, around 85% of all ammonia is used to produce synthetic nitrogen fertilisers and is responsible for around 45% of global hydrogen

[198] This decision is available on the Funding and Tenders Portal, in the reference documents section for Horizon Europe, under 'Simplified costs decisions' or through this link: https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/guidance/lsdecision_he_en.pdf

consumption, or around 33 Mt of hydrogen in 2020. Hydrogen production by ammonia cracking has received growing attention in recent years for several reasons: i) an established and complete supply chain with considerable growth due to the high supply and demand ammonia for several sectors, ii) ammonia cracking emits only nitrogen as a byproduct, iii) ammonia has attractive gravimetric and volumetric densities for hydrogen storage applications, allowing an easy transport with reduced cost.

While several projects have developed novel concepts for ammonia cracking technologies in recent years, the feasibility of up-scaling these technologies in terms of reactor design and hydrogen production rate to match industrial demand at various scales needs to be validated. This includes optimisation of thermal management, for instance, by considering integrating the cracking plant in a use-case scenario and implementing a modular approach to the cracking technology for rapid scale-up and deployment in various sectors.

The topic addresses the value chain from ammonia molecules to purified hydrogen for delivery in downstream applications. Hence, it addresses system design optimisation to reduce the energy consumption of cracking reactions and integrate it with purification/separation processes.

To bring ammonia cracking technology to the next stage of maturity, project results are expected to contribute to all the following expected outcomes:

- Provide breakthrough and game-changing technologies for hydrogen production by ammonia cracking;
- Contribute to replicability and modular scalability of new ammonia cracking technology to enable future commercial applications at different scales;
- Improve the efficiency of the ammonia conversion process also integrating purification of produced hydrogen;
- Contribute to European technology leadership in ammonia cracking technology, integration of high-efficiency heat management, and hydrogen purification;
- Improve and develop new business models of hydrogen production by ammonia cracking for various scales of production;
- Contribute to the understanding of Europe's needs in terms of infrastructure and regulation for managing the ammonia supply chain for hydrogen production;
- Contribute to the sustainability of the European materials supply chain, strengthening the recyclability of CSRM (Critical and Strategic Raw Materials).

Project results are expected to contribute to all the following objectives:

- Total Cost of Ownership: <1.5 €/kgH2 delivered[199];
- Ammonia dehydrogenation unit CAPEX <1000k€/(tonnesH2.day);
- Demonstrate high tunability and a wide range of dynamic operations (30-100%) for several user cases;
- The availability of the system should be no less than 90%;

[199] Not including NH3 cost production and transport. H2 output at 30 bar(g) and in compliance with ISO 14687. The TCO includes Energy + Capex+ Operating cost + depreciation.

- Recovery rate of hydrogen should be > 80%[200].

Scope

The topic focuses on developing a highly efficient, modular and scalable cracking technology to convert ammonia into high-purity hydrogen to the specifications needed for specific applications and scales. The modular and scalable technology will enable cost-competitive and safe use of hydrogen in industrial and market sectors such as hard-to-decarbonise and off-grid power generation applications. The primary outcomes should be an innovative, low-cost, and compact technology enabling dynamic operations for energy-efficient hydrogen production, contributing to the overall objectives of the Clean Hydrogen JU SRIA to reduce hydrogen production and transport costs. The scope of this topic is to design, manufacture and demonstrate in an operational environment a system prototype for efficient ammonia cracking for at least 100 kg/day production.

The topic should cover the following elements:

- Design, fabrication and testing of a system (also modular) that enables process intensification and improved electrical and thermal integration to produce high-purity hydrogen that is compliant with the application it plans to address;
- Novel catalyst and/or reactor design to improve efficiency and manufacturing, including if necessary, integrating novel separation processes to produce dry hydrogen, as well as potentially novel principles of the cracking/reforming process;
- Ammonia cracking scale-up and efficient integration for power/heat generation and/or hydrogen utilisation;
- Assess the integrity of materials exposed to ammonia with respect to corrosion and mechanical failure;
- Design the cracking reactor and Balance of Plant components to ensure flexible operation of the system and for optimising economic energy usage;
- Perform a safety assessment of the system and contribute to establishing a robust background and roadmap for standardisation;
- Present a demonstration system running for at least 5000 hours and producing ≥100 kg H2/day;
- Demonstrate the potential scalability of the developed technology into a plant size of up to 10 tonnes of H2/day, enhancements of the total process efficiency through techno-economic and life-cycle assessment and social analysis of the proposed technology (e.g. Techno-Economic Assessment (TEA), Life Cycle Assessment (LCA), Life-Cycle Cost Assessment (LCCA), Life-Cycle and Sustainability Assessment (LCSA));
- Provide a sustainability analysis establishing the impact of CSRM usage and path forward for its potential reduction.

Proposals are encouraged to seek synergies and complement ongoing projects producing renewable ammonia (including within the Innovation Fund[201]) with a view to demonstrating the

[200] The recovery rate is calculated from NH3 molecule (liquid form sub cooled) to gaseous hydrogen at 30 bar delivered to a pipeline. The efficiency includes: the NH3 needs to heat up the reactor, the NH3 as feed, all recirculation and purification modules, all utilities associated (in the top of the NH3 for the heater) and GH2 if needed.

[201] https://climate.ec.europa.eu/eu-action/eu-funding-climate-action/innovation-fund/innovation-fund-projects_en

production of renewable hydrogen.

Proposals are expected to collaborate with the activities of EURAMET concerning metrology for ammonia[202] and in particular with the successful project under the topic “Metrology to support ammonia use in emerging applications” under the European Partnership on Metrology call for proposals 2024[203].

Potential synergies can be explored with P4P (Partnership for Planet), including envisaging work for ammonia as hydrogen carriers.

Proposals are expected to demonstrate the contribution to EU competitiveness and industrial leadership of the activities to be funded including but not limited to the origin of the equipment and components as well infrastructure purchased and built during the project. These aspects will be evaluated and monitored during the project implementation.

Proposals should provide a preliminary draft on ‘hydrogen safety planning and management’ at the project level, which will be further updated during project implementation.

For additional elements applicable to all topics please refer to section 2.2.3.2.

[202] E.g MetroHyVe https://www.euramet.org/european-metrology-networks/energy-gases/activities-impact/projects/project-details/project/metrology-for-hydrogen-vehicles-2 and Met4H2 https://www.euramet.org/european-metrology-networks/energy-gases/activities-impact/projects/project-details/project/metrology-for-the-hydrogen-supply-chain

[203] https://metpart.eu/green-deal-call-2024-s2 and https://metpart.eu/component/edocman/call-2024-srt-v16/download.html?Itemid=0

HORIZON-JU-CLEANH2-2025-03-01: Configurable Fuel Cell Powertrain for Non-Road Mobile Machinery

Specific conditions	
Expected EU contribution per project	The JU estimates that an EU contribution of maximum EUR 5.00 million would allow these outcomes to be addressed appropriately.
Indicative budget	The total indicative budget for the topic is EUR 5.00 million.
Type of Action	Research and Innovation Action
Technology Readiness Level	Activities are expected to start at TRL 4 and achieve TRL 6 by the end of the project - see General Annex B.
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G. The following exceptions apply: Eligible costs will take the form of a lump sum as defined in the Decision of 7 July 2021 authorising the use of lump sum contributions under the Horizon Europe Programme – the Framework Programme for Research and Innovation (2021-2027) – and in actions under the Research and Training Programme of the European Atomic Energy Community (2021-2025)[204].

<u>*Expected outcomes*</u>

To achieve the ambitious goals of the Fit-for-55 and REPowerEU Plans, reducing greenhouse gas (GHG) emissions attributed to all segments of transport is key. In this endeavour, Non-Road Mobile Machinery (NRMM) vehicles also require alternative designs and technologies, as current internal combustion engines (ICE) powered NRMMs remain significant contributors to European GHG emissions. Particularly, hydrogen powered fuel cells (FC) are an attractive option when longer operability or fast fuelling are desired.

NRMMs have various specific requirements depending on their end-use (agriculture, ports, mining, logistic centres, construction, etc.), thereby constraining the dimensions, operation and architecture of their powertrain. More specifically, NRMMs widely vary in size and power level requirements, including power use for non-propulsion purposes. Additionally, a wide range of power levels and autonomy requirements make it difficult for NRMM manufacturers to adopt an appropriate FC solution without significant investments of time and money. An adequate degree of hybridisation (including battery packs), the selection of optimal fuel tank sizes and an efficient refuelling alternative are key challenges for deployment of FCs and hydrogen for NRMM applications. Moreover, NRMM applications are characterised by temporary use in areas with limited infrastructure and weak or no grid connection. Finally, both NRMM power train building blocks and refuelling infrastructure need to work in harsh environments, including extreme temperature, salt, fog, vibration, dust etc.

To support the decarbonisation of NRMMs, configurable FC/battery hybrid powertrains specifically suited for these vehicles, addressing different power levels, hybridisation strategies and autonomy requirements (including reliable, fast and safe refuelling), will be

[204] This decision is available on the Funding and Tenders Portal, in the reference documents section for Horizon Europe, under 'Simplified costs decisions' or through this link: https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/guidance/lsdecision_he_en.pdf

required in the future. As such, individual building blocks which can be assembled into a functioning powertrain by the NRMM manufacturer without in-house FC expertise should be developed.

Project results are expected to contribute to all the following expected outcomes:

- Extend the deployment of hydrogen and FC based powertrains to NRMM applications, thus establishing and consolidating a European supply chain for FC powertrains and components;
- Validation of safe hydrogen FC solutions and systems in demanding NRMM applications, contributing to building a European supply chain for FC powertrains and components;
- Proving efficiency and applicability of hydrogen FC solutions in NRMM applications via necessary improvements gained at system level;
- Provide a complete calculation of total cost of ownership (TCO) and comparison with incumbent ICE and battery-based technologies;
- Building confidence in FC technology and hydrogen refuelling for all of the off-road industry sectors and thus accelerating the market uptake;
- Identification of suitable solutions to any legal or standards barriers likely to prevent the successful introduction of hydrogen FC technology in the various NRMM fields of application;
- Support the development of next generation, cost competitive commercial/industrial scale Proton Exchange Membrane Fuel Cell (PEMFC) systems from EU suppliers for NRMM and potentially other applications.

Project results are expected to contribute to the following 2030 KPIs of the Clean Hydrogen Joint Undertaking (JU) Strategic Research and Innovation Agenda (SRIA) for heavy duty vehicles:

- FC module CAPEX < 100 €/kW (annual production rate greater or equal 25,000 units);
- Hydrogen tank (CG H_2) CAPEX < 300 €/kg H_2;
- FC stack durability (no harsh environment) > 30,000 hrs;
- FC module availability > 98%.

2030 KPIs for NRMM are reported below (ports and agriculture applications: dusty and with high salinity environment):

- NRMM FC stack durability: At least 80% of heavy duty on road;
- NRMM FC module CAPEX: no more than double the target for heavy duty on road;
- NRMM FC module availability: at least 80% of heavy duty on road;
- FC module is defined as FC stack plus air supply system, cooling system, internal (electronic control unit (ECU), media manifold and other BOP (recirculation, humidifier, sensors, DC/DC, etc)).

Scope

The topic aims to demonstrate a configurable fuel cell powertrain capable of being integrated in at least two NRMM applications preferably related to ports or agriculture where one application has a minimum fuel cell power of 200 kW and the other a minimum fuel cell power of 100 kW.

A performance comparison of the fuel cell powertrain with existing technology (i.e. internal combustion engine) should be part of the demonstration and should clearly show fc powertrain advantages.

Furthermore, in the development of the configurable powertrain, the same building blocks should be used but configured in different powertrains with a different form factor or a different power level or a combination of both.

The applications where this NRMM powertrain should be demonstrated include those which are complementary to already funded projects (H2Ports[205] and H2Mac[206]), but excluding the same type of mobile machinery which has already been funded. A complementary application may be one that belongs to the same environment (e.g. port) but is not funded by previous projects (e.g. straddle carrier, Rubber Tyred Gantry cranes , etc), and is expected to go beyond the already demonstrated activities.

Consortia should choose the application segment(s) based on an impact analysis (cradle to grave approach) showing the sustainability improvement, like the potential for CO_2 emission reduction, upon the full segment coverage in Europe compared with the already used technology.

In particular, a complete analysis of the market potential for the selected application/s and the corresponding CO_2 emission reduction has to be a deliverable of the project.

Following validation in a relevant environment, the demonstration in a relevant environment should be carried out for at least 2,000 hours of operation of an NRMM specific load profile to show the necessary stack lifetime and powertrain reliability. The demonstration hours may include the idles and stops which are naturally included in the typical NRMM application load profile. The 2,000 hrs demonstration should be done on the powertrain with the largest power output. The other powertrain/s demonstration testing should last at least 1,000 hrs.

Proposals should cover all the following elements:

- Develop and/or adapt a kit of building blocks which can be assembled into an easily configurable powertrain, including:
    - Fuel cell module/s (compliant with StasHH interface and size standards);
    - Energy management system;
    - Power electronics;
    - Cooling system;
    - Air and fuel management (including appropriate filtration means);
    - Optional components for mitigating the effects of harsh environment;
    - On-board hydrogen storage and equipment for fast refuelling.
- Develop an overarching software and control structure to effectively combine different building blocks into a fully functioning powertrain including batteries for hybrid operation;
- Mapping, identifying and disseminating key requirements (operating envelopes, environmental aspects etc.) of different NRMM platforms highlighting those which are

[205] H2Ports funds a yard tractor and a reach stacker, https://cordis.europa.eu/project/id/826339
[206] H2MAC funds an excavator and a crusher, https://cordis.europa.eu/project/id/101137786

in common between them and those which can have an impact on powertrain design and the selection of various building block elements;

- Analyse operation data and disseminate specific learnings from the FC and hydrogen based NRMM solution compared to incumbent technologies (fossil fuelled internal combustion engines and battery-based technologies);
- Developing solutions, including diagnostics and prognostication methods, to mitigate the impact of harsh environments on fuel cell lifetime and powertrain reliability;
- Developing strategies and incorporate measures to optimise powertrain efficiency, reliability, and lifetime while considering cleaning and maintenance procedures for all powertrain components;
- Select and validate a suitable and flexible refuelling solution compatible with the selected NRMM application and compatible with a wide range of end-users' requirements; This may be done with a comprehensive study that includes simulation and modelling, techno-economic assessments and even RCS considerations. The technical assessment should consider the special conditions as well in which temporary/mobile solutions would have to operate.
- Perform a Sustainable Life Cycle Assessment (SLCA) of the NRMM powertrain solution for at least one relevant case study;
- Performing a techno-economic assessment to demonstrate the progress toward reducing the powertrain capital cost and identify scale factors which could accelerate this progress.
- Adequately address regulatory aspects and contribute to prevailing regulations, codes and standards (RCS) activities.

It is expected that the fuel cell powertrain for NRMM is capable of handling:

- Fast transients from idle to full load in repetition;
- Dust on the nozzle that could impact the refilling;
- Continuous high power for long periods of time.

Consortia for this project should involve at least one NRMM manufacturer, a research institution and a Fuel Cell System integrator.

In addition, proposals should indicate how learnings from the project will be disseminated, in terms of potential spillover effects to segments other than NRMMs, such HD transport, marine, rail, stationary, etc. The development of single components such as the fuel cell stack, battery (cells & packs) and hydrogen tanks are not in the scope of this topic.

For activities developing test protocols and procedures for the performance and durability assessment of electrolysers and fuel cell components proposals should foresee a collaboration mechanism with JRC[207] (see section 2.2.4.3 "Collaboration with JRC"), in order to support EU-wide harmonisation. Test activities should adopt the already published EU harmonised testing protocols[208] to benchmark performance and quantify progress at programme level.

For additional elements applicable to all topics please refer to section 2.2.3.2.

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[207] https://www.clean-hydrogen.europa.eu/knowledge-management/collaboration-jrc-0_en

[208] https://www.clean-hydrogen.europa.eu/knowledge-management/collaboration-jrc-0/clean-hydrogen-ju-jrc-deliverables_en

HORIZON-JU-CLEANH2-2025-03-02: Scalable innovative processes for the production of PEMFC MEAs

Specific conditions	
Expected EU contribution per project	The JU estimates that an EU contribution of maximum EUR 5.00 million would allow these outcomes to be addressed appropriately.
Indicative budget	The total indicative budget for the topic is EUR 5.00 million.
Type of Action	Research and Innovation Action
Technology Readiness Level	Activities are expected to reach TRL 6 by the end of the project - see General Annex B
Manufacturing Readiness Level	Activities are expected to start at MRL 3 and achieve MRL 5 by the end of the project - see Call management and general conditions section.
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G. The following exceptions apply: Eligible costs will take the form of a lump sum as defined in the Decision of 7 July 2021 authorising the use of lump sum contributions under the Horizon Europe Programme – the Framework Programme for Research and Innovation (2021-2027) – and in actions under the Research and Training Programme of the European Atomic Energy Community (2021-2025)[209].

Expected outcomes

Membrane Electrode Assemblies (MEAs) are a core component of fuel cells (FCs), which are expected to be produced at large scale in order to meet the different mobility industry needs and support the market growth of FCs for these applications.

However, state-of-the-art manufacturing processes still suffer from shortcomings such as:

- Production processes manufacturing speed lagging behind the necessary capacity to meet the demand (often still utilising batch processes);
- Catalyst Coated Membrane (CCM) deposition processes cannot reach an industrial production quality;
- In-line quality control processes and technologies have limited defect detection capabilities, resulting in potential escape of defective parts to market and premature equipment failures in-service;
- Manual steps induce a loss of reproducibility and quality by allowing defects all along the different manufacturing steps;
- Recyclability by design, and associated supply chain needs, necessitate new industrial processes.

Hence, the maturity of production processes requires new developments to achieve higher production volumes and meet the stringent product quality expectations of emerging FC

[209] This decision is available on the Funding and Tenders Portal, in the reference documents section for Horizon Europe, under 'Simplified costs decisions' or through this link: https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/guidance/lsdecision_he_en.pdf

markets and applications (*e.g.*, stationary applications, heavy duty road transport, maritime, rail and aviation). Considering the significant Critical Raw Material (CRM) content of state-of-the-art MEAs, development of high-volume MEA production processes should include efficient material use, together with eco-design and Life Cycle Analysis of the components and the production line.

Accordingly, project results are expected to contribute to the following expected outcomes:

- Development of innovative solutions for material supply and/or processing for catalyst layer deposition and lamination of Gas Diffusion Layer GDLs/sub-gaskets demonstrated in a MEA compatible with industrial manufacturing process with a significant volume scale-up;
- Demonstrate scale-up capability and maturity of the MEA process to produce industrial standard quality MEAs, including cycle time, yield, materials input, reliability of the production process, product reproducibility, quality control and increased control over specifications;
- Process design for recycling, including Life Cycle Assessment (LCA) and cost analysis.
- Support the development of cost competitive Proton Exchange Membrane Fuel Cell (PEMFC) components from an EU supply chain.

Project results are expected to contribute to the achievement of manufacturing KPIs including:

- Dedicated manufacturing KPIs should be used to fully quantify the maturity of a production system:
    - Yield of the manufacturing process[210]: >90% by 2030;
    - Automation of the fabrication process: reducing to a minimum human intervention, especially manual steps should be avoided during manufacturing to improve reproducibility and repeatability;
    - Scrap rate[211]: <5% by 2030;
    - Annual production capacity[212]: 100 000 m² for aviation purpose and 500 000 m² for other mobility applications.

Proposals are encouraged to propose additional manufacturing KPIs to further quantify the maturity of the production system.

Produced MEAs should demonstrate high durability, power density, and low PGM loading. Reference values are:

- 30,000h in transport applications (aviation, heavy-duty trucks, rail, maritime and/or passenger vehicles) that could be demonstrated by using accelerated stress-tests;
- Power density of 1.2 W.cm-2 under standard testing conditions;
- PGM loading in MEA 0.3g/kW.

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210 The yield should be calculated comparing the theoretical number of MEA that should be obtained in a defined time period from a given quantity of components (membrane and catalysts) with the actual number of MEA produced during this period.

211 The scrap rate is calculated by dividing the amount of scrap produced in a given time period by the total amount of MEA produced in that same time period.

212 The annual production capacity means the annual nominal capacity for a facility, calculated based on operations during the 24 hours of the day for an entire year

For large scale production the cost target for road and rail applications is <50€/kW in 2030.

Scope

This project aims at developing and scaling-up innovative manufacturing processes for MEAs of PEMFCs. Each step of the MEA manufacturing process should be addressed and achieve TRL 6 and MRL 5 by the end of the project, therefore demonstrating process technology in a relevant environment with capability to produce MEAs at a rate and characteristics mentioned. In this context, to meet the expected outcomes, the following Research and Development (R&D) activities should be addressed: the design, development, and construction of a prototype production line for MEAs, which will be tested in a relevant industrial environment to validate its performance, scalability, and ability to meet the required manufacturing specifications. Here under a detailed activities that need to be included:

- Innovative up-scaling of processes (continuous production, batch production) and processes based on outcomes of previous and current research projects (MAMA-MEA[213], VOLUMETRIQ[214], NIMPHEA[215]). Addressing new techniques or innovative approaches should be considered if needed on the production line to fill the gap with previously developed processes;
- Development of known processes and innovative processes (*e.g*. ink-jet, spray, electrospray, slot-die coating, screen-printing) for large scale catalyst and/or microporous layer deposition. Large scale should be applied to MEAs active area relevant for the large-size unit cell of the applications considered (> 200 cm^2) and high-volume production as indicated above (10000 m^2/year);
- Development of methods to produce optimised large size (scale-1 for the application) MEAs and high-quality interfaces (*e.g.* layer-to-layer manufacturing, efficient assembling and bonding of components, additive manufacturing);
- Demonstrate the technology at scale compatible with high volume and high yield, considering challenges from an industrialisation perspective (automated process, reduced processing steps at the line, end-of-line quality control, flexibility support, design adaptability, versatility, reproducibility). Process monitoring, parts validity and control means should also be evaluated on several parts at scale;
- In-line quality control considering relevant parameters related to manufacturing targets and MEAs specifications (such as but not limited to scrap rate, catalyst loading, catalyst-coated membrane thickness…);
- The prototype pilot line should be adapted to several raw materials and components (membrane or GDL, catalysts) and able of making different compositions and properties (such as porosity and hydrophobicity).
- The prototype pilot line operational effectiveness will be validated through its capability of manufacturing several MEAs at scale 1, as requested to achieve the targeted MRL 5;
- Demonstration of expected operation vs. cost, performance, durability KPIs: representative testing and characterisation of produced MEAs in single cells and small stacks, at technologically relevant scale (active area) and in application-relevant conditions (all heavy-duty transport sectors are targeted) should be undertaken as part

[213] https://cordis.europa.eu/project/id/779591
[214] https://cordis.europa.eu/project/id/671465
[215] https://cordis.europa.eu/project/id/101101407

of the project;

- Demonstration of reliable scalability expected *vs.* cost, performance, durability for the various applications targeted – Assessment of progress vs SoA at beginning of project;
- Application of Design for Sustainability (DfS) principles to maximise potential of recycling processes to recover CRMs and minimise environmental impact and end-of-life;
- Industrial plan should include life cycle analysis, cost analysis, intellectual property and environmental health action plan.

A cost reduction assessment should also be undertaken at the end of the project highlighting the gains brought by the new concepts developed in the project.

In addition, a fully integrated collect and recycling channel associated to the production line should be described.

Proposals should develop and bring to the market an innovative manufacturing processes of MEAs for PEMFC. The process should demonstrate high production rates in line with the future needs of European fuel cell industries. The produced MEAs should simultaneously perform at relevant KPIs of the PEMFC technology.

Proposals should involve a PEMFC and MEA manufacturer and consider regulatory context as well as safety aspects.

A pilot line should be available at the end of the project with an estimation of its full potential:

- Capacity: 2000 m^2/year (or a projection for a year with higher level of maturity);
- Scrap rate: 40% (or a projection for a year with higher level of maturity).

Proposals should achieve a membrane electrode assembly production line mature enough to be qualified for industrial standards (*e.g.* standards depending on the applications targeted by the proposal). To do so, the proposal should include European partnerships with industrials (and their supply chain ecosystem) and academics to work on Life Cycle System Analysis, development and implementation of processes, MRL analysis (with a strong focus on the maturity of the supply chain) and propose a reliable and industry-scalable concept of MEA production. This topic is hence expected to contribute to EU competitiveness and industrial leadership by supporting a European supply chain for fuel cell components.

Consortia are encouraged to explore synergies and cooperation with Made in Europe partnership[216] and the Zero Detect Manufacturing platform[217].

For additional elements applicable to all topics please refer to section 2.2.3.2.

[216] https://www.effra.eu/made-in-europe-state-play/
[217] https://www.zdmp.eu/

HORIZON-JU-CLEANH2-2025-03-03: Reliable, efficient, scalable and lower cost 1 MW-scale PEMFC system for maritime applications

Specific conditions	
Expected EU contribution per project	The JU estimates that an EU contribution of maximum EUR 7.00 million would allow these outcomes to be addressed appropriately.
Indicative budget	The total indicative budget for the topic is EUR 7.00 million.
Type of Action	Research and Innovation Action
Technology Readiness Level	Activities are expected to start at TRL 4 and achieve TRL 6 by the end of the project - see General Annex B.
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G. The following exceptions apply: Eligible costs will take the form of a lump sum as defined in the Decision of 7 July 2021 authorising the use of lump sum contributions under the Horizon Europe Programme – the Framework Programme for Research and Innovation (2021-2027) – and in actions under the Research and Training Programme of the European Atomic Energy Community (2021-2025)[218].

Expected outcome

Shipping represents over 90% of world trade and about 3% of global Green House Gases (GHG) emissions. For this reason, shipping companies are under increasing pressure to reduce their carbon footprint and comply with stringent environmental regulations. This demand for sustainable solutions is driven by the EU's FuelEU Maritime Regulation, the International Maritime Organization (IMO), and the Emissions Trading System (ETS). The EU ETS for maritime transport has become operational on January 1, 2024, and is going to be progressively implemented up to 2026. Currently, it applies to all large ships (5,000 gross tonnage and above) that enter EU ports, regardless of their flag. It covers 50% of emissions from voyages that start or end outside the EU and 100% of emissions from voyages between EU ports and within EU ports. Initially, covering CO_2 emissions, ETS plans to include methane (CH_4) and nitrous oxide (N_2O) emissions from 2026. Shipping companies will then need to purchase and surrender allowances for their emissions. Therefore the sector is looking for a fast technological route to decarbonise the existing fleet, and, in recent years, ammonia and hydrogen have been acknowledged as promising green fuels to do so.

In this context, fuel cells represent a conversion technology that provides a clean, efficient, and reliable power for ships, and for this reason, over the past twenty years, there has been a significant increase in maritime fuel cell projects, exploring various fuel cell solutions. These projects span a power range from 25 kW to 3 MW and incorporate different technologies, including Proton Exchange Membrane Fuel Cells (PEMFC), Solid Oxide Fuel Cells (SOFC),

[218] This decision is available on the Funding and Tenders Portal, in the reference documents section for Horizon Europe, under 'Simplified costs decisions' or through this link: https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/guidance/lsdecision_he_en.pdf

and Molten Carbonate Fuel Cells (MCFC)219. Notably, running projects like HyShip[220] (funded by the FCH2JU) and HyEkoTank[221] (funded by ZEWT) are integrating larger scale fuel cell systems. The former focuses on design and validation of a 2 MW fuel cell liquid hydrogen powered ship, while the latter on the development, approval and demonstration of a 2.4 MW hydrogen fuel cell system.

While these inititatives are focusing on higher Technology Readiness Level (TRL) for system integration and retrofitting, the current technological and economic landscape, particularly for scalable multi-stack fuel cell systems (FCS), still faces critical hurdles in cost, reliability, efficiency and durability. Further advancements in terms of lower TRL research and innovation efforts are hence still requred to meet the ambitious targets set by regulatory bodies and to gain a competitive edge in an increasingly eco-conscious industry. While new multi-MW size propulsion systems are needed to decarbonise maritime transport, 1 MW sized FCS could already support decarbonising ca. 30% of the global fleet and providing auxilliary power for half of it[222]. Topic HORIZON-JTI-CLEANH2-2023-03-02: Development of a large fuel cell stack for maritime applications stipulated "*Following the validation of "marine ready" and reliable FC stacks (able to operate in multi-modal-modular systems) the proposed project should lay the foundations for future developments of fuel cell system for maritime applications*", therefore this topic represents the next logical step supporting development from stack to fuel cell system for maritime applications.

Project results are therefore expected to contribute to all of the following outcomes:

- Development of low-cost, efficient, and flexible multi-stack FCS architectures suitable for multi-MW deployments, aiming for full-scale demonstrators compatible with end-user requirements by 2030;
- Further strengthening and consolidating the European fuel cell system supply chain, thereby securing European industry's competitiveness and strategic independence in critical technologies in a global market for large (MW) scale fuel cell systems;
- Providing more robust, durable and lower cost MW scale fuel cell systems suitable for future integration in the 10s of MW scale in maritime applications;
- Encouraging demonstrations that lead to broader local, regional, and Union-wide deployment in various transport sectors;
- Facilitating the development of and feeding into European and international regulations, codes, and standards for wide spread use of hydrogen and large scale fuel cell systems;
- Facilitating cross-sector collaboration and knowledge transfer, supporting industry-related skills, and enhancing Small and medium EnterpriseEs' (SME) involvement in the hydrogen economy;
- Improvements in design, diagnostics and monitoring procedures of FCS (also looking at innovative measuring / sensor devices at this purpose);
- Improvements of testing protocols for the quantification of FCS performance and lifetime in maritime environments, including accelerated stress tests;

[219] Elkafas, A. G., Rivarolo, M., Gadducci, E., Magistri, L., & Massardo, A. F. (2023). Fuel Cell Systems for Maritime: A Review of Research Development, Commercial Products, Applications, and Perspectives. *Processes*, 11(1), 97. https://doi.org/10.3390/pr11010097
[220] https://cordis.europa.eu/project/id/101007205
[221] https://cordis.europa.eu/project/id/101096981
[222] The 2020 World Merchant Fleet Statistics from Equasis (link)

- Improvement of overall system performance of FCS in order to increase the availability and durability and meet the needs of naval and maritime end users.

Project results are expected to contribute to the following KPIs of the Clean Hydrogen Joint Undertaking (JU) Strategic Research and Innovation Agenda (SRIA) by 2030 for maritime use of PEMFC systems:

- Fue cell power rating: 10 MW;
- Lifetime: 80,000 hours;
- CAPEX 1000 €/kW.

Scope

The scope of this topic is to develop, validate and demonstrate a reliable, efficient, and low-cost PEM based fuel cell system (FCS) with a minimum power output of 1 MW, suitable for further scaling to at least 10 MW for use in maritime applications. Fuel cell stack development and integration of the FCS in a vessel are outside the scope of the project. Proposals should address the following:

- Develop, build and validate a new hydrogen fuelled FCS with a net power output of at least 1 MW showing actual improvements with respect to SoA regarding reliability, efficiency and cost. The system may contain multiple stacks and multiple modules. The full 1 MW FCS should be demonstrated in relevant environment for at least 1000 hours, enabling to test in moisty and salty conditions and considering different air inlet temperature (to simulate different installation areas on board of vessels). A part of the system, providing at least 200 kW and operating against an emulation of the rest of the FCS, should be demonstrated for 40,000 hours by means of Accelerated Stress Test procedures. The FCS should be validated to provide power according to sailing profile/load request of a real vessel in a simulation approach;
- The FCS architecture should follow a flexible and scalable methodology, encompassing both stacks and balance-of-plant (BoP) components. The methodology should allow extension to at least 10 MW of net power output, minimise the required workload of system integrators and original equipment manufacturers (OEM) (e.g., by exploiting pre-existing standards such as StasHH), and adapt to the requirements of different operating conditions and vessel classes;
- The project should evaluate the impact of the developed architecture on the Total Cost of Ownership (TCO) of the FCS, as well as the cost characteristics for systems up to 10 MW building on the 1 MW FCS architecture compared to currently available propulsion solutions. Alternative architectural choices may be evaluated to identifying the best solutions for different market segments;
- The architecture should satisfy the high reliability requirements of maritime applications, and the system should be able to operate robustly in case of failure of single or multiple components, identifying and emulating relevant incident and accident scenarios (e.g., human error, on-board fire, collisions, bad weather conditions) that require specific procedures. Safety aspects should hence be thoroughly analysed for the architectures developed, for all relevant operations (propulsion, hotelling when docked, maintenance, etc.), producing adequate procedures, recommendations and best practices for end users;
- Develop or adapt open-source simulation tools for multi-MW Fuel Cell Systems (available e.g., from the VirtualFCS project), making them available to system

integrators and OEMs to help their design activities. The tools should be demonstrated by performing dynamic simulations of the FCS and all its subsystem in its realised configuration and relevant alternative ones, scaling up to at least 10 MW;

- Develop and publish open-source control software amenable to be deployed with no or minimal adaptations on real-world vessels, using appropriate communication interfaces. The control algorithms should satisfy relevant operational requirements, such as dynamics, efficiency, reliability and safety. The software should be able to gather, process and communicate relevant data for FCS diagnostics and prognostics. Diagnostics and prognostics for the demonstrator may be developed or adapted from previous projects;
- Liaise with regulatory bodies and identify the requirements that such a FCS needs to satisfy for type approval, and what implications it has on the design methodology.

Looking at future development and on-board integration, the following activities should be envisaged:

- Scale up activities (targeting specific multi-stack FC systems sizes and cost functions), the setup of a roadmap to TRL9 and the development of potential studies for MW-scale integration on board (and FC stack/system design) are also required. At least one use case, supported by an industrial ship-owner/manager (expected to be part of the consortium or of the Advisory Board) should be developed during the project;
- Engagement of end-users is crucial to collect their feedback about the proposed FC technology, also at regulatory and non-technical level.

Cooperation with FC application in other maritime or similar projects is expected (such as StaSHH[223], HyShip[224], FLAGSHIPS[225], MARANDA, ShipFC[226], etc.) in order to start from their results on system design. The proposals should build upon project H2MARINE[227] (HORIZON-JTI-CLEANH2-2023-03-02: Development of a large fuel cell stack for maritime applications) which is highly complementary; liaison between successful proposals and H2MARINE is expected to ensure complementarity, leverage synergies and avoid duplication of efforts. Applicants should demonstrate how this will be achieved (e.g. by sharing members of the respective advisory boards, by organizing regular exchanges).

Proposals are expected to explore synergies with the activities of Zero Emission Waterborne Transport (ZEWT) partnership.

While designing the FCS system, applicants should apply a ‘circularity by design’ approach and assess the sustainability of the proposed solutions from a life cycle perspective (also benchmarking it with batteries and other FCs not investigated in design/demonstration). e.g., should estimate the carbon footprint expressed in gr CO2-eq/kWhel.

Consortia should involve at least one system integrator, Original Equipment Manufacturers (OEM) and end user, and consider to involve an adequate panel of stakeholders to enable identifying the best solutions for various market segments.

In addition, proposals may investigate the spillover potential of the developed FCS architectures in other sectors where MW-class FCS may be employed, such as rail, aviation or stationary gensets, and how the methodology may need to be modified to address these.

223 https://cordis.europa.eu/project/id/101005934
224 https://cordis.europa.eu/project/id/101007205
225 https://cordis.europa.eu/project/id/826215
226 https://cordis.europa.eu/project/id/875156
227 https://cordis.europa.eu/project/id/101137965

For activities developing test protocols and procedures for the performance and durability assessment of electrolysers and fuel cell components proposals should foresee a collaboration mechanism with JRC[228] (see section 2.2.4.3 "Collaboration with JRC"), in order to support EU-wide harmonisation. Test activities should adopt the already published EU harmonised testing protocols[229] to benchmark performance and quantify progress at programme level.

For additional elements applicable to all topics please refer to section 2.2.3.2.

[228] https://www.clean-hydrogen.europa.eu/knowledge-management/collaboration-jrc-0_en
[229] https://www.clean-hydrogen.europa.eu/knowledge-management/collaboration-jrc-0/clean-hydrogen-ju-jrc-deliverables_en

HYDROGEN END USES: CLEAN HEAT AND POWER

HORIZON-JU-CLEANH2-2025-04-01: Demonstration of stationary fuel cells in renewable energy communities

Specific conditions	
Expected EU contribution per project	The JU estimates that an EU contribution of maximum EUR 5.00 million would allow these outcomes to be addressed appropriately.
Indicative budget	The total indicative budget for the topic is EUR 5.00 million.
Type of Action	Innovation Action
Technology Readiness Level	Activities are expected to start at TRL 5 and achieve TRL 7 by the end of the project - see General Annex B.
Admissibility conditions	The conditions are described in General Annex A. The following exceptions apply: The page limit of the application is 70 pages.
Eligibility	The conditions are described in General Annex B. The following additional eligibility criteria apply: At least one partner in the consortium must be a member of either Hydrogen Europe or Hydrogen Europe Research. The maximum Clean Hydrogen JU contribution that may be requested is EUR 5.00 million – proposals requesting Clean Hydrogen JU contributions above this amount will not be evaluated.
Procedure	STEP Seals will be awarded to proposals exceeding all of the evaluation thresholds set out in this work programme.
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G. The following exceptions apply: Eligible costs will take the form of a lump sum as defined in the Decision of 7 July 2021 authorising the use of lump sum contributions under the Horizon Europe Programme – the Framework Programme for Research and Innovation (2021-2027) – and in actions under the Research and Training Programme of the European Atomic Energy Community (2021-2025)[230]. Purchases of equipment, infrastructure or other assets used for the action must be declared as depreciation costs. However, for the following equipment, infrastructure or other assets purchased specifically for the action (or developed as part of the action tasks): fuel cell system, hydrogen storage and other hydrogen related infrastructure needed for the fuel cell application, costs may exceptionally be declared as full capitalised costs.

[230] This decision is available on the Funding and Tenders Portal, in the reference documents section for Horizon Europe, under 'Simplified costs decisions' or through this link: https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/guidance/lsdecision_he_en.pdf

Expected outcomes

Energy communities enable collective and citizen-driven energy actions to support the clean energy transition. They can contribute to increasing public acceptance of renewable energy projects and make it easier to attract private investments in the clean energy transition. Energy communities can be an effective means of re-structuring our energy systems, by empowering citizens to drive the energy transition locally and directly benefit from better energy efficiency, lower bills, reduced energy poverty and more local green job opportunities. Through the 'Clean energy for all Europeans' package, adopted in 2019, the EU differentiated between citizen energy communities and renewable energy communities. Since then, legislation on energy communities has been further strengthened by new or revised EU rules. Renewable energy communities, as defined in Article 2(16) of Recast Renewable Energy Directive (Directive (EU) 2018/2001) can introduce positive environmental impacts by increasing the use of renewable energy, thereby enhancing local energy security and reducing energy import from the main power grid, lowering energy bills. This aggregation therefore increases collective advantages and furthermore benefits the local distribution grid thanks to sharing resources and to a more efficient energy distribution, respectively. Energy communities are also key in bearing the adoption of new energy technologies and practices, thus paving the way toward innovation in the energy landscape.

Project results are expected to contribute to the following expected outcomes:

- Support the industrialisation of European Fuel Cell technology;
- Showcase combined heat and power generation based on hydrogen technologies in real life applications;
- Decentralised control of microgrids supported by real-time optimisation, which increases grid reliability and resilience, and allows for autonomous operation during disturbances;
- Contribute to demand-side strategies, which can reduce energy bills and provide overall benefits to the energy system such as stability and less emissions;
- Provide ancillary services to the overall energy system such as frequency control and power reliability;
- Empower citizens and put them at the centre of the clean energy transition, which improves lives and supports energy and climate policies.

Project results are expected to contribute to the following objectives and Key Performance Indicators (KPI) of the Clean Hydrogen Joint Undertaking (JU) Strategic Research and Innovation Agenda (SRIA):

- Prepare and demonstrate the next generation of fuel cells for stationary applications able to run under 100% hydrogen and other hydrogen-rich fuels whilst keeping high performances;
- Demonstrate the deployment of the next generation of commercial/industrial scale fuel cell Combined Heat and Power (CHP) units from European suppliers (from 50 kWe to several MWe);
- Contribute to the achievement of relevant KPIs, depending on the technology that will be applied, as defined in the relevant Clean Hydrogen Joint Undertaking (JU) Strategic Research and Innovation Agenda (SRIA) Annexes for 2030, namely:
    - CAPEX below 2,000 €/kW for Solid Oxide stationary fuel cells and below 900

€/kW for PEM stationary fuel cells;

- O&M cost below 1.5 €ct/kWh for SO stationary fuel cells and below 2 €ct/kWh for PEM stationary fuel cells;
- Availability of the system above 99% for systems applying Solid Oxide stationary fuel cells and above 98% for systems applying PEM stationary fuel cells;
- Warm start time below 2 min for solid oxide stationary fuel cells and below 10 seconds for PEM stationary fuel cells.

Scope

In the context of the scope of renewable energy communities provided above, proposals are expected to demonstrate an integrated renewable energy system applying stationary fuel cells, possibly in combination with other hydrogen technologies, to supply reliable and efficient energy in at least one renewable energy community. In the context of this topic a renewable energy community is expected to have the characteristics defined in Article 2(16) of the Recast Renewable Energy Directive 2018/2001 “Renewable Energy Community” even if not legally established as a legal entity.

Advantages that stationary fuel cells can bring to renewable energy communities are manyfold. Besides presenting high electrical efficiencies, stationary fuel cells can provide additional heat that can be valorised for utilisation by local industries and small businesses. They can moreover play a role in providing ancillary services to the grid, thus constituting a source of economic benefits for energy communities. They can in fact provide demand response and dispatchable power generation, and be furthermore reliably employed for backup, standby, and peak shaving applications. Last but not least, they can boost the utilisation of local resources (e.g. biomass, waste streams, etc.) and can furthermore reduce the curtailment of renewable energy.

The integrated system should address multiple energy vectors such as hydrogen, electricity, and heat and/or cooling. To this end, installations may include technologies for hydrogen handling and storage, while they should involve a fuel cell-based power supply unit, which should have a nominal capacity of 50 to 200 kWe, and whose development should stand at least at Technology Readiness Level (TRL) 5 at the beginning of the project. The final nominal capacity of the fuel cell should be appropriate for the specific renewable energy community and application. The overall system should moreover include all balance of plant components, e.g., fuel processing, compressors, valves, as well as power electronics, auxiliary power supply for the fuel cell, monitoring systems, etc., needed for continuous and efficient operation. The demonstration of the prototype system should be performed in an operational environment (TRL 7). The prototype system should be fully (i.e. electrically, thermally, etc.) integrated within the local energy system and enhance the reliability of energy supply. Utilisation of exhaust streams like biogenic CO2 and water may also be addressed.

The renewable fuel to be used in the power supply unit (renewable hydrogen and/or other renewable hydrogen-rich fuels) may either be produced on-site or be delivered at the site. As a fuel, renewable hydrogen or other types of renewable fuels such as hydrogen-rich fuels, synthetic fuels or bio-fuels may be used.

The demonstration campaign should include the transportation of all system components at the site, their installation, and their subsequent testing for at least 3000 hours of cumulative operation in a renewable energy community (covering at least 2 different seasons, ideally summer and winter, thus, depending on the number of daily operating hours of the system, it could be split into two non-subsequent periods of 1500 hours each, yet other partitions may be possible if well justified), at a real end-user site (e.g. to supply power and heating to the residential sector, such as multi-family or individual buildings, the secondary sector, such as local industries, and/or the tertiary sector, such as administration offices, schools, university/research centre campuses, hotels, etc.).

The focus and innovation of this topic resides in the demonstration of the added value of fuel cell technologies when integrated in a local energy system, which can be either grid connected or off-grid. Proposals should build and complement projects funded by the Clean Hydrogen JU such as REMOTE[231], DEMOSOFC[232] and CRAVE-H2[233]. In addition, proposals should benefit from the learnings of already funded projects in order to push fuel cell technologies to market readiness.

Proposals should also:

- Choose a fuel cell system which is appropriate for the final application optimising the sizing of the system according to the heat and electricity demand of the application within the renewable energy community;
- Integrate instrumentation for all relevant units for addressing the implementation of optimal operation;
- Address the implementation of real-time optimisation and control smart tools (for both heat and power), as part of the renewable energy community engagement strategy;
- Assess and quantify the environmental, economic and social community benefits of the demonstration (in terms of reduction on greenhouse gases emissions during demonstration) including a comparison to other technological options where relevant for the renewable energy community;
- Assess CAPEX, OPEX and operation and maintenance (O&M) requirements;
- Assess the environmental, technical and economic feasibility for scale up and replication in other renewable energy communities and include activities aimed at promoting replication within the project;
- Actively engage and seek commitment from the renewable energy community in which the demonstration campaign will take place, at least in the form of a Letter of Intent (LOI), to be included in Part B of the Proposal;
- Analyse non-technological barriers related to the integration of the fuel cell system in the (existing) renewable energy community (e.g. administrative, legislative, public acceptance) and recommend an adapted legal framework for the roll out of the technology;
- Contribute to meet the overall community demand (i.e. heat, electricity and cooling) with renewable energy based on renewable hydrogen.

The topic provides a chance for significantly rising the maturity level of hydrogen-based energy generating systems and for allowing for their further deployment in other areas of the hydrogen economy.

Proposals are expected to demonstrate the contribution to EU competitiveness and industrial leadership of the activities to be funded including but not limited to the origin of the equipment

[231] https://cordis.europa.eu/project/id/779541
[232] https://cordis.europa.eu/project/id/671470
[233] https://cordis.europa.eu/project/id/101112169

and components as well infrastructure purchased and built during the project. These aspects will be evaluated and monitored during the project implementation.

It is expected that Guarantees of origin (GOs) will be used to prove the renewable character of the hydrogen that is used. In this respect consortium may seek out the purchase and subsequent cancellation of GOs from the relevant Member State issuing body and if that is not yet available the consortium may proceed with the issuance and cancellation of non-governmental certificates (e.g CertifHy[234]).

For activities developing test protocols and procedures for the performance and durability assessment of electrolysers and fuel cell components proposals should foresee a collaboration mechanism with Joint Research Centre (JRC)[235] (see section 2.2.4.3 "Collaboration with JRC"), in order to support EU-wide harmonisation. Test activities should adopt the already published EU harmonised testing protocols[236] to benchmark performance and quantify progress at programme level.

Proposals should provide a preliminary draft on ‘hydrogen safety planning and management’ at the project level, which will be further updated during project implementation.

For additional elements applicable to all topics please refer to section 2.2.3.2.

[234] https://www.certifhy.eu
[235] https://www.clean-hydrogen.europa.eu/knowledge-management/collaboration-jrc-0_en
[236] https://www.clean-hydrogen.europa.eu/knowledge-management/collaboration-jrc-0/clean-hydrogen-ju-jrc-deliverables_en

HORIZON-JU-CLEANH2-2025-05-01: Simultaneous ionomer and iridium recycling

Specific conditions	
Expected EU contribution per project	The JU estimates that an EU contribution of maximum EUR 3.50 million would allow these outcomes to be addressed appropriately.
Indicative budget	The total indicative budget for the topic is EUR 3.50 million.
Type of Action	Research and Innovation Action
Technology Readiness Level	Activities are expected to start at TRL 3 and achieve TRL 5 by the end of the project - see General Annex B
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G. The following exceptions apply: Eligible costs will take the form of a lump sum as defined in the Decision of 7 July 2021 authorising the use of lump sum contributions under the Horizon Europe Programme – the Framework Programme for Research and Innovation (2021-2027) – and in actions under the Research and Training Programme of the European Atomic Energy Community (2021-2025)[237].

<u>*Expected outcomes*</u>

Low-carbon hydrogen, produced via methods such as proton exchange membrane water electrolysis (PEMWE), offers a promising alternative to fossil fuel consumption in various energy sectors. However, the practical implementation of the clean energy transition requires: (i) sustainable supplies of critical raw materials such as platinum group metals (PGMs) and (ii) strategic processed materials such as fluoropolymers. Increasing material recycling rates can: (i) reduce environmental impact, (ii) enhance production efficiency, and (iii) create new jobs. These outcomes are aligned with the European Commission's goal to strengthen European value chains. Additionally, the European Commission and industry stakeholders aim to increase electrolyser manufacturing capacities tenfold by 2025 to support the EU's target of 10 million tons of renewable hydrogen production by 2030 (REPowerEU)[238].

The core and key component of Proton Exchange Membrane Water Electrolysers (PEMWEs) is the catalyst-coated membrane (CCM). To facilitate water splitting into its constituent elements (*i.e.*, hydrogen and oxygen), iridium (Ir)-based catalysts at the anode, platinum-based electrocatalysts at the cathode, and a proton exchange membrane (PEM) are utilised. Furthermore, state-of-the-art membranes are based on perfluorosulfonic acid (PFSA) polymers.

Currently, no viable alternatives to Ir as an electrocatalyst provide the same efficiency and durability under the high-voltage and acidic conditions prevalent in PEMWE. The implications for Ir demand can be significant if PEMWE anodes with a low loading of Ir and improved collection systems for end-of-life Ir-containing materials from other industries are not

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[237] This decision is available on the Funding and Tenders Portal, in the reference documents section for Horizon Europe, under 'Simplified costs decisions' or through this link: https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/guidance/lsdecision_he_en.pdf

[238] https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/repowereu-affordable-secure-and-sustainable-energy-europe_en

developed[239].

Another crucial component of PEMWEs is the proton exchange membrane, which is used as a barrier between anode and cathode and selectively allows the migration of protons. Currently, no technologically mature alternatives to replace PFSA-based membranes in PEM technologies can meet the required industrial targets (*e.g.*, performance, durability, lifetime, and industrial scaling). PFSAs are also used in the formulation of the electrocatalytic layers. Currently, the end-of-life (EoL) path for PFSA materials is incineration in dedicated ovens, which destroys the valuable ionomer in the process and requires scrubbers to handle the highly corrosive fluor acids in the exhaust fumes. Recycling the polymer at EoL is crucial to minimise environmental impacts of per- and polyfluoroalkyl substances, and reduce the CO_2 footprint of end of life (EoL) stacks by providing a second life for the ionomer. Therefore, this topic aims to contribute to the industrial solutions for addressing emerging environmental concerns and regulations related to fluorinated materials in the long term.

Project results are expected to contribute to the following outcomes:

- Contributing to the EU's net-zero strategy by providing technological guidelines for recycling Ir and the PFSA ionomer;
- Demonstrating the ability to alleviate potential Critical Raw Material (CRM) shortages and increased supply chain resilience for PEMWE manufacturing in the EU;
- Developing standardised test method(s) for evaluating EoL PFSA ionomer and Ir.

Project results are expected to contribute to the following objectives and Key Performance Indicators (KPI) of the Clean Hydrogen Joint Undertaking (JU) Strategic Research and Innovation Agenda (SRIA)[240]:

- Minimum CRMs/PGMs (other than Pt) recycled from scraps and wastes (30% by 2024, 50% by 2030);
- Minimum ionomer recycled from scraps and wastes (70% by 2024, 80% by 2030).

Project results are expected to contribute to the following objectives:

- Analyse the effectiveness and efficiency of Ir recycling technologies with respect to costs and environment;
- Minimum purity thresholds for recycled ionomer that will be used in electrochemical, hydrogen-related applications: >99,5%. Bivalent Metal Ions (Fenton-metals) impurities < 15 ppm and other impurities < 500 ppm;
- Performance and durability of a membrane produced from mixed sources to be comparable to a state-of-the-art reference assessed within PEMWE applications;
- Delivery of viable test methods to assess the degradation state of end-of-life materials;
- Life Cycle Assessment (LCA) and Techno-Economic Analysis (TEA) of both (Ir, ionomer) recycling routes.

Scope

This topic aims at simultaneously recycling Ir and ionomers after catalyst-coated membrane

[239] A study by the German Mineral Resources Agency (DERA) found that by 2040 the global annual Ir demand for PEMWE can reach 10 tons/year and up to a total of 34 tons/year under the shared socioeconomic pathway (SSP) 1 (Sustainability – Taking the green road).

[240] Clean Hydrogen Partnership, Strategic Research and Innovation Agenda 2021-2027, 2022.

(CCM) separation from the PEMWE stack at the EoL and/or from scraps and waste. The novelty and contribution of this topic is to understand the impact of the separation process of the waste stream on the ionomer and PGMs (possible impurities, degradation of the polymer's molecular structure, change in physical/chemical properties, performance, etc.). This fundamental understanding of material degradation is crucial for optimising their quality before their re-use in PEMWE cells to ensure sustainable circularity. Recycling efforts are also being pursued in projects, such as SUSTAINCELL[241] and BEST4Hy[242]. The critical difference is that the BEST4Hy project targets fuel cell technologies and platinum only, while this topic focuses on PEMWE technology, specifically addressing the recycling of Ir and the ionomer. Further, the project funded by this call can contribute to and be complemented by EU-funded projects on sustainable hydrogen production, such as CLEANHYPRO[243] and H2SHIFT[244]. CLEANHYPRO could facilitate (partial) testing within the scope of the open innovation test bed whereas H2SHIFT could complement in the need of a techno-economic analysis.

The scope of the project should include:

- Development of new measurement technologies for characterising the degradation state of ionomer in both the PEM and the electrocatalytic layers;
- Assessment of physical-chemical properties of membranes from recycled ionomer and mesoscale morphology;
- Development of new methods to separate the ionomer;
- Manufacturing of CCMs with Ir and recycled ionomer from production waste, and assessment of their beginning-of-life performance and durability via accelerated stress tests (ASTs) in PEM water electrolysis single cell or short stacks (>1000 hrs cell test and comparison to a short stack comprising of a virgin ionomer membrane)[245];
- Evaluation and demonstration of the feasibility of the developed recycling processes through techno-economic analysis and life cycle assessment;
- Evaluation of the possibility of mixing different ionomers (*e.g.*, recycled ionomer with virgin ionomer, different chemistries, etc.) for their application in catalyst layers, membranes, and alternative applications;
- Manufacturing and testing of membranes from a blend of fluoropolymers from different sources in PEMWE cells, focusing on hydrogen gas crossover, performance and tolerance to accelerated ageing;
- Evaluation of the performance of recycled ionomer in a laboratory scale environment (e.g., 0.5-10 grams of ionomer); *in-situ* cell testing and *ex-situ* testing (scanning

[241] SUSTAINCELL's primary goal is to recycle ionomer and precious group metals (PGM) sourced from end-of-life cells, membrane electrode assemblies (MEAs), scraps, and waste. They are also focused on implementing eco-design principles and environmentally-friendly manufacturing methods to develop new materials and architectures. Additional information at https://cordis.europa.eu/project/id/101101479

[242] Best4Hy aimed at achieving a platinum recovery rate of ≥80% via a hydrometallurgical process and an ionomer recovery of ≥80% via an alcohol dissolution process. Additional information at https://cordis.europa.eu/project/id/101007216

[243] The primary objective of the project is to develop and organise a sustainable Open Innovation Test Bed (OITB) for electrolysis materials and components, providing a network of facilities and services through a Single Entry Point (SEP). Additional information at https://cordis.europa.eu/project/id/101091777

[244] H2SHIFT's primary focus is to create an innovation and excellence center for innovative hydrogen production technologies open to start-ups and small to medium-sized enterprises from Europe and around the world. Additional information at https://cordis.europa.eu/project/id/101137953

[245] EU harmonised accelerated stress testing protocols for low-temperature water electrolyser, https://publications.jrc.ec.europa.eu/repository/handle/JRC133726

electron microscopy, thermogravimetric analysis, tensile testing, swelling behaviour in water, equivalent weight (EW), study of the electrical response) compared to virgin ionomer;

- Evaluation of the quality of production waste and EoL ionomer batches (e.g., 50-500 g) by:
    - Using the recycled ionomer in the catalyst layer and membrane of PEMWE cells;
    - Analysing of ionomer performance both ex-situ and in cells with accelerated stress testing;
    - Developing new measuring methods for determining ionomer degradation state;
    - Enable short stack testing for at least 1000 h comprising of the recycled ionomer.
- Verifying the purity of the recycled Ir in collaboration with industrial partners. A purity for Ir of ≥99.9% should be achieved;
- Verifying the quality and performance of recycled iridium from new recycling methods
- Assessing alternative applications of the recycled ionomer;
- Development of pre-processing guidelines for the input materials (granulation, extraction, homogenisation etc.) to reduce the recycling time and enhance efficiency;
- Providing advice on stack design considerations to improve the recyclability of ionomer by allowing better separation of CCMs from the stack and ionomer from the CCM;
- Industrial methods for making membranes and CCMs of the EoL ionomer with the ability to run short stack testing.

For the success of the project funded by this call, the project consortium should have access to end-of-life PEMWE components (*e.g.*, cells, MEAs, CCMs) to evaluate real industrial waste and ensure the practical applicability of the developed solutions.

Proposals are expected to build further on the findings and targets of previous projects and find synergies with running projects (namely the projects mentioned above), as well as with the recently established Innovative Materials for EU Partnership.

For additional elements applicable to all topics please refer to section 2.2.3.2.

HORIZON-JU-CLEANH2-2025-05-02: Understanding emissions of PFAS from electrolysers and/or fuel cells under product use

Specific conditions	
Expected EU contribution per project	The JU estimates that an EU contribution of maximum EUR 2.00 million would allow these outcomes to be addressed appropriately.
Indicative budget	The total indicative budget for the topic is EUR 2.00 million.
Type of Action	Research and Innovation Action
Technology Readiness Level	n/a
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G. The following exceptions apply: Eligible costs will take the form of a lump sum as defined in the Decision of 7 July 2021 authorising the use of lump sum contributions under the Horizon Europe Programme – the Framework Programme for Research and Innovation (2021-2027) – and in actions under the Research and Training Programme of the European Atomic Energy Community (2021-2025)[246].

<u>*Expected outcomes*</u>

Per- and polyfluoroalkyl substances (PFAS) are a class of thousands of chemicals, with different properties, safety profiles and uses[247]. In January 2023, the authorities of Denmark, Germany, the Netherlands, Norway, and Sweden submitted a proposal to the European Chemicals Agency (ECHA) that calls for a near complete phase-out of the manufacture, import, sale, and use of per- and polyfluorinated substances (commonly known as PFAS)[248]. Transitional periods are foreseen for uses that currently have no alternatives. Within the class of PFAS chemicals included in the proposal are fluoropolymers, a subgroup of PFAS that is used in various industrial and professional applications.

Water electrolysers and fuel cells use fluorinated membranes for their unique physical and chemical properties such as elevated proton conductivity and excellent durability. However, these systems are known to emit levels of inorganic fluoride during operation of the product. In fact, the degree of fluoride release may be used as a measure of the rate of degradation of the membrane in a fuel cell or an electrolyser[249]. Hence, component and stack manufacturers aim to minimise any inorganic fluoride release rate in order to ensure commercially viable lifetimes to their products by reducing degradation. However, until now, corresponding degradation mechanisms, the quantification of organic fluorine compounds, and their potential impact on the environment have not been understood or even investigated[250]. There are

[246] This decision is available on the Funding and Tenders Portal, in the reference documents section for Horizon Europe, under 'Simplified costs decisions' or through this link: https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/guidance/lsdecision_he_en.pdf

[247] OECD, "oecd.org," 2021. [Online]. Available: https://www.oecd.org/chemicalsafety/portal-perfluorinated-chemicals/terminology-per-and-polyfluoroalkyl-substances.pdf. [Accessed April 2024]

[248] ECHA, 2022. [Online]. Available: https://echa.europa.eu/hot-topics/perfluoroalkyl-chemicals-pfas. [Accessed April 2024

[249] M. C. a. A. Z. W. Ahmet Kusoglu, "Effect of Mechanical Compression on Chemical Degradation," ECS Electrochemistry Letters, vol. 3, no. 5, pp. F33-F35, 2014

[250] J. W. R. K. J. M. F. B. a. V. V. Dharmjeet Madhav, "A Review of Proton Exchange Membrane Degradation Pathways, Mechanisms, and Mitigation Strategies in a Fuel Cell," *Energies,* vol. 17, no. 5, p. 998, 2024

therefore no testing protocols ready for electrolyser/fuel cell degradation with focus on PFAS release and considering the use of adequate analytics (e.g. sum parameters). In particular, there is no defined, agreed analytical technique available to reliably identify individual organic fluorine containing compounds due to their low concentrations and heterogeneity[251] (explicitly excluding existing, regulated substances like PFOS,… and the corresponding analytical methods as described therein).

Moreover, electrolysers and fuel cells will have to rely on commonly available fluorinated membranes for the upcoming years as the few alternatives to fluorinated membranes are at low TRL (e.g. HORIZON-JTI-CLEANH2-2024-05-02), and any alternatives may not become viable and scale in time. It is therefore relevant to enhance the understanding of PFAS emission based on currently used fluorinated membranes, developing pre-normative testing protocols and methods, and investigate the emission of the degradation products in applications under product use.

Project results are expected to contribute to all the following expected outcomes:

- Allow science-based decision making for policy makers and industry players;
- Enable industry, policy makers and the public to deepen their understanding of potential PFAS emissions of electrolyser and/or fuel cell systems under product use, and their impact on the environment;
- Identify the emission pathway (vapour, aerosol, liquid phase);
- Allow for targeted solutions to prevent potential PFAS emissions in these systems from new or existing players in the hydrogen field;
- Allow industry to use a standardised method for PFAS emissions measurement under product use;
- Provide mature sampling and testing methods, analytical tools to assess PFAS release to the environment, and to ensure sustainability of fuel cells and/or water electrolysis;
- Pave the way to make fuel cells and/or water electrolysis more sustainable;
- Provide context with the potential emissions and their potential impact, educating the public on balancing the risks of those emissions.

Scope

This proposal is expected to focus on the fundamental understanding of the potential PFAS emissions in water electrolysers and fuel cells under product use. It aims to identify the root cause of PFAS compounds in water electrolysers and fuel cells, and to quantify the potential release of these substances into the environment during operation. Additionally, this project should propose solutions to manage and minimise emissions from current products corresponding to their amount and relevance of emission. It should include recommendations on a reduced release into the environment and propose possible mitigation options for avoidance of emissions. Considering the application-based, industrial scope of the project, subsequent non-industrial processes like subsequent biodegradation in the environment, the individual properties of persistency and incorporation into the food chain should not be contained within the scope and future possible applicants of this proposal. However, the project should support a preliminary liaison of the industrial community with these complementary aspects. Applicants are therefore expected to propose activities to build a

[251] M. Bodner et al. "Determining the Total Fluorine Emission Rate in Polymer Electrolyte Fuel Cell Effluent Water", ECS Trans. 80 559, 2017 https://iopscience.iop.org/article/10.1149/08008.0559ecst

significant state of the art collection and review of recent studies related to PFAS biodegradation. Besides, projects are expected to build further on the findings and targets of previous projects and find synergies with running projects, as well as with the novel Innovative Materials for EU co-Programmed Partnership. Specific attention should be given to Horizon Europe, Cluster 4[252].

An integral step of the project is the development of a uniform testing (operation, sampling and analysis) protocol for PFAS emissions under product use. The results should further be additionally validated by means of statistics, and repetitive sample taking and evaluation.

- As a guideline, project proposals should define the process of test sample taking, considering e.g.:
  - Transport conditions, sampling devices, sample probing, and sample taking conditions (beginning of life, run-in units) at different sites in a system (fuel cell or electrolyser) under product use conditions (e.g. temperature, hydrodynamic conditions, product water emission or air taken, …);
  - Establish comparable and robust results for the samples, and a measure of proper data representation (statistics, relevance, database, reference, administration…);
  - Define harmonised test protocols for fuel cells and electrolysers during which samples are taken for analysis, providing a procedure how, when, and where the samples are taken (gas, liquid and aerosols).
- Establish a comprehensive analytical methodology:
- Establishing a list of relevant substances for targeted analysis of the corresponding samples[253];
  - Defining method(s) for analysis based on selected samples;
  - Investigating the limits and restrictions of the applied analytical method(s): limits of detection (LOD), limits of quantification (LOQ), mass determination and selectivity, etc.;
  - Evaluating possible impurities and misinterpretations of generated analytical results.

As a recommendation for upcoming analytical methods, it should be highlighted that while analysing PFAS at parts per trillion (ppt) concentrations, superior sampling, hygiene and laboratory handling procedures, and repetition of measurements are essential to ensure statistically validated results. Proposals should thus additionally establish a standard sampling process with appropriate sample hygiene instructions for fuel cell and/or electrolyser effluents. As indicated, an understanding of the sources of emissions should be tackled within the scope of the project.

It is further suggested that an analysis should answer the question of the proper combination of targeted residuals analyses, balancing non-targeted residuals analyses of both fluorinated and non-fluorinated compounds, and methods for quantification as Total Organic Fluorine

[252] Including results of 2025 calls (e.g. HORIZON-CL4-2025-INDUSTRY-01-51: Development of safe and sustainable by design alternatives to PFAS (IA))

[253] S. H. K. e. al., "A critical review of the application of polymer of low concern regulatory criteria to fluoropolymers II: fluoroplastics and fluoro-elastomers," Integrated Environmental Assessment and Management, vol. 2, no. 19, p. 326–354, 2023.

(TOF) or Total Organic Carbon (TOC). The project scope should not exclude certain chemistries from the scanning exercise, as results might be mispresented if the protocol is biased.

Projects should explore at least the following innovations:

- Representative sample taking from Low Temperature Proton Exchange Membrane Fuel Cells (LT- PEMFC) and Low Temperature - Proton Exchange Membrane Water Electrolysers (LT- PEMWE) in application, providing an adequate statistical approach including e.g. blind samples, reference samples, multiple-sample taking, and sample redundancy;
- Development of sampling methods and hygiene protocols for emission analyses from hydrogen systems under product use;
- Development of a combination of targeted, non-targeted, and TOF, TOC or other total parameter analysis techniques for system manufacturers to understand the sources of potential PFAS emissions under product use;
- Development of a combination of targeted and non-targeted analysis techniques for policy makers to understand the amount of potential PFAS emissions of electrochemical hydrogen systems.

Proposals are encouraged to contribute to the activities of EURAMET - European Metrology Networks for Pollution Monitoring[254] which addresses the challenges of measuring chemical pollutants including PFAs.

For activities developing test protocols and procedures for the performance and durability assessment of electrolysers and fuel cell components proposals should foresee a collaboration mechanism with JRC[255] (see section 2.2.4.3 "Collaboration with JRC"), in order to support EU-wide harmonisation. Test activities should adopt the already published EU harmonised testing protocols[256] to benchmark performance and quantify progress at programme level.

Proposals are expected to contribute towards the activities of Mission Innovation 2.0 - Clean Hydrogen Mission. Cooperation with entities from Clean Hydrogen Mission member countries, which are neither EU Member States nor Horizon Europe Associated countries, is encouraged (see section 2.2.6.7 International Cooperation).

For additional elements applicable to all topics please refer to section 2.2.3.2.

[254] https://www.euramet.org/european-metrology-networks/pollution-monitoring/pollutants/chemical-pollutants
[255] https://www.clean-hydrogen.europa.eu/knowledge-management/collaboration-jrc-0_en
[256] https://www.clean-hydrogen.europa.eu/knowledge-management/collaboration-jrc-0/clean-hydrogen-ju-jrc-deliverables_en

HORIZON-JU-CLEANH2-2025-05-03: Knowledge transfer and training of civil servants, safety officials, and permitting staff to improve safety assessment and licensing procedures across Europe

Specific conditions	
Expected EU contribution per project	The JU estimates that an EU contribution of maximum EUR 1.00 million would allow these outcomes to be addressed appropriately.
Indicative budget	The total indicative budget for the topic is EUR 1.00 million.
Type of Action	Coordination and Support Action
Technology Readiness Level	n/a
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G. The following exceptions apply: Eligible costs will take the form of a lump sum as defined in the Decision of 7 July 2021 authorising the use of lump sum contributions under the Horizon Europe Programme – the Framework Programme for Research and Innovation (2021-2027) – and in actions under the Research and Training Programme of the European Atomic Energy Community (2021-2025)[257].

Expected outcomes

Public entities responsible for licensing and safety analysis of hydrogen projects play a crucial role in the practical implementation of hydrogen as an energy vector. However, there is still widespread uncertainty with public bodies at a local level, as to how to classify projects and which specific protocols and methodologies to apply in assessing projects. Moreover, there remains a fragmentation across the EU, with evaluation and permitting procedures and processes governed by local, regional, and Member State regulations that are not harmonised. This creates hurdles, friction, and uncertainty for project developers across Europe in that they have to adjust to a variety of different permitting regulations and requirements when working internationally within the EU.

The project targets the training of public officials, staff of certification bodies, and engineers who are tasked with preparing permitting applications, evaluating such applications, and issuing permits for hydrogen projects. It will supply them with the necessary background knowledge to securely and confidently navigate the processes involved. The audience will consist of any staff involved in permitting processes on both sides of the table, as listed above, but could also include fire brigades and other institutions involved in permitting processes in a consulting role. By raising awareness of the differences in these processes between Member States, the project will be able to contribute towards a harmonisation of procedures throughout the EU. The primary addressees of the project will be the regions and countries of the current and future Hydrogen Valley projects funded through the Clean Hydrogen JU.

Project results are expected to contribute to all of the following outcomes:

- Collecting information on differences in Member States regulations in permitting and

[257] This decision is available on the Funding and Tenders Portal, in the reference documents section for Horizon Europe, under 'Simplified costs decisions' or through this link: https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/guidance/lsdecision_he_en.pdf

licensing processes of hydrogen projects across the EU;

- Giving public officials of the Hydrogen Valley regions and in the EU access to specific training plans and materials in order to spread knowledge on hydrogen technologies, their safety analysis and permitting processes;
- Supporting the move towards the use of digital tools to improve the efficiency in evaluation and licensing processes;
- Contributing to retain the EU leadership in efficiency and systematised licensing procedures, thus leveraging green hydrogen projects.

Project results are expected to contribute to the following objectives and Key Performance Indicators (KPI) of the Clean Hydrogen JU SRIA:

- Develop educational and training material and build training programmes for civil servants/safety officials in different languages on licensing procedures for the hydrogen value chain.
- Trained professionals (qualified workers, technicians, and engineers) in 2030:
    - 120,000 in Tier 1 countries (Germany, Denmark, United Kingdom and France);
    - 40,000 in Tier 2 countries (Belgium, Netherlands, Austria, Sweden, Norway, Finland, Latvia, Spain and Italy);
    - 20,000 in Tier 3 countries (rest of EU27 and rest of associated countries to Horizon Europe).

    These Tiers consider different awareness levels in the EU based on the HyLaw[258] project analysis.

Scope

The project will compile the existing evaluation, permitting, and licensing procedures for hydrogen projects across Europe in order to establish the training material. From this base, the project will compile present best practices for permitting Fuel Cells and Hydrogen (FCH) technologies across the EU into a handbook. The project will provide training to public officials and all other types of staff engaged in permit applications, project assessment and certification, and permit granting. This will allow streamlining project implementation and ensure effective permitting and licensing procedures. Projects should further address the knowledge transfer between Hydrogen Valleys and between Member States on permitting and certification of hydrogen projects, for example, based on the best practice handbook.

Assessment, permitting, and licensing processes to be covered include all those referring to the built environment, the energy system infrastructure and industrial infrastructures. This, for instance, includes hydrogen refuelling stations and hydrogen technology installations in residential, administrative, or commercial buildings, as well as the application of hydrogen in industry, and the implementation of energy distribution infrastructure, which all might require a permit or license to be built and/or to operate, depending on European, Member State or Associated Country regulations.

Trainings are to be provided in at least 10 EU languages in order to assure application to the existing Hydrogen Valleys funded by the JU and further widespread uptake in a significant number of EU and Associated Countries. Training material is to be provided in blended learning mode, mixing online asynchronous elements with on-site, in-person, or synchronous

[258] https://cordis.europa.eu/project/id/735977

online training measures. This will allow trainees to follow courses alongside their day-to-day work, managing their own educational effort and the time spent on the courses. The success of training will be assessed, and participants issued with a meaningful and recognised certificate of accomplishment. Train-the-trainer activities should also be foreseen to multiply the impact. Suitable material should be made available to the public free of charge.

Proposals should address all of the following:

- Analysis of evaluation, permitting, and licensing procedures across the EU, covering at least all countries with Hydrogen Valleys. In addition proposals should cover all remaining Tier1 and Tier2 countries, and a selection of Tier3 countries as deemed suitable by the applicants, ensuring an effective implementation of training programmes that can understand and explain the differences in procedures in the different target countries;
- Development and implementation of comprehensive training programmes in the target countries and/or regions (at least, as a minimum, in all countries with Hydrogen Valleys supported by the JU[259]) for public officials and staff involved in permit applications, assessment, evaluation, permitting, and licensing of hydrogen projects, covering relevant areas to ensure a deep understanding of principles and practices related to hydrogen projects. This should:
  - Focus on specific evaluation, licensing protocols and procedures in permitting of hydrogen projects;
  - Create educational materials in at least 10 official languages of the EU, ensuring inclusive access to training in the target countries, adding further countries, depending on the languages offered by the project;
  - Align training material with the format and delivery type of the European Hydrogen Academy (HyAcademy.EU[260]);
  - Supply of hands-on, practical hydrogen safety training in all countries covered by the above;
- Supply of train-the-trainer courses to training service providers and institutions with internal training programmes in all countries covered by the above;
- Assessment of educational progress, issuing a certificate recognised by the EU hydrogen industry;
- Introduction of the use of new digital tools to enhance efficiency and effectiveness in local evaluation and licensing processes, encouraging trainees to use such tools in their day-to-day practice.

Activities should consider synergies with ongoing and past projects developed in Horizon Europe, such as HyLaw[261], HyFacts[262], HYPOP[263], HyAcademy.EU[264] and, as applicable, HyResponder[265], as well as collaboration with ongoing other similar activities in Member States and internationally. Activities should consider cooperation, synergies, and alignment with the future Net-Zero Industry Academies in general. In addition, synergies with projects

259 https://www.clean-hydrogen.europa.eu/get-involved/hydrogen-valleys_en
260 https://cordis.europa.eu/project/id/101137988
261 https://cordis.europa.eu/project/id/735977
262 https://cordis.europa.eu/project/id/256823
263 https://cordis.europa.eu/project/id/101111933
264 https://cordis.europa.eu/project/id/101137988
265 https://cordis.europa.eu/project/id/875089

supported by other programmes and instruments should be explored, e.g the Hy2Market[266]. Finally, collaboration with the Hydrogen Valleys supported by the JU[267] as well as with other related activities such as those supported in the public contract for the “Hydrogen Valleys Facility” can be expected.

The licensing and certification of transport vehicles (e.g. automobiles, ships, aeroplanes) or of movable goods (e.g. heating boilers, CE certification, etc.) is out of scope.

For additional elements applicable to all topics please refer to section 2.2.3.2.

[266] Project supported by the Interregional Innovation Investments (I3) instrument which is a funding instrument under the ERDF regulation https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/projects-details/44416173/101083592/I3

[267] https://www.clean-hydrogen.europa.eu/get-involved/hydrogen-valleys_en

HYDROGEN VALLEYS

HORIZON-JU-CLEANH2-2025-06-01: Large-scale Hydrogen Valley

Specific conditions	
Expected EU contribution per project	The JU estimates that an EU contribution of maximum EUR 20.00 million would allow these outcomes to be addressed appropriately.
Indicative budget	The total indicative cumulative budget for the two Hydrogen Valleys topics is EUR 80.00 million (see section 2.2.3.1)
Type of Action	Innovation Action
Technology Readiness Level	The TRL of the applications in the project should be at least 6 at the beginning of the project while the overall concept should target a TRL 8 at the end of the project - see General Annex B.
Admissibility conditions	The conditions are described in General Annex A. The following exceptions apply: The page limit of the application is 70 pages.
Eligibility	The conditions are described in General Annex B. The following additional eligibility criteria apply: At least one partner in the consortium must be a member of either Hydrogen Europe or Hydrogen Europe Research. The maximum Clean Hydrogen JU contribution that may be requested is EUR 20.00 million – proposals requesting Clean Hydrogen JU contributions above this amount will not be evaluated.
Procedure	The procedure is described in General Annex F. STEP Seals will be awarded to proposals exceeding all of the evaluation thresholds set out in this work programme.
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G. The following exceptions apply: Eligible costs will take the form of a lump sum as defined in the Decision of 7 July 2021 authorising the use of lump sum contributions under the Horizon Europe Programme – the Framework Programme for Research and Innovation (2021-2027) – and in actions under the Research and Training Programme of the European Atomic Energy Community (2021-2025)[268]. Purchases of equipment, infrastructure or other assets used for the action must be declared as depreciation costs. However, for the following equipment, infrastructure or other assets purchased specifically for the action (or developed as part of the action tasks): hydrogen production plant, distribution and storage infrastructure and hydrogen end-uses, costs may exceptionally be declared as full capitalised costs.

[268] This decision is available on the Funding and Tenders Portal, in the reference documents section for Horizon Europe, under 'Simplified costs decisions' or through this link: https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/guidance/lsdecision_he_en.pdf

Expected Outcome

Hydrogen Valleys are hydrogen ecosystems that cover a specific geography ranging from local or regional focus (e.g. industrial cluster, ports, airports, etc.) to specific national or international regions (e.g. cross border hydrogen corridors)[269]. Hydrogen Valleys showcase the versatility of hydrogen by supplying several sectors in their geography such as mobility, industry and energy end-uses. They are ecosystems or clusters where various final applications share a common hydrogen supply infrastructure. Across their geographic scope, Hydrogen Valleys cover multiple steps in the hydrogen value chain, ranging from hydrogen production (and often even dedicated renewables production) to the subsequent storage of hydrogen and distribution to off-takers via various modes of transport. Whilst most of the projects are in the EU, over the past years, Hydrogen Valleys have gone global, with new projects emerging worldwide. Mission Innovation has set a target of deploying 100 large-scale Hydrogen Valleys worldwide by 2030[270].

Hydrogen Valleys are starting to form the first regional "hydrogen economies". Already under the previous programme, the Clean Hydrogen Partnership provided support to several Hydrogen Valleys across different locations in EU and of different sizes. It is however necessary to continue the accelerated deployment of Hydrogen Valleys as required by RePowerEU (with a target to double the number of hydrogen valleys by 2025) and to contribute to the objectives of the European Hydrogen Strategy, the EU Green Deal, and Fit for 55, and finally overcome common challenges linked to storage and distribution that may be territory specific. To do this it is necessary to have 'testbed' projects to act as first real-life cases for piloting global hydrogen markets. These projects need to be expanded in scale to demonstrate the full range of benefits from the use of hydrogen and to create interlinkages to allow for the emergence of a hydrogen economy in these regions.

Project results are expected to contribute to all the following expected outcomes:

- Anchorage of new demand for renewable hydrogen;
- Interaction and synergies among initial test beds;
- Full integration into the broader cross-sectoral energy ecosystem;
- Improvement of the perception of public towards hydrogen technologies, by ensuring a high visibility of the project and associated technologies to the local public and EU citizens;
- Emergence of new hydrogen valleys, through dissemination of learnings.

Hydrogen Valleys also offer an opportunity to support the objectives of the Net Zero Industry Act by promoting and facilitating the relocation of net-zero technologies manufacturing facilities in areas with Hydrogen Valleys. In addition, Hydrogen Valleys are very well suited to further support innovation by facilitating the access to Small Medium Enterprises (SME)/Startups to the Hydrogen Valleys, especially those which have technologies that need to scale- up and prove them in a living lab environment.

Scope

The scope of this flagship topic is to develop and demonstrate a large-scale Hydrogen Valley. It could demonstrate a combination of technologies either in existing and/or new markets for clean hydrogen (including hard-to-abate sectors), especially when applications are used in

[269] https://h2v.eu/media/7/download
[270] https://ec.europa.eu/info/news/mission-innovation-launches-new-global-coalition-support-clean-hydrogen-economy-2021-jun-02_en

symbiose with each other. Proposals should demonstrate innovative approaches at system level: systemic and synergetic integration of hydrogen production (not restricted to electrolysis), distribution and end-use technologies. Proposals may also investigate interoperability, cause-effect stability of the overall system. Technologies demonstrated should be state-of the-art following technological developments previously funded by (but not limited to) the Clean Hydrogen Partnership.

Proposals should respond to the following requirements:

- Production of at least 4000 tonnes of clean hydrogen[271,272] per year using new hydrogen production capacity (at least for the last 2-years of project demonstration). Due to the large volumes of hydrogen involved, production plants may be distributed across the territories involved but should share common hydrogen supply infrastructure;
- At least two hydrogen applications from two different sectors should be part of the project, with clear focus on energy, industry and transport sectors;
- Demonstrate how new built infrastructure can be integrated and function with existing infrastructure (when relevant), with the aim to maximise the impact of the hydrogen valley in all sectors addressed;
- Monitoring and assessment activities including at least two years of operations;
- Provision of a clear, professional, and ambitious communication plan to ensure high visibility to the public including clear, measurable, and ambitious Key Performance Indicators (KPI);
- Demonstration of how hydrogen enables sector coupling, allows for example H2 storage and/or large integration of renewable energy[273] and provides an optimum techno economic solution for the decarbonisation of the activities in the geographical area being addressed;
- Reduction of the carbon emissions and impact on air quality related to the end-uses compared to incumbent technologies;
- Demonstration of how financial viability is expected to be reached after two years of operation.

Proposals should also:

- Provide concrete project implementation plans with a clear calendar, defining the key phases of the implementation of the action (i.e., preparation of the specifications of equipment, manufacturing, permitting, deployment, and operation) and their duration;
- Provide a funding plan to ensure implementation of the project in synergies with other sources of funding. If no other sources of funding will be required, this should be stated clearly in the proposal, with a commitment from the partners to provide own funding. If additional sources of funding will be required, proposals should present a clear plan

[271] As defined in the SRIA of the Clean Hydrogen JU, clean hydrogen refers to renewable hydrogen. To the demonstration addressed in the proposal it can be foreseen that in the early stages low carbon hydrogen could be used. However, the objective is to move to renewable or clean hydrogen as an ultimate objective in the project. Please refer to the paragraph Rationale for support of the section 3.7 of the SRIA of the Clean Hydrogen JU.

[272] Renewable hydrogen is hydrogen produced using renewable energy (Renewable Energy Directive 2018/2001/EU)

[273] In line with the definitions provided in the Renewable Energy Directive 2018/2001/EU

on which funding programmes at EU and/or national levels will be targeted[274]. In these cases, applicants should present a credible planning that includes forecasted funding programmes and their expected time of commitment;

- Clearly and coherently present the Hydrogen Valley (across the whole value chain including hydrogen production, distribution and storage and end uses) including the investments/actions supported directly by this topic as well as other investments / actions supported by other funding /financing sources[275] which are part of the hydrogen valley to be deployed and demonstrated in line with the topic requirements;
- Provide evidence of the commitment and role of public authorities (Member States, Regions, and Cities) and of any other necessary stakeholders (e.g. hydrogen off-takers) at least in the form of Letters of Intent (LOI). The practical implementation of these LOI will be followed during the Grant Agreement implementation;
- Provide a preliminary 'hydrogen safety planning and management plan'[276] at the project level, which will be further updated during project implementation;
- Ensure coverage of aspects such as replicability and (cross-border) cooperation between regions to facilitate transfer of knowledge across the EU with a focus on fostering replication of Hydrogen Valleys elsewhere;
- Demonstrate how synergies with existing hydrogen valleys will be ensured especially when it comes to skills and know-how exchange;
- Provide a scalability analysis that includes the broader energy system showing how the valley is expected to grow, where applicable, in view to connect initial demonstrations and create synergies with existing energy infrastructure, as well as its possible contribution to the progress of the five hydrogen corridors;
- Highlight sustainability aspects in their description.

The costs for the construction and commissioning phase of the hydrogen production technologies including connection (e.g connection to the electricity grid, electricity costs) and other hydrogen infrastructure (e.g Hydrogen Refuelling Station (HRS), storage, pipelines, etc) may be funded while costs of renewable energy plants (e.g., photovolthaic or wind plant) or related costs for operation of the Hydrogen Valley (e.g., electricity for electrolysers) will not be funded.

Proposals are expected to collaborate with the successful applicants under topic HORIZON-JU-CLEANH2-2025-05-03 on 'Knowledge transfer and training of civil servants, safety officials, and permitting staff to improve safety assessment and licensing procedures across Europe'.

Proposals are expected to demonstrate the contribution to EU competitiveness and industrial leadership of the activities to be funded including but not limited to the origin of the equipment and components as well infrastructure purchased and built during the project. These aspects will be evaluated and monitored during the project implementation.

It is expected that Guarantees of origin (GOs) will be used to prove the renewable character

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[274] Including applications for funding planned, applications for funding submitted and funding awarded.

[275] In the context of the topic other investments/actions refer to parts of the hydrogen valley which are necessary to respond to the topic requirements and to deliver a fully functional hydrogen valley but that are not supported with the funding of the Clean Hydrogen JU (e.g. hydrogen production plant supported with national funding, or HRS supported with funding from the Connecting Europe Facility – Transport (CEF-T))

[276] In the context of this topic this refers to an early plan indicating how safety will be managed in the project https://www.clean-hydrogen.europa.eu/get-involved/european-hydrogen-safety-panel-0/reference-documents_en

of the hydrogen that is produced/used. In this respect consortium may seek out the issuance/purchase and subsequent cancellation of GOs from the relevant Member State issuing body and if that is not yet available the consortium may proceed with the issuance and cancellation of non-governmental certificates (e.g CertifHy[277]).

Proposals are expected to contribute towards the activities of the EU Mission on Climate-Neutral and Smart Cities, Mission Innovation 2.0 - Clean Hydrogen Mission and the H2V platform. Cooperation with entities from Clean Hydrogen Mission member countries, which are neither EU Member States nor Horizon Europe Associated countries, is encouraged (see section 2.2.6.7 International Cooperation).

Proposals should provide a preliminary draft on 'hydrogen safety planning and management' at the project level, which will be further updated during project implementation.

For additional elements applicable to all topics please refer to section 2.2.3.2.

[277] https://www.certifhy.eu

HORIZON-JU-CLEANH2-2025-06-02: Small-scale Hydrogen Valley

Specific conditions	
Expected EU contribution per project	The JU estimates that an EU contribution of maximum EUR 9.00 million would allow these outcomes to be addressed appropriately.
Indicative budget	The total indicative cumulative budget for the two Hydrogen Valleys topics is EUR 80.00 million (see section 2.2.3.1)
Type of Action	Innovation Action
Technology Readiness Level	The TRL of the applications in the project should be at least 6 at the beginning of the project while the overall concept should target a TRL 8 at the end of the project - see General Annex B.
Admissibility conditions	The conditions are described in General Annex A. The following exceptions apply: The page limit of the application is 70 pages.
Eligibility	The conditions are described in General Annex B. The following additional eligibility criteria apply: At least one partner in the consortium must be a member of either Hydrogen Europe or Hydrogen Europe Research. The maximum Clean Hydrogen JU contribution that may be requested is EUR 9.00 million – proposals requesting Clean Hydrogen JU contributions above this amount will not be evaluated.
Procedure	The procedure is described in General Annex F. Sovereignty STEP Seals will be awarded to proposals exceeding all of the evaluation thresholds set out in this work programme.
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G. The following exceptions apply: Eligible costs will take the form of a lump sum as defined in the Decision of 7 July 2021 authorising the use of lump sum contributions under the Horizon Europe Programme – the Framework Programme for Research and Innovation (2021-2027) – and in actions under the Research and Training Programme of the European Atomic Energy Community (2021-2025)[278]. Purchases of equipment, infrastructure or other assets used for the action must be declared as depreciation costs. However, for the following equipment, infrastructure or other assets purchased specifically for the action (or developed as part of the action tasks): hydrogen production plant, distribution and storage infrastructure and hydrogen end-uses, costs may exceptionally be declared as full capitalised costs.

[278] This decision is available on the Funding and Tenders Portal, in the reference documents section for Horizon Europe, under 'Simplified costs decisions' or through this link: https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/guidance/lsdecision_he_en.pdf

Expected Outcome

Hydrogen Valleys are hydrogen ecosystems that cover a specific geography ranging from local or regional focus (e.g. industrial cluster, ports, airports, etc.) to specific national or international regions (e.g. cross border hydrogen corridors)[279]. Hydrogen Valleys showcase the versatility of hydrogen by supplying several sectors in their geography such as mobility, industry and energy end uses. They are ecosystems or clusters where various final applications share a common hydrogen supply infrastructure. Across their geographic scope, Hydrogen Valleys cover multiple steps in the hydrogen value chain, ranging from hydrogen production (and often even dedicated renewables production) to the subsequent storage of hydrogen and distribution to off-takers via various modes of transport. Whilst most of the projects are in the EU, over the past years, Hydrogen Valleys have gone global, with new projects emerging worldwide. Mission Innovation has set a target of deploying 100 large-scale Hydrogen Valleys worldwide by 2030[280].

Hydrogen Valleys are starting to form the first regional "hydrogen economies". Already under the previous programme, the Clean Hydrogen Partnership provided support to several Hydrogen Valleys across different locations in EU and of different sizes. It is however necessary to continue the accelerated deployment of Hydrogen Valleys as required by RePowerEU (with a target to double the number of hydrogen valleys by 2025) and to contribute to the objectives of the European Hydrogen Strategy, the EU Green Deal, and Fit for 55, and finally overcome common challenges linked to storage and distribution that may be territory specific. To do this it is necessary to have 'testbed' projects to act as first real-life cases for piloting global hydrogen markets. These projects need to be expanded in scale to demonstrate the full range of benefits from the use of hydrogen.

Project results are expected to contribute to all the following expected outcomes:

- Anchorage of new demand for renewable hydrogen;
- Interaction and synergies among initial test beds;
- Full integration into the broader cross-sectoral energy ecosystem;
- Improvement of the perception of public towards hydrogen technologies, by ensuring a high visibility of the project and associated technologies to the local public and EU citizens, to connect initial demonstrations and to create synergies with existing energy infrastructure;
- Emergence of new hydrogen valleys, through dissemination of learnings.

Scope

The scope of this flagship topic is to develop and demonstrate a small-scale Hydrogen Valley. It could demonstrate a combination of technologies either in existing and/or new markets for clean hydrogen, especially when applications are used in symbiose with each other.

Proposals should demonstrate innovative approaches at system level: systemic and synergetic integration of hydrogen production (not restricted to electrolysis), distribution and end-use technologies. Proposals may also investigate interoperability, cause-effect stability of the overall system. Technologies demonstrated should be state-of the-art following technological developments previously funded by (but not limited to) the Clean Hydrogen Partnership.

[279] https://h2v.eu/media/7/download
[280] https://ec.europa.eu/info/news/mission-innovation-launches-new-global-coalition-support-clean-hydrogen-economy-2021-jun-02_en

Proposals should respond to the following requirements:

- Production of at least 500 tonnes of clean hydrogen[281,282] per year using new hydrogen production capacity (at least for the last 2-years of project demonstration). Due to the large volumes of hydrogen involved, production plants may be distributed across the territories involved but should share common hydrogen supply infrastructure;
- Use of the hydrogen produced to supply one or more end sector or application in the energy, industry, and transport sectors;
- Monitoring and assessment activities including at least two years of operations;
- Provision of a clear, professional, and ambitious communication plan to ensure high visibility to the public including clear, measurable, and ambitious Key Performance Indicators (KPI);
- Demonstration of how hydrogen enables sector coupling, allows for example H2 storage and/or large integration of renewable energy[283] and provides an optimum techno economic solution for the decarbonisation of the activities in the geographical area being addressed;
- Reduction of the carbon emissions and impact on air quality related to the end-uses compared to incumbent technologies;
- Demonstration of how financial viability is expected to be reached after two years of operation.

Proposals should also:

- Provide concrete project implementation plans with a clear calendar, defining the key phases of the implementation of the action (i.e., preparation of the specifications of equipment, manufacturing, permitting, deployment, and operation) and their duration;
- Provide a funding plan to ensure implementation of the project in synergies with other sources of funding. If no other sources of funding will be required, this should be stated clearly in the proposal, with a commitment from the partners to provide own funding. If additional sources of funding will be required, proposals should present a clear plan on which funding programmes at EU and/or national levels will be targeted[284]. In these cases, applicants should present a credible planning that includes forecasted funding programmes and their expected time of commitment;
- Clearly and coherently present the Hydrogen Valley (across the whole value chain including hydrogen production, distribution and storage and end uses) including the investments/actions supported directly by this topic as well as other investments/actions supported by other funding /financing sources[285] which are part of the hydrogen valley to be deployed and demonstrated in line with the topic

[281] As defined in the SRIA of the Clean Hydrogen JU, clean hydrogen refers to renewable hydrogen. To the demonstration addressed in the proposal it can be foreseen that in the early stages low carbon hydrogen could be used. However, the objective is to move to renewable or clean hydrogen as an ultimate objective in the project. Please refer to the paragraph Rationale for support of the section 3.7 of the SRIA of the Clean Hydrogen JU.
[282] Renewable hydrogen is hydrogen produced using renewable energy (Renewable Energy Directive 2018/2001/EU).
[283] In line with the definitions provided in the Renewable Energy Directive 2018/2001/EU
[284] Including applications for funding planned, applications for funding submitted and funding awarded.
[285] In the context of the topic other investments/actions refer to parts of the hydrogen valley which are necessary to respond to the topic requirements and to deliver a fully functional hydrogen valley but that are not supported with the funding of the Clean Hydrogen JU (e.g. hydrogen production plant supported with national funding or HRS supported with funding from the Connecting Europe Facility – Transport (CEF-T))

requirements;

- Provide evidence of the commitment and role of public authorities (Member States, Regions, and Cities) and of any other necessary stakeholders (e.g. hydrogen off-takers) at least in the form of Letters of Intent (LOI). The practical implementation of these LOI will be followed during the Grant Agreement implementation;
- Provide a preliminary 'hydrogen safety planning and management plan'[286] at the project level, which will be further updated during project implementation;
- Ensure coverage of aspects such as replicability and (cross-border) cooperation between regions to facilitate transfer of knowledge across the EU with a focus on fostering replication of Hydrogen Valleys elsewhere;
- Demonstrate how synergies with existing hydrogen demonstration projects or hydrogen valleys will be ensured especially when it comes to skills and know-how exchange;
- Provide a scalability analysis that includes the broader energy system showing how the valley is expected to grow, where applicable;
- Highlight sustainability aspects in their description.

Proposals are expected to collaborate with the successful applicants under topic HORIZON-JU-CLEANH2-2025-05-03 on 'Knowledge transfer and training of civil servants, safety officials, and permitting staff to improve safety assessment and licensing procedures across Europe'.

The costs for the construction and commissioning phase of the hydrogen production technologies including connection (e.g connection to the electricity grid, electricity costs) and other hydrogen infrastructure (e.g HRS, storage, pipelines, etc) may be funded while costs of renewable energy plants (e.g., PV or wind plant) or related costs for operation of the Hydrogen Valley (e.g., electricity for electrolysers) will not be funded.

Proposals are expected to demonstrate the contribution to EU competitiveness and industrial leadership of the activities to be funded including but not limited to the origin of the equipment and components as well infrastructure purchased and built during the project. These aspects will be evaluated and monitored during the project implementation.

It is expected that Guarantees of origin (GOs) will be used to prove the renewable character of the hydrogen that is produced/used. In this respect consortium may seek out the issuance/purchase and subsequent cancellation of GOs from the relevant Member State issuing body and if that is not yet available the consortium may proceed with the issuance and cancellation of non-governmental certificates (e.g CertifHy[287]).

Proposals are expected to contribute towards the activities of the EU Mission on Climate-Neutral and Smart Cities, Mission Innovation 2.0 - Clean Hydrogen Mission and the H2V platform. Cooperation with entities from Clean Hydrogen Mission member countries, which are neither EU Member States nor Horizon Europe Associated countries, is encouraged (see section 2.2.6.7 International Cooperation).

Proposals should provide a preliminary draft on 'hydrogen safety planning and management'

[286] https://www.clean-hydrogen.europa.eu/get-involved/european-hydrogen-safety-panel-0/reference-documents_en
[287] https://www.certifhy.eu

at the project level, which will be further updated during project implementation.

For additional elements applicable to all topics please refer to section 2.2.3.2.

2.2.3.2. Conditions of the call and call management rules

Conditions for the Call

Call identifier: **HORIZON-JU-CLEANH2-2025-1**

Overall Indicative Budget: **EUR 184.5 MEUR**

***Indicative budget(s)*[288]**

Topic	Type of Action	Budgets (EUR million)	Expected EU contribution per project [289] (EUR million)	Number of projects expected to be funded
Publication[290]: 15 January 2025 Deadline[291]: 23 April 2025				
HORIZON-JU-CLEANH2-2025-01-01	RIA	4	4	1
HORIZON-JU-CLEANH2-2025-01-02	RIA	8	4	2
HORIZON-JU-CLEANH2-2025-01-03	RIA	8	4	2
HORIZON-JU-CLEANH2-2025-01-04	IA	6	6	1
HORIZON-JU-CLEANH2-2025-01-05	RIA	4	4	1
HORIZON-JU-CLEANH2-2025-01-06	IA	8	8	1
HORIZON-JU-CLEANH2-2025-01-07	RIA	2	2	1
HORIZON-JU-CLEANH2-2025-02-01	RIA	5	5	1
HORIZON-JU-CLEANH2-2025-02-02	RIA	5	5	1
HORIZON-JU-CLEANH2-2025-02-03	IA	6	6	1
HORIZON-JU-CLEANH2-2025-03-01	RIA	5	5	1
HORIZON-JU-CLEANH2-2025-03-02	RIA	5	5	1
HORIZON-JU-CLEANH2-2025-03-03	RIA	7	7	1
HORIZON-JU-CLEANH2-2025-04-01	IA	5	5	1
HORIZON-JU-CLEANH2-2025-05-01	RIA	3.5	3.5	1
HORIZON-JU-CLEANH2-2025-05-02	RIA	2	2	1
HORIZON-JU-CLEANH2-2025-05-03	CSA	1	1	1
HORIZON-JU-CLEANH2-2025-06-01	IA	80	20	See section 2.2.3.1
HORIZON-JU-CLEANH2-2025-06-02	IA		9	See section 2.2.3.1

[288] Budget flexibility — The budgets set out in the call and topics are indicative. Unless otherwise stated, final budgets may change following evaluation. The final figures may change by up to 20% compared to the total budget indicated in each individual part of the work programme. Changes within these limits will not be considered substantial within the meaning of Article 110(5) of Regulation (EU, Euratom) No 2018/1046.

[289] Unless otherwise stated in the specific topic conditions, this does not preclude submission and selection of a proposal requesting different amounts

[290] The Executive Director may decide to open the call up to one month prior to or after the envisaged date of publication.

[291] The Executive Director may delay the deadline by up to two months. The deadline is at 17.00.00 Brussels local time.

General conditions relating to the Call

This section sets the general conditions applicable to call and topics for grants under this Annual Work Programme. It also describes the evaluation and award procedures and other criteria.

The call included in this Work Programme, including evaluation and award procedures, will be managed according to and the proposals should comply with the call conditions below and with the General Annexes to the Horizon Europe Work Programme 2023-2025[292] that shall apply mutatis mutandis to the call covered in this Annual Work Programme (with the exceptions introduced in the specific topic conditions).

There is no derogation from the Horizon Europe Rules for Participation.

Admissibility conditions	The conditions are described in General Annex A.
Eligibility conditions	The conditions are described in General Annex B.
Financial and operational capacity and exclusion	The criteria are described in General Annex C.
Award criteria	The criteria are described in General Annex D.
Documents	The documents are described in General Annex E.
Evaluation Procedure	The procedure is described in General Annex F.
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G.

If a topic deviates from the general conditions or includes additional conditions, this is explicitly stated under the specific conditions for the topic.

General Annex A (Admissibility conditions): Exceptions

- For all Innovation Actions the page limit of the applications are 70 pages.

General Annex B (Eligibility conditions): Additional conditions

- For some topics, in line with the Clean Hydrogen JU SRIA, an additional eligibility criterion has been introduced **to limit the Clean Hydrogen JU requested contribution** mostly for actions performed at high TRL level, including demonstration in real operational environment and with important involvement from industrial stakeholders and/or end users such as public authorities. Such actions are expected to leverage co-funding as commitment from stakeholders. It is of added value that such leverage is shown through the private investment in these specific topics. Therefore, proposals requesting contributions above the amounts specified per each topic below will not be evaluated:

Additional eligibility condition: Maximum JU contribution per topic
HORIZON-JU-CLEANH2-2025-01-04
HORIZON-JU-CLEANH2-2025-01-06
HORIZON-JU-CLEANH2-2025-02-03
HORIZON-JU-CLEANH2-2025-04-01
HORIZON-JU-CLEANH2-2025-06-01
HORIZON-JU-CLEANH2-2025-06-02

[292] https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/wp-call/2023-2024/wp-13-general-annexes_horizon-2023-2024_en.pdf

- For the topics listed below, in line with the Clean Hydrogen JU SRIA, an additional eligibility criterion has been introduced to ensure that **one partner in the consortium is a member of either Hydrogen Europe or Hydrogen Europe Research**. This concerns topics targeting actions for large-scale demonstrations, flagship projects and strategic research actions, where the industrial and research partners of the Clean Hydrogen JU are considered to play a key role in accelerating the commercialisation of hydrogen technologies by being closely linked to the Clean Hydrogen JU constituency, which could further ensure full alignment with the SRIA of the JU. This approach shall also ensure the continuity of the work performed within projects funded through the H2020 and FP7, by building up on their experience and consolidating the EU value-chain. In the Call 2025 this applies to: demonstration of efficient electrolysis coupling with variable renewable electricity and/or heat integration, demonstration of innovative hydrogen and solid carbon production from renewable gases/biogenic waste processes, demonstration of scalable ammonia cracking technology, and demonstration of stationary fuel cells in renewable energy communities. This will also apply to the Hydrogen Valley (flagship) topics as they are considered of strategic importance for the European Union ambitions to double the number of Hydrogen Valleys by 2025. For the Hydrogen Valleys topics a large amount of co-investment/co-funding of project participants/beneficiaries including national and regional programmes is expected.

Additional eligibility condition: Membership to Hydrogen Europe/Hydrogen Europe Research
HORIZON-JU-CLEANH2-2025-01-04
HORIZON-JU-CLEANH2-2025-01-06
HORIZON-JU-CLEANH2-2025-02-03
HORIZON-JU-CLEANH2-2025-04-01
HORIZON-JU-CLEANH2-2025-06-01
HORIZON-JU-CLEANH2-2025-06-02

Technology Readiness level

Where specific call/topic conditions require a Technology Readiness Level (TRL), the definitions included in the General Annexes to the Horizon Europe Work Programme 2023-2025[293] apply.

Manufacturing Readiness Level

For some topics a definition of Manufacturing Readiness Level has been introduced in the Annexes of the Annual Work Programme. This is necessary to evaluate the status of the overall manufacturing activities included in the following topics:

Topics for which the Manufacturing Readiness Level (MRL) has been introduced
HORIZON-JU-CLEANH2-2025-01-03
HORIZON-JU-CLEANH2-2025-03-02

[293] https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/wp-call/2023-2024/wp-13-general-annexes_horizon-2023-2024_en.pdf

General Annex F (Evaluation procedure):

Budget envelope for Hydrogen Valleys Topics:

STEP (Sovereignty) Seal

For the topics below topics the STEP Seal (so called "Sovereignty Seal" under the STEP Regulation[294]) will be awarded to proposals exceeding all of the evaluation thresholds set out in this Annual Work Programme. The STEP Seal is a label, which aims to increase the visibility of quality projects available for funding and help attract alternative and cumulative funding for quality projects, and simultaneously to provide a potential project pipeline for regional and national programmes[295]

STEP (Sovereignty) Seal is applicable to the following topics
HORIZON-JU-CLEANH2-2025-01-04
HORIZON-JU-CLEANH2-2025-01-06
HORIZON-JU-CLEANH2-2025-02-03
HORIZON-JU-CLEANH2-2025-04-01
HORIZON-JU-CLEANH2-2025-06-01
HORIZON-JU-CLEANH2-2025-06-02

General Annex G (Legal and financial set-up of the grant agreements): Specific provisions

In addition to the standard provisions, the following specific provisions in the model grant agreement will apply:

1. *Lump Sum*

   This year's call for proposals will take the form of lump sums [296] as defined in the Decision of 7 July 2021 authorising the use of lump sum contributions under the Horizon Europe Programme – the Framework Programme for Research and Innovation (2021- 2027) – and in actions under the Research and Training Programme of the European Atomic Energy Community (2021-2025)[297].

   Lump sums will be used across all topics in the Call 2025.

2. *Full capitalised costs for purchases of equipment, infrastructure or other assets purchased specifically for the action*

   For some topics, in line with the Clean Hydrogen JU SRIA, mostly large-scale demonstrators or flagship projects specific equipment, infrastructure or other assets purchased specifically for the action (or developed as part of the action tasks) can exceptionally be declared as full capitalised costs. This concerns the topics below:

[294] https://strategic-technologies.europa.eu/about_en#paragraph_207
[295] https://strategic-technologies.europa.eu/about_en#paragraph_207
[296] https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/programmes/horizon/lump-sum
[297] DECISION authorising the use of lump sum contributions under the Horizon Europe Programme – the Framework Programme for Research and Innovation (2021-2027) – and in actions under the Research and Training Programme of the European Atomic Energy Community (2021-2025) ls-decision_he_en.pdf (europa.eu)

Exceptional declaration of full capitalised costs
HORIZON-JU-CLEANH2-2025-01-04
HORIZON-JU-CLEANH2-2025-01-06
HORIZON-JU-CLEANH2-2025-02-03
HORIZON-JU-CLEANH2-2025-04-01
HORIZON-JU-CLEANH2-2025-06-01
HORIZON-JU-CLEANH2-2025-06-02

3. *Subcontracting*

   For all topics: an **additional obligation regarding subcontracting** has been introduced, namely that subcontracted work may only be performed in target countries set out in the call conditions.

   The beneficiaries must ensure that the subcontracted work is performed in the countries set out in the call conditions.

   The target countries are all Member States of the European Union and all Associated Countries.

4. Intellectual Property Rights (IPR), background and results, access rights and rights of use (article 16 and Annex 5 of the Model Grant Agreement (MGA)).

   An additional information obligation has been introduced for topics including standardisation activities: 'Beneficiaries must, up to 4 years after the end of the action, inform the granting authority if the results could reasonably be expected to contribute to European or international standards'. These concerns the topics below:

Additional information obligation for topics including standardisation activities
HORIZON-JU-CLEANH2-2025-02-01

Common elements applicable to all topics in the Call

EU competitiveness and industrial leadership

In line with the activities started already under the FCH 2 JU, the Clean Hydrogen JU will continue to work to reinforce the EU supply chain of critical key components by e.g. a higher range of common/standardised parts to be produced in EU and Horizon Europe Associated Countries, and to enable start investments in production facilities for further ramp-up in these markets.

All topics included in the Call for proposals 2025 are expected to contribute to EU competitiveness and EU industrial leadership by supporting a European value chain for hydrogen and fuel cell systems components, cells and stacks as well as hydrogen related infrastructure. In particular, proposals are expected to demonstrate supporting European hydrogen value chain, resilience of the supply chains, development of new technology, creating new IP rights, partnerships with European research bodies, recycling and other strategy helping to reduce dependency on critical raw materials, contribution to new industrial ecosystems or other positive spillover effect, jobs created , training or other actions to develop know-how in Europe. As a result, proposals, and specially for all Innovation Actions topics, are expected to demonstrate the contribution to EU competitiveness and industrial leadership of the activities to be funded including but not limited to the origin of the equipment and components as well infrastructure purchased and built during the project. These aspects will be evaluated and monitored during the project implementation.

Synergies

Applicants are expected to pursue the specific opportunities for synergies with other partnerships and programmes as identified in each of the topics (see also section 2.2.6.1).

Applicants in the Call 2025, especially for flagship projects, may consider additional synergies with other Programmes (e.g. European Structural and Investment Funds, Recovery and Resilience Facility, Just Transition Fund, Connecting Europe Facility, Innovation Fund, Modernisation Fund, LIFE, etc.) and/or clustering with other projects within Horizon Europe or funded under other EU, national or regional programmes, or having loans through the EIB or other promotional or commercial banks; such synergies should be reflected in a financing structure and strategy describing the business model, including envisaged sources of co-funding/co-financing and in line with state-aid rules. To this end the European Commission has published a guidance notice which explains the new possibilities for synergies with ERDF programmes and offers guidance on their practical implementation[298].

Contribution to the monitoring framework of the Clean Hydrogen JU

For the purpose of monitoring technology progress against state-of-art, but also to identify how each of the projects contributes to the Clean Hydrogen JU targets, objectives and indicators described in the SRIA, supported projects will be required to report on an annual basis in a secure online data collection platform (such as TRUST or the Knowledge Hub, when operational) managed by the Clean Hydrogen Joint Undertaking during the course of Horizon Europe. The reporting will involve filling template questionnaire(s) relevant to the project content (and the technology development and TRL). The projects will need to submit all information included in the questionnaire(s), unless they receive an exception from the Programme Office. The information is submitted by default as public, but the projects can request for certain fields to be considered as "confidential"[299] except for the fields that constitute or directly inform KPIs of the Clean Hydrogen JU. The submission of the questionnaire(s) will be integrated as a specific annual deliverable in the grant agreement. Indicative template questionnaire(s) can be consulted online[300].

Guarantees of origin of hydrogen

For some of the Innovation Actions it is expected that GOs will be used to prove the renewable character of the hydrogen that is produced/used. In this respect consortium may seek the issuance/purchase and subsequent cancellation of GOs from the relevant Member State issuing body and if that is not yet available, the consortium may proceed with the issuance/purchase and cancellation of non-governmental certificates (e.g CertifHy[301]).

Safety

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[298] Commission Notice Synergies between Horizon Europe and ERDF programmes 2022/C 421/03, C/2022/7307; https://eur-lex.europa.eu/legal-content/EN/TXT/?toc=OJ%3AC%3A2022%3A421%3AFULL&uri=uriserv%3AOJ.C_.2022.421.01.0007.01.ENG

[299] The Clean Hydrogen JU is committed to respect data confidentiality according to the conditions setup by the Grant Agreement and will only use them in the respect of this attribute: confidential data will not be disclosed as such, but only in aggregated form (following a clean-room approach), and in a manner that ensures non-attribution of their source). Progress and findings that can be shown will be made public (normally associated to the Clean Hydrogen JU annual Programme Review exercise).

[300] https://www.clean-hydrogen.europa.eu/knowledge-management/technology-monitoring-trust_en

[301] https://www.certifhy.eu/

For all topics a ‘safety by design’ approach should be considered. In particular, in Innovation Actions proposals should provide a preliminary draft of ‘hydrogen safety planning and management’ at the project level, which will be further developed during project implementation (deliverables to be reviewed by the European Hydrogen Safety Panel). Reference documentation and guidance is available on the EHSP webpage[302]. In particular: (i) Safety Planning and management in EU hydrogen and fuel cells projects – guidance document and (ii) simple template for a safety plan

For all topics, projects should report any safety-related event that may occur during the project implementation to the European Commission's Joint Research Centre (JRC) dedicated mailbox JRC-PTT-H2SAFETY@ec.europa.eu, which manages the European hydrogen safety reference database, HIAD 2.1[303]. Projects reporting on safety should report annually either the safety-related events[304]: near misses, incidents, accidents, or the absence of events.

Contribution to Regulation, Codes and Standards

For Innovation Actions, proposals should consider a public report with both the Legal and Administrative Processes (LAP) and the Regulations, Codes and Standards relevant to the technologies and/or applications at the project scope, and the barriers and/or gaps identified during the project implementation alongside any other relevant information in order to share the lessons learned and provide recommendations to support the update and/or development of suitable and enabling legal and regulatory frameworks for hydrogen and fuel cell technologies and applications.

Contribution to sustainability and circularity

For all topics applicants are encouraged to address sustainability and circularity aspects in the activities proposed.

While proposals have a certain leeway to address the sustainability and circularity aspects in general as a function of their activities, for all topics, proposals undertaking Life-Cycle Assessments (LCAs) should follow and comply with the LCA checklist developed by the JRC[305].

Activities developing test protocols

For all topics, activities developing test protocols and procedures for the performance and durability assessment of electrolysers and fuel cell components proposals should foresee a collaboration mechanism with JRC (see section 2.2.4.3 "Collaboration with JRC"), in order to support EU-wide harmonisation. Test activities should adopt the already published EU harmonised testing protocols[306] to benchmark performance and quantify progress at programme level.

Exploitation of project results

For all Research and Innovation actions proposals should describe a clear exploitation pathway through the different necessary steps (research, manufacturing, regulatory approvals and licensing, IP management etc.) in order to accelerate exploitation of the results.

For all Innovation Actions, exploitation and dissemination of results should include a strong

[302] https://www.clean-hydrogen.europa.eu/get-involved/european-hydrogen-safety-panel-0/reference-documents-ehsp_en
[303] https://minerva.jrc.ec.europa.eu/en/shorturl/capri/hiadpt
[304] Definitions of near-miss, incident, and accident according to EIGA document INCIDENT/ACCIDENT INVESTIGATION AND ANALYSIS SAC Doc 90/13/E
[305] https://www.clean-hydrogen.europa.eu/knowledge-management/collaboration-jrc-0_en
[306] https://www.clean-hydrogen.europa.eu/knowledge-management/collaboration-jrc-0_en

business case and sound exploitation strategy. The exploitation plan should include preliminary plans for scalability, commercialisation, and deployment (feasibility study, business plan) indicating the possible funding sources to be potentially used (in particular the Innovation Fund). As a project output a more elaborated exploitation plan should be developed including preliminary plans for scalability, commercialisation, and deployment (feasibility study, business plan and financial model) indicating the possible funding sources to be potentially used (e.g., Innovation Fund, LIFE, InvestEU, ESIF).

Beneficiaries are invited to put their results on the Horizon Results Platform, while exploring the use of relevant support services offered by the Commission, such as the Horizon Results Booster. These services can prove useful in bringing results generated from research closer to the market.

International Collaboration

In recognition of the benefits that international collaboration can bring, it will also be promoted via the Calls for Proposals by encouraging international collaboration beyond EU Member States and Horizon Europe Associated Countries.

For the call 2025, low TRL research activities on (hydrogen) non-fluorinated components for fuel cells and electrolysers and the flagship topics on Hydrogen Valleys, are encouraged to include legal entities established in the countries members/participant[307] in the Clean Hydrogen Mission under MI2.0 under the following topics, without prejudice to the countries eligible for funding or applicable participation restrictions set out in HE Main Work Programme 2023-2025 General Annexes:

Explicit encouragement for International Collaboration
HORIZON-JU-CLEANH2-2025-05-02
HORIZON-JU-CLEANH2-2025-06-01
HORIZON-JTI-CLEANH2-2025-06-02

2.2.3.3. List of countries entrusting the JU with national funds for the call 2025

Not applicable

2.2.3.4. Country specific eligibility rules

The conditions described in part B of the General Annexes to the Horizon Europe Work Programme 2023-2025[308] will be applied by the Clean Hydrogen Joint Undertaking without derogation.

[307] For the list of countries which are members/participant to Clean Hydrogen Mission, please see: http://mission-innovation.net/missions/hydrogen/

[308] https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/wp-call/2023-2024/wp-13-general-annexes_horizon-2023-2024_en.pdf

2.2.4. Calls for tenders and other actions

2.2.4.1. Calls For Tenders

In 2025, the Clean Hydrogen Joint Undertaking will carry out a number of operational activities via calls for tenders (i.e. public procurement) for an indicative amount of **EUR 1.5 million.** These activities will be financed with Horizon Europe funds.

The procurement activities are covering subjects of a strategic nature for the Clean Hydrogen JU, providing input to R&I priority setting and supporting further financing, deployment and commercialisation of renewable hydrogen and fuel cells projects.

The following indicative list of procurements is currently foreseen:

Subject (Indicative title)	Indicative budget (EUR)	Expected type of procedure	Indicative Schedule
Legal and administrative processes relevant to fuel cell and hydrogen technologies The Clean Hydrogen JU is planning to launch a call for tenders to assess the legal and administrative processes relevant to fuel cell and hydrogen technologies across the EU (and some associated countries). The exact scope of the call will be further elaborated while preparing the tender specifications to avoid duplication with planned activities in this area.	1.000.000 EUR	Open procedure	Q1-Q2
H2 in Port Environments The Clean Hydrogen JU is planning to launch a call for tenders to support European ports to deepen the analysis and develop plans on the opportunities to use hydrogen and derivatives, to facilitate the link with renewable producers and with other local industries, with the shipping and heavy-duty transport operators, and to partner with other ports internationally.	400.000 EUR	Open Procedure	Q2-Q3
e-HRS Availability Study The Clean Hydrogen JU is planning to launch a call for tenders to support the implementation of the requirements included in the Alternative Fuels Infrastructure Regulation including the obligation of operators of having publicly accessible (hydrogen) refuelling stations to ensure the availability of certain static and dynamic data for their stations.	100.000 EUR	Open Procedure	Q2-Q3

The exact budget to be allocated to the calls for tenders will be decided before preparing the tender specifications and will be supported by market research. This will allow to align the final scope of each procurement procedure with a particular budget. In addition, according to the results of the market research, the relevance and need for each of the studies will be revisited (in view of current ongoing and planned studies on some of the areas addressed by the planned procurements above).

The final budgets awarded to actions implemented through procurement procedures may vary by up to 20% of the total value of the indicative budget. Changes within these limits will not be considered substantial within the meaning of Article 110(5) of Regulation (EU, Euratom) No 2018/1046.

2.2.4.2. Support to EU policies

Support to Climate and Energy Policies

In 2025, the Clean Hydrogen JU will continue supporting climate related policies, similar to 2024. For instance, the Clean Hydrogen JU will continue to support DG CLIMA on a number of initiatives aiming at bringing the JU family of projects closer to the Innovation Fund programme. In 2024, the Clean Hydrogen JU provided input following ad-hoc requests by DG CLIMA and DG ENER. The JU remains available to get involved in such ad-hoc requests and to bridge the gap between the JU projects (especially on Hydrogen Valleys) and funding opportunities under these initiatives.

In addition, the planned procurement on ‘Sustainable paths for the use and management of water in the hydrogen value chain’ will analyse the impact of green hydrogen production in Europe and Neighbouring Countries on water basins. The study should prove relevant to contribute to the European Commission planned initiative on water resilience.

Support to Industrial Policy

The Clean Hydrogen JU remains ready to continue supporting DG GROW and cooperate with the European Clean Hydrogen Alliance (ECH2A)[309] activities, to ensure synergies as foreseen in Art. 78 (2) of the SBA. The aim is to have a more integrated approach linking research partnerships with the industrial strategy, bringing closer together the hydrogen research and industry communities, as well as sharing more widely the results of research. In line with this, the Clean Hydrogen JU intends to continue taking part in the Steering Committee of the ECH2A. In addition, as requested, the Clean Hydrogen JU is ready to present winning and demonstration ready technologies for further deployment to the Round Tables under the European Clean Hydrogen Alliance. It may also share and discus the state of play of research and development with members of the European Clean Hydrogen Alliance.

In 2025, the Clean Hydrogen JU, building on the cooperation that started in 2023, will continue collaborating and supporting DG GROW to reach the ambitions of the EU Net-Zero Industry Act [310] on the area of hydrogen in general and concerning skills in particular.

In addition, the outcomes of the JU study concluded in 2024 and shared with DG GROW on sustainable supply chain and industrialisation of hydrogen technologies is expected to be of relevance to policy makers at DG GROW and Clean Hydrogen Alliance; for instance for monitoring the progress on the competitiveness of clean energy technologies. This study analysed the current and future strengths and weaknesses of the European renewable hydrogen supply chain related to 14 different hydrogen technologies across the value chain and provided recommendations to enable Europe to keep its leadership in the hydrogen

[309] https://ec.europa.eu/growth/industry/policy/european-clean-hydrogen-alliance_en
[310] https://single-market-economy.ec.europa.eu/publications/net-zero-industry-act_en

economy and to support long-term economic growth through a sustainable and reliable hydrogen supply chain.

Support to transport policies

On the maritime sector the collaboration with European Commission services and Zero Emission Waterborne Transport (ZEWT) on fostering the development of alternative powertrains and supply of zero emissions fuels will continue. This consists of steady exchanges on projects, topics of call for proposals and strategic research and innovation agenda updates. So that the work of the two entities addresses the decarbonisation of the maritime in a concerted and synergetic manner. In May 2024, a workshop entitled "hydrogen as Maritime Fuel: Defining New Guidelines for a Sustainable Future" at CEN/CENELEC aimed at supporting market operators from both standardization and policy perspectives, fostering alignment between companies and policymakers regarding barriers and challenges to be overcome. A subsequent CEN workshop in July "Pre-normative plan for H2 applications to passenger ships - Guidelines for H2 passenger ships from the early stage of design" started the development of a CEN Workshop Agreement which provides a set of design and installation recommendations for the arrangement and installation of propulsion systems, using hydrogen as fuel, on passenger ships.

Strategic Energy Technology (SET) Plan

The Clean Hydrogen JU will continue following and contributing as necessary to the SET-Plan[311] activities, in particular to the Implementation Working Group (IWG) on "Renewable Fuels and Bioenergy" where the Clean Hydrogen JU is participating in the Core Group and the recently established IWG on "Green Hydrogen". The IWG on green hydrogen set up in 2023 aims at implementing part of the Strategic Research and Innovation Agenda (SRIA) of the European Research Area (ERA) pilot on green hydrogen and coordinating the work on hydrogen previously split between different IWGs of the SET Plan. This European Research Agenda (ERA) Pilot on green hydrogen SRIA addresses specifically the need to ensure mutual coordination on an ongoing basis among national and regional hydrogen R&I programmes.

2.2.4.3. Collaboration with JRC – Rolling Plan 2025

The Commission's Joint Research Centre (JRC) undertakes high quality research in the field of fuel cells and hydrogen that is of considerable relevance to the implementation of the Clean Hydrogen JU activities. During the Horizon 2020 period, a Framework Contract between the FCH 2 JU and JRC was approved by the Governing Board on 23/12/2015 and signed by both parties on 18/02/2016. Under Horizon Europe, a new Framework Agreement between Clean Hydrogen JU and JRC was signed in the spirit and as continuation of the previous Framework Contract on 29/11/2022.

The scope of the Framework Agreement covers the activities that JRC provides to the Clean Hydrogen JU, against payment from the Clean Hydrogen JU operational budget. In line with the JRC mission, these support activities will primarily support the formulation and implementation of the Clean Hydrogen JU strategy and activities in the areas of standardisation, technology monitoring and assessment and sustainability. In addition, Clean Hydrogen JU may call upon JRC to perform specific actions for individual projects, by which the JRC provides added value to programme objectives.

The JRC support activities to the Clean Hydrogen JU programme covered by the Framework Agreement are discussed and agreed on an annual basis between the JRC and the Programme Office of the Clean Hydrogen JU, with involvement of representatives of Hydrogen

[311] https://energy.ec.europa.eu/topics/research-and-technology/strategic-energy-technology-plan_en

Europe and Hydrogen Europe Research. This annual Rolling Plan is then presented at the Governing Board of the Clean Hydrogen JU, as well as its outcomes. For the year 2025, a maximum budget of EUR 969.000 from the Clean Hydrogen JU operational budget is foreseen.

The annual Rolling Plan 2025 describes the annual activities and their related deliverables provided by JRC to Clean Hydrogen JU (Article 2 in the Framework Agreement) against payment. Modifications of the annual Rolling Plan are possible at every moment, upon request of all parties involved, and agreed according to the same procedure. These modifications must however remain below the maximum budget agreed beforehand.

A Support to RCS Strategy Task Force

In general, RCS activities at Clean Hydrogen JU consist of identifying and prioritising RCS needs of strategic importance for the EU including the Pre-Normative Research (PNR) activities required to support the RCS priorities identified. Specific to PNR activities, it is critical to ensure that their results are developed for and used for RCS development. The Clean Hydrogen JU contributes to supporting the implementation of hydrogen-specific regulatory and enabling frameworks by a strategic and coordinated approach to RCS issues within the Programme, which is mostly implemented through PNR activities.

Under Horizon Europe, the approach to RCS strategy has been revised, and a RCS SC Task Force has been set up to better coordinate these activities. JRC contributes to the high-level activities of this body, participating to the activities of the RCS SC Task Force, jointly with all stakeholders. The RCS SC Task Force meets regularly; hence the proposed deliverables may be modified according to the priorities set by the RCS SC Task Force.

A.1 Support to the RCS SC Task force by contributing to its activities.

A.2 Report on the international progress in RCS by international bodies (e.g. UN-ECE, ISO/TC 197, IEC/TC105, IMO, IPHE) (December 2025).

B European harmonisation of testing protocols and procedures

The Clean Hydrogen JU supports working groups led by JRC, aiming at a European harmonisation of the existing testing protocols and procedures for fuel cells and electrolysers. The harmonised testing facilitates the assessment of technology progress: they offer a tool to measure in a coherent and consistent way the performance of hydrogen systems and to compare project results without compromising on IPR issues.

While the use of these tests is voluntary, there is increasing evidence that research and industry stakeholders frequently utilise them. In 2025 and the following years, efforts will be made to experimentally validate and improve the published testing protocols for water electrolysis at the JRC site, also involving testing facilities from volunteering partners of the dedicated working group of experts. The JRC will conduct a multi-year testing process, starting with a JRC 30 kW electrolyser stack in 2025. Afterwards, in the subsequent year, the stack will be distributed to additional partners for further examination.

In addition, the results of the dedicated survey conducted in 2024 will be discussed with the working group to plan eventual follow-up work.

JRC will also continue participation in the activities of International Standardization Organization (ISO)/Technical Committee (TC) 197 Hydrogen technologies, IEC/TC 9 Electrical equipment and systems for railways and International Electronic Commission (IEC)/TC 105 Fuel cell technologies dedicated to hydrogen energy systems including fuel cells and electrolyser/reversible fuel cells testing standardisation. This work, performed by means of JRC own resources, allows to disseminate in a global context the achievements of European tests harmonisation efforts and to support European interests. Moreover, JRC follows similar ongoing efforts in the US and elsewhere and searches for possible normative collaboration.

Possible input to further activities regarding electrolyser performance and safety may be proposed and discussed during the Clean Hydrogen JU-NEDO workshop. Depending on the workshop outcome, agreed additional activities can be supported given available resources.

Finally, JRC will continue providing technical support and assistance to individual users on request with regards to the ZERO∇CELL, a single cell test hardware developed by JRC in 2017-2018. The design documentation is available on-line and assistance is granted if requested. The assistance will include advice and technical help during manufacturing phase as well as performing verification testing of the produced hardware when requested by users.

B.1 Report on experimental validation of EU harmonised test methods, testing procedure and protocols for electrolyser (December 2025).

C Contribution to programme monitoring and assessment

Programme Monitoring and Technology benchmarking. The JRC will continue supporting the Clean Hydrogen JU on its task under Article 74 of the SBA to "assess and monitor technological progress and technological, economic and societal barriers to market entry, including in emerging hydrogen markets".

The Clean Hydrogen JU is requested to monitor a number of KPIs as described in Section 7 of its SRIA. These indicators concern the Horizon Europe KPIs, the Partnership KPIs, the Clean Hydrogen JU KPIs and its technology KPIs. The JRC may support – as required – in collaboration with the Clean Hydrogen JU in setting up the methodology for defining and monitoring of these KPIs.

The Clean Hydrogen JU has awarded a tender at the end of 2023 with the objective to develop a unique digital platform that will encompass and enrich information and data of the available tools/platforms of the JU. The Hub is expected to provide the necessary tools and capabilities to better collect and manage the knowledge concerning JU activities and funded projects, as well as to facilitate the access to non-confidential information to its members and the wider public. The JRC will support the contractors for the Knowledge Hub on work regarding TRUST data, with a focus on methodology and use of the Knowledge Hub in the future for the APTAR and historical analyses.

In 2023 JRC has delivered a keyword structure, based on the SRIA, for the purpose of mapping projects and call topics, enabling a gap analysis. A corresponding tool is presently being developed by the JU. JRC will continue developing this keyword structure with the aim to be able to classify all projects on hydrogen technologies, with the aim to integrate this work into the knowledge hub.

The JRC will continue performing historical analyses on the performance of selected Clean Hydrogen JU projects against the overall Programme Targets, using, wherever possible, quantitative values and Key Performance Indicators (KPI) for assessment. The purpose of this exercise is to see how the programme has enhanced the state of the art for selected technologies and to identify potential gaps for their future development. This work will be continued in 2025 with an update of the historical analysis of stationary fuel cells. In general, this type of analysis will be increasingly included as part of the Annual Programme Technical Assessment. Stationary fuel cells have been supported by the Clean Hydrogen JU and its predecessors and the technology has seen much improvement over the years. In spite of these advances, there is still a lack of commercialisation of these products. The report will cover these aspects and also provide an overview of the international landscape for stationary fuel cells.

The JRC will also provide support to the JU in monitoring the progress of the study on management of water.

C.1 Update of 2018 historical analysis report on project portfolio of Clean Hydrogen JU on stationary fuel cells. Deliverables will be datasets, graphs and a presentation summarising the findings (July 2025). In addition a report will be written, providing an overview of the achievements and barriers encountered for this technology (December 2025).

C.2 Update of the keyword structure and support to its implementation into a tool for the JU, together with the JUs IT experts/knowledge hub (December 2025).

C.3 Report on methodology of TRUST data treatment (December 2025).

C.4 Summary of support provided to Knowledge Hub and the study on water management (December 2025).

Support to Programme Monitoring and Assessment by means of JRC's TIM analytics.

Unit JRC.T.5 will continue to adapt the Clean Hydrogen instance of Tools for Innovation Monitoring (TIM) Analytics to the JU. The mapping of technology fields (e.g.: alkaline electrolysers/FC, H2 production methods, polymer electrolyte membrane FC/electrolysers and solid oxide FC/electrolysers, transport applications, hydrogen safety) will be annually broadened. To ensure the precision of the findings, TIM provides regular data cleaning.

In particular, JRC expects to provide the following services:

- Carry out the maintenance, operation, and extension of the FCH (Fuel Cells and Hydrogen) Technology Innovation Monitoring System for the Clean Hydrogen JU. This includes ensuring that the system is up-to-date, fully functional, and extended to cover any new requirements or technological developments in the field of Clean Hydrogen.
- Maintain and enhance the public clean hydrogen dashboards, involving the Clean Hydrogen JU in the review, approval, and testing process.
- Facilitate direct access to the TIM platform for Clean Hydrogen JU staff as internal users, which includes utilizing Scopus data for scientific literature keyword searches.
- Deliver consistent content and analysis tailored to the specific requirements of the Clean Hydrogen JU.

In addition JRC.C.5 will also perform the following tasks:

- Name harmonization of beneficiary organizations at the level of a) the parent group and b) the single entities identified by Participant Identification Code (PIC) IDs.
- Consolidation of metrics at the level of the parent company, including subsidiary organizations that are not picked up by the name harmonization algorithm. This task will rely on information obtained via the Orbis DB.
- Continuation of data enhancement including information on company size (SME/non-SME) and Strategic Research and Innovation Agenda (SRIA) research areas.
- Support to and coordination with the contractors of the Clean Hydrogen Knowledge Hub for data and indicators integration between TIM and the Knowledge Hub platform.

C.6 Maintenance, operation and extension of FCH Technology Innovation Monitoring System for the Clean Hydrogen JU (January to December 2025), including performance of all related supporting tasks and services (as above).

Annual Technical Programme Assessment. As in previous years, JRC will perform a full programme review cycle for the year 2024, in the form of an internal report.

C.7 Draft report delivered for commenting to JU. If required, including an update of methodology for the Programme Assessment considering the lessons learnt from the previous Programme Review (1st draft May 2025, 2nd draft July 2025).

C.8 Final report containing confidential information, delivered before the EU research days 2025 (November 2025).

C.9 Final version without confidential information for distribution to JU members (December 2025)

D Contribution to assessment of sustainability of hydrogen and fuel cells

According to the Clean Hydrogen JU SRIA, sustainability is one of the three focus areas of the Horizontal Activity 1: Cross-cutting Issues. To improve sustainability and circularity, the JU key focus areas for development and support are: i) complete and integrated life cycle thinking tools; ii) enhanced recovery and substitution of PGMs/CRMs including per- and polyfluoroalkyl substances (PFAS); iii) development of recycling integrated processes; and iv) development of eco-design guidelines and eco-efficient processes.

In 2024, the Clean Hydrogen JU launched the European Hydrogen Sustainability and Circularity Panel (EHS&CP) to address the sustainability and circularity at both the programme and project levels, encompassing environmental, social and economic aspects. The JRC collaborates with the EHS&CP to provide additional support to the Clean Hydrogen JU to assessing the sustainability of hydrogen technologies.

In 2025, JRC will continue assessing the life cycle-based deliverables of all ongoing projects and will work with the EHS&CP to develop a methodology to rate the quality of LCA deliverables produced by JU projects. The methodology will build on the LCA checklist delivered by JRC in 2024, serving as a key framework for programme evaluation by offering an objective framework to track enhancements in the quality of LCA deliverables.

JRC will keep advising JU-funded projects focused on key aspects for improving the sustainability of hydrogen technologies. JRC will be in the advisory board of the HyPEF project, aimed at drafting the first Product Environmental Footprint Category Rules for hydrogen technologies, and of NHyRA[312], aimed at improving our understanding of the environmental impact of hydrogen losses from the hydrogen value chain.

JRC will also provide support in evaluating the sustainability of the Hydrogen Valley projects in collaboration with the EHS&CP. The Clean Hydrogen JU is currently funding 15 Hydrogen Valley projects initiated through the 2022 and 2023 Calls. As part of their development, these projects are expected to consider environmental impacts, with many planning to conduct life cycle assessments (LCAs). To support this effort, JRC will give a presentation during the Hydrogen Valley days 2025 and organise a dedicated discussion on best practices on conducting life cycle sustainability assessments. The aim is to work out guidelines that enhance the comparability and reliability of results, and to improve communication with stakeholders and the public regarding the sustainability benefits of Hydrogen Valleys.

[312] https://cordis.europa.eu/project/id/101137770

JRC will also further develop the social impact assessment methodologies for hydrogen technologies. In 2024 JRC provided a framework for assessing the social risk and impacts related to hydrogen technologies and their value chains. Based on the outcome of a feasibility study, JRC will apply in 2025 the social framework to assess the risks and impacts of importing hydrogen to a selected European port.

JRC will continue supporting the Clean Hydrogen JU by collaborating with projects to collect life cycle inventory data, and for using the Life Cycle Data Network infrastructure to host the developed datasets. This collaboration will rely on the two JRC reports "LCA Checklist: a tool to improve the communication of the environmental sustainability of the Clean Hydrogen Joint Undertaking projects" and "Developing life cycle inventory datasets for the hydrogen value chain" published in 2024 and focus on refining the development of datasets to ensure alignment with data quality requirements (e.g., International Reference Life Cycle Data System (ILCD) compliance/EF compliance). JRC will support selected projects, identified with the Clean Hydrogen JU, to improve the quality of life cycle inventory data and modelling aspects, and also to provide support during the review process. These efforts will contribute to strengthening the methodological framework and data quality, with a focus on EF compliance, as well as incorporating considerations for End of Life modelling and the Circular Footprint Formula.

Additionally, JRC is also available to collaborate with the EHS&C panel for the full deployment of life cycle thinking, including with robust and adapted methodologies and quality-assured datasets in the hydrogen value chain.

Detailed tasks for 2025 include:

D.1 Development of a methodology to quantitatively evaluate the quality of LCA deliverables produced by JU projects in collaboration with the EHS&CP (December 2025).

D.2 Reporting the outcomes of the regular review and assessment of the life cycle-based deliverables of all ongoing JU projects (i.e., spreadsheet with the review of each deliverable, and a summary of the main outcomes of the review) (December 2025)

D.3 Reporting the outcomes of the application of the framework for assessing the social risk and impacts, including safety aspects, related to hydrogen technologies and their value chains to a case study (i.e., import of hydrogen to a European port) (December 2025)

D.4 Reporting on the support JRC will provide to the activities of the EHS&CP (December 2025).

D.5 Summary of support provided by JRC to the JU-funded projects HyPEF and NHyRA (December 2025).

D.6 With the support of the EHS&CP, organising a session during the Hydrogen Valley days on best practices for conducting life cycle sustainability assessments. A summary of the outcomes of the session will be provided (June 2025).

D.7 Reporting on the activities performed with regards to the life cycle inventory (LCI) data collection process and on the development of datasets to be integrated into the Life Cycle Data Network infrastructure. Deliverables will be IT development and a summary of the activities (December 2025).

E Contribution to safety, and safety awareness

Since the launching the European Hydrogen Safety Panel (EHSP) (see the dedicated section in the MAWP), JRC activities related to hydrogen safety have been integrated in those of ESHP. These activities consisted of, in the first instance, the maintenance and continuous population of the hydrogen accidents database HIAD 2.0, which was the focus of Task 3 of the EHSP.

Since 2020, JRC had to reduce its safety-related activities in the field of hydrogen technologies. However, the termination of the EHSP has left JRC alone with the duty to guarantee availability of the database, its updates and upgrades. In the 2022-24 period, JRC has maintained the relationship with the customers, input approximately 100 new events and issued a new database version Hydrogen Incident and Accident Database (HIAD) 2.1, now available at https://minerva.jrc.ec.europa.eu/en/shorturl/capri/hiadpt.

The activities 2025 will depend on whether the EHSP will be relaunched.

Case I = the EHSP will be re-formed early in 2025. JRC will present the development work done in the last 3 years to the EHSP, reforming the group of experts who worked in the year 2019-21 to assess the events according to the already methodology adopted. At the same time, it will contact the Knowledge Management Hub for the creation of a new database structure.

Case II = the EHSP does not form. JRC will then proceed to select the best options for the upgrade to HIAD 3.0, execute the changes on the EXCEL file and continue with the already existing internal collaboration with the JRC Major Accidents Hazard Bureau, which enable the publication and sharing of HIAD on the platform Minerva.

In both cases, JRC will carry out the following tasks:

- To keep updating the database with new events: those occurring now, and those that occurred in the past, but not yet in HIAD because of previous lack of access to the information (it includes country specific databases, and new collections of incidents).
- To perform a continuous action of improvement of the descriptors, possibly also improving/completing the descriptions of incidents already in HIAD with additional information.
- To collaborate with the JRC MAHB to make HIAD more visible and easily accessible and to improve the existing dashboard which provided quick statistical results.
- To propose options for an upgrade to HIAD 3.0. Several descriptors needs to be better encoded, some others could profit from a splitting, and especially the set causes requires a theoretical reflection.

In addition, JRC will:

- Perform dissemination actions (LinkedIn, conferences, publications), by interacting with other experts and selecting cases to analyse in depth.
- Support the next edition International Conference on Hydrogen Safety[313] as members of the Scientific and Organisation Committees, and whenever possible with scientific contributions.
- Put in action the JRC – KHK[314] Memorandum of Collaboration on hydrogen safety. This will consist in sharing information on and the joint analysis of hydrogen related

[313] September 23-25, 2025 – Seoul – Republic of Korea, https://hysafe.info/ichs2025/
[314] The High Pressure Gas Institute of Japan, https://www.khk.or.jp/english/

incidents. It implies as well the development of an interface with the CHJU – NEDO collaboration, which has a broader scope but also cover safety topics.

E.1 Report on the JRC input to enable and develop HIAD as a public database (December 2025). It will contain the summary of the work done in maintaining, updating and valorising the database.

E.2 **All cases – HIAD** Guidelines to be used for the re-building the structure of the database by the KM Hub (March 2025).

E.3 **All cases** – Report identifying the needs to improve the database descriptors and structure and its contents, to enable the structural upgrade to HIAD 3.0 (March 2025).

E.3 **Case I (i.e. EHSP ready to work at the start of 2025)** – A structural upgrade the database to version HIAD 3.0, based on a consented decision by EHSP mid 2025 (End 2025).

E.3 **Case II (i.e. no EHSP formed at the start of 2025)** – JRC-based improvement of the database descriptors, structure and contents, resulting in an upgrade of the database (end 2025).

Enclosure I – RESOURCES REQUIRED FOR THE SUPPORT AT PROGRAMME LEVEL

(these are values reflecting approximately the true figures from the Cost Evaluation Form of the Framework Contract)

	Deliverable title	**Effort [PM]**
A	Support to formulation and implementation of RCS strategy (RCS SC group)	0.5
B	Direct contribution to implementing RCS strategy (Harmonisation)	5
C	Contribution to programme monitoring and assessment	19.5
D	Assessment of sustainability	13
E	Hydrogen Safety	3
	Manpower Totals [PM]	**41**
		Overview indicative costs (with overhead) [k€]
Personnel costs		*590*
Missions		*12*
Consumables (for Deliverables B)		*10*
Software licence (SIMAPRO, Deliverables D)		*22*
Subcontract[315] (for Scientific & Technical services, Deliverables D, sLCA)		*15*
Subcontract[316] (for Scientific & Technical services, Deliverables D, data network)		*60*
Hardware (TIM Deliverables C.3[317])		*10*
Service providers[318] (for TIM Deliverable C.3)		*240*
Scopus license (for TIM Deliverables C.3)		*10*
Total indicative cost for 2025		**969**

[315] Expert contracts as a follow-up of social LCA analysis
[316] Expert contract for data network
[317] Purchase of hardware whose capacity will be used to support TIM activity
[318] These costs include the work of IT consultants, as well as queries design, visualisations customization, cleaning of results and other activities identified in the rolling plan. Costs also cover hosting Clean Hydrogen systems, software upgrades, security fixes and maintenance.

Costs includes support to EU Habillage.

JRC will report on a regular basis (every month) on deliverables progress.

2.2.5. Follow-up activities linked to past calls: monitoring, evaluation and impact assessment

2.2.5.1. Knowledge management.

Knowledge management refers to a range of practices and techniques used by organisations to create, share and exploit knowledge to achieve organisational goals. The primary focus of these activities in the Clean Hydrogen JU is:

a. Monitor progress towards the achievement of the objectives of the Clean Hydrogen JU objectives and its technology KPIs;

b. Strengthen the knowledge capacity of hydrogen value chain actors through data collection and knowledge collection;

c. Support evidence-based implementation of Union policies.

The ultimate goal of this approach is to gradually turn the Clean Hydrogen Joint Undertaking into the knowledge hub for hydrogen in Europe, and the Programme Office into a knowledge intensive organisation.

For the coming year, the Knowledge Management Team is planning to work towards these goals through the actions below. JRC will continue being an important partner to the Clean Hydrogen JU, supporting all knowledge activities, as described in Section 2.2.4.3.

A. Programme Review 2025

Technology and programme monitoring will continue through the annual Programme Review performed by the JU, which can be separated into four main activities: (a) The annual data collection exercise, (b) the JRC Annual Programme Technical Assessment Report, (c) the Programme Review Report and (d) the portfolio and projects presentations as part of the European Hydrogen Week.

The annual data collection exercise from projects was mainly performed until 2024 via the internally developed data collection platform TRUST (Technology Reporting Using Structured Templates)[319] and complemented via a questionnaire to collect additional qualitative information, initially through EU Survey, and from 2023 via the Project Fiche form. For 2025, the aim is to perform the data collection via the Clean Hydrogen Knowledge Hub (see below), consolidating the different data collection processes and minimising the input effort from the side of the projects. Projects will be invited to provide their data in the month of February 2025 concerning results generated in 2024.

Similar to the previous years, a workshop with the data providers will be organised in the second half of January, to introduce the new platform and provide clarifications on the process and the templates that the projects need to fill in.

Following the successful participation of the first non-Clean Hydrogen JU project in the data collection exercise of 2024, the GH2 project of EIC, an invitation will again be sent to other EU funding programmes supporting hydrogen projects in the beginning of the year, aiming for the participation of more projects. The reason for this initiative lies on the increasing trend of supporting hydrogen relevant topics in various EU programmes and partnerships under

[319] https://www.fch.europa.eu/sites/default/files/documents/TRUST_ExplanationFile_Draft_2019%20%28ID%2057 09356%29%20%28ID%205833842%29.pdf

Horizon Europe[320]. With this approach, the Clean Hydrogen JU will be able to monitor technology progress and deployment also for these projects, integrating this information in a single EU hydrogen database. The ultimate goal would be that all projects relevant to hydrogen participate in the Clean Hydrogen JU's annual data collection exercise, thus providing an up to date and complete database of the output from all EU funded projects.

Data collected will allow the benchmarking of the technology progress reported by the projects against the SoA and the Clean Hydrogen JU targets, as defined in the SRIA. Moreover, the annual iterations of the data collection exercise provide the necessary input for the development of a database of project results over time. The Clean Hydrogen JU is committed to respect data confidentiality (according to the conditions setup by the Grant Agreement) and will only use them in the respect of this attribute: confidential data will not be disclosed as such, but only in aggregated form and in a manner that ensures anonymity of their origin.

Following the conclusion of the annual data collection exercise, JRC will perform its detailed technical assessment of the Programme and will produce a report, the Annual Programme Technical Assessment, with observations on the major accomplishments of the projects, difficulties encountered and evaluating the performance of the Programme against the KPIs.

Progress and findings of the Programme Review will be presented in the annual Programme Review Report, planned to be published end of 2025.

Continuing the good experience and practice, the Clean Hydrogen JU will present its project portfolio and their achievements, accompanied by individual projects presentations, as part of the European Hydrogen Week (see also section 2.3.1). Initiated in 2011 (as an answer to the JU mid-term evaluation recommendations), this annual event presents the progress of the portfolio of hydrogen relevant projects funded by the EU research programmes, identifying key achievements but also potential areas to be addressed or reinforced in subsequent years. The exercise also provides an excellent visibility platform for projects and technological developments achieved in the sector. Furthermore, the Best Success Stories and the Best Innovation Awards have been lately introduced to highlight and celebrate annually the results of collaboration between research, industry and policy makers, and projects achievements.

B. European Hydrogen Observatory (EHO)

The Clean Hydrogen JU contributes towards the monitoring of the deployment of hydrogen technologies, the adoption of related policies and academic activities and research results through the European Hydrogen Observatory[321] (EHO). EHO is an open platform providing data and up to date information about the entire hydrogen sector, aiming to address the lack of data publicly available at EU and national level concerning the uptake of hydrogen technologies on the EU market and the absence of a coordinated methodology on how to monitor their market evolution.

In September 2023 the EHO was successfully relaunched. A number of new data sets and functionalities have already added compared to its predecessor, the Fuel Cell and Hydrogen Observatory. In 2025 the data sets, reports and tools offered by EHO will be further expanded, aiming to have by end of 2025 the complete set of functionalities and resources envisaged in the related contract. Moreover, the newly implemented restricted portal of EHO (end of 2024) will be used as a means to facilitate the collaboration of EHO with third parties and data

[320] Initial contacts have taken place with most relevant partnerships and EU Programmes. Nevertheless, expanding the scope of the technology monitoring is dependent on how the other partnerships and EU Programmes will assure that their projects contribute as requested to the annual data collection exercise of the JU.

[321] https://observatory.clean-hydrogen.europa.eu/

providers.

Considering the importance of acquiring high quality validated data for EHO, while recognising the key position of private members Hydrogen Europe and Hydrogen Europe Research in the collection of such data for their own uses, a separate contract signed with these two parties supports EHO by ensuring the periodic delivery of predefined, up-to-date and validated datasets to the JU, to support (and complement) the regular update of EHO.

C. Collaboration in terms of knowledge management with Member States and Hydrogen Valleys

Collaboration with Member States and Hydrogen Valleys will be vital in ensuring the knowledge management goals of the Clean Hydrogen JU. There are significant mutual benefits by exchanging information on hydrogen activities and technology developments. The Clean Hydrogen JU provides the opportunity to the Member States and Hydrogen Valleys to present more widely their activities, mainly through the State Representative Group (SRG), and the IWG on Green Hydrogen of the SET-Plan and the Hydrogen valleys - Smart Specialisation Platform[322].

Moreover, the Hydrogen Valley platform (H2V)[323], funded by the JU in support to the European Union in its co-lead role under the Mission Innovation, will continue to be updated to foster exchange of know-how and best practices at the EU and international level. Within its 'toolbox' section, the Platform will enhance its role in providing useful information about other hydrogen websites and platforms, features the most recent and important studies from key players and organizations in the hydrogen world, and presents insights about the Hydrogen Valley platform stakeholders. The previous contract of Hydrogen Valley platform ended in May 2024, with the contractor of the Clean Hydrogen Knowledge Hub performing the IT support until the selection of the contractor for the Hydrogen Valley Facility, who will take over the maintenance of H2V. In 2025, the maintenance and update of the Hydrogen Valley platform will be done as part of the activities of the Hydrogen Valleys Facility (contract awarded under a public procedure). It is expected that the Hydrogen Valleys Platform and the Knowledge Hub to be compatible with each other from an IT point of view.

D. Clean Hydrogen Knowledge Hub

The Knowledge Hub is going to be a unique digital platform that is expected to provide the necessary tools and capabilities to better collect and manage the knowledge concerning its activities and funded projects, as well as to facilitate the access to non-confidential information to its members and the wider public. It is the main instruments that will help it gradually turn the JU into the central knowledge repository and access point for hydrogen in Europe.

The Knowledge Hub will be a single platform that will not only address many of the aspects regarding access and handling of the data, but also encompass information and data from the available tools/platforms into an integrated new system. Clean Hydrogen JU aspires that this platform will have access and be linked to the different data sources, and will be able to manipulate, analyse and visualise the information and data in order to allow Hub users to navigate through them based on their access rights. Apart from the JU staff, additional Hub users are expected to be policy makers (including the EC, national and regional authorities), decision makers, international organisations, academics, the industry and the general public, all with different roles and access levels.

[322] https://s3platform.jrc.ec.europa.eu/hydrogen-valleys
[323] https://www.h2v.eu/hydrogen-valleys

Work on the Clean Hydrogen Knowledge Hub began in the beginning of 2024, following the publication of a Call for Tenders in 2023[324]. The first deliverables of the project, i.e. the Project Repository and the internal Knowledge Hub analytical tool/platform are expected early 2025. After their completion, the Knowledge Hub will be expanded with additional tools and functions, link with other platforms supported by the JU to allow the exchange of data, while also launching a public portal towards the summer of 2025. It is expected that the Knowledge Hub will absorb or replicate the functionalities of all individual knowledge management tools that have been developed internally over the years, while also provide information to the JU website concerning the implementation of the Programme, in the form of dashboards and project factsheets. Combined with EHO, the two platforms shall become the central source of information related to clean hydrogen in Europe.

2.2.5.2. Feedback to policy

The climate and energy policy framework at EU level is constantly expanding. In the last few years it has been further reinforced by the Fit-for-55 gradual delivered acts, combined with the Gas and Hydrogen Market packages adopted in 2021, the REPowerEU Plan and recently with more initiatives like the Hydrogen Bank. Hydrogen has a prominent position in many of these acts and so the Clean Hydrogen JU is frequently asked to contribute to the activities of several services in the European Commission (EC). Contributions vary in content and format, but the common goal is to provide fact-based information on the state-of-the-art of fuel cells and hydrogen technologies and their contribution to the EU initiatives and policies especially in the energy, transport and industry sectors as well as to competitiveness and growth.

In practical terms, this means taking part in several technical groups organised by the EC (e.g. the Horizon Feedback to Policy Group[325]) and other bodies, participation in meetings, providing written technical input and ensuring that hydrogen and fuel cells technologies are properly represented. It also includes feedback from projects and studies to the EC in contribution to relevant energy, transport and clean air policy files.

In 2025, the Programme Office will continue to reinforce its collaboration with policy makers in the European Commission by providing input, under ad-hoc requests or in a more structured manner. The new Framework for Feedback to Policy (F2P) is expected to support evidence-informed policy design and evaluation. Prepared and piloted by the Common Implementation Centre, the new Framework is expected to support and coordinate the process within the Climate, Energy and Mobility Cluster (Cluster 5) in Pillar II of the Programme. The Joint Team in its core consists of members from RTD, DG CLIMA, DG ENER and DG MOVE[326]. The Clean Hydrogen JU will contribute ad-hoc or through sub-groups upon request by the Joint Team or based on the F2P plan of Cluster 5. The implementation of the framework will be also supported by the F2P repository, as part of the R&I knowledge base[327].

In summary, the Clean Hydrogen JU expects frequent interactions and a high level of requested contributions in this context. For more information on expected activities refer to Section 2.2.4.2.

Finally, the knowledge platforms supported by the Clean Hydrogen JU and described under Section 2.2.5.1, currently the European Hydrogen Observatory and the Hydrogen Valleys platforms and in the future – when implemented – the Clean Hydrogen Knowledge Hub, will

[324] https://etendering.ted.europa.eu/cft/cft-display.html?cftId=15172
[325] The Horizon Feedback to Policy Group will be one of the pillars of the governance structure to coordinate implementation, according to the D&E Strategy for the post-H2020 period and the Horizon Europe.
[326] https://webgate.ec.europa.eu/fpfis/wikis/pages/viewpage.action?pageId=1330839701
[327] https://webgate.ec.europa.eu/fpfis/wikis/display/RIKB

allow the capture, use and sharing of know-how, information and experience from the research and innovation funded activities, with the ultimate goal to become a sustainable tool serving research and industrial communities as well as general public. This will include lessons learnt in particular regarding innovation actions and large flagship initiatives. Alliance members will be invited to cooperate with this Knowledge Hub to help identifying hydrogen solutions at high market readiness levels, solutions mature enough for market deployment.

2.2.6. Cooperation, synergies and cross-cutting themes and activities

2.2.6.1. Synergies implemented via the Call for Proposals at programming level

Synergies with other European Partnerships and programmes at programming/planning level

The Clean Hydrogen JU will remain proactive in taking up opportunities for collaboration with other EU Programmes, European partnerships, EU agencies, initiatives and actions with the potential for synergy with its research and innovation agenda.

Regular exchanges with the relevant European partnerships is foreseen either through the Stakeholders Group, the Clean Planet Inter-Partnerships Assembly or bilaterally on an ad-hoc basis, in view of aligning priorities of JU roadmaps[328] with the different Work Programmes timeframes. The aim is to coordinate annual topics to ensure strong complementarity and synergies.

Since the early stages of preparation of the topics included in the Call for Proposals the Clean Hydrogen JU has interacted with the members of its Stakeholder Group as well as with a number of European partnerships, responsible for different parts of EU programmes. To the extent possible, the view of all stakeholders has been considered in the design of this Call for Proposals. In addition, the Clean Hydrogen JU has taken into account the support provided to hydrogen topics in the draft Horizon Europe Work Programme 2025. All this has allowed to identify synergies on an ad-hoc basis and avoid potential overlaps during the drafting process.

Synergies with the activities of members of the Stakeholder Group of the Clean Hydrogen JU have been identified as follows.

Synergies with the ZEWT partnership have been identified for topic HORIZON-JU-CLEANH2-2025-03-03 'Reliable, efficient, scalable and lower cost 1 MW-scale PEMFC system for maritime applications'. Similarly, synergies with the P4P partnership have been identified for topic HORIZON-JU-CLEANH2-2025-02-03 'Demonstration of scalable ammonia cracking technology' the use of ammonia as a Hydrogen carrier in industrial processes. In addition , synergies are also relevant with the activities of the recently established Innovative Materials for EU Partnership for topic HORIZON-JU-CLEANH2-2025-05-01 'Simultaneous ionomer and iridium recycling' and HORIZON-JU-CLEANH2-2025-05-02 'Understanding emissions of PFAS from electrolysers and/or fuel cells under product use'.

Concrete synergies and collaborations with EURAMET (and European Partnership on Metrology) projects and activities have been identified in topics 'HORIZON-JU-CLEANH2-2025-01-06: Innovative hydrogen and solid carbon production from renewable gases/biogenic waste processes', 'HORIZON-JU-CLEANH2-2025-02-01: Development of mined, lined rock cavern for gaseous hydrogen storage', 'HORIZON-JU-CLEANH2-2025-02-01: Development of mined, lined rock cavern for gaseous hydrogen storage', 'HORIZON-JU-CLEANH2-2025-02-01: Development of mined, lined rock cavern for gaseous hydrogen storage' and

[328] Annex 7 of the Clean Hydrogen JU SRIA provides more information on Common R&I Roadmap between the Clean Hydrogen JU and other partnerships

‘HORIZON-JU-CLEANH2-2025-05-02: Understanding emissions of PFAS from electrolysers and/or fuel cells under product use’. In addition, potential synergies are identified with the activities of EURAMET (and European Partnership on Metrology) for topics ‘HORIZON-JU-CLEANH2-2025-01-05: Innovative co-electrolysis systems and integration with downstream processes’, and HORIZON-JU-CLEANH2-2025-01-07: Towards exploration and evaluation of European natural hydrogen potential.

Additional synergies are encouraged in topic ‘HORIZON-JU-CLEANH2-2025-01-03: Scale-up and Optimisation of manufacturing processes for electrolyser materials, cells, or stacks’ with the clean-tech (hydrogen) manufacturing projects supported by the Innovation Fund as well as with the hydrogen related Open Innovation Test Bed supported by other parts of Horizon Europe.

Also, potential synergies have been identified with the Circular Bio-based Europe Joint Undertaking for topic HORIZON-JU-CLEANH2-2025-01-06 ‘Innovative hydrogen and solid carbon production from renewable gases/biogenic waste processes’. In addition, synergies with the Made in Europe European partnership and the Zero-Defect Manufacturing Platform are encouraged for topics HORIZON-JU-CLEANH2-2025-01-03 ‘Scale-up and Optimisation of manufacturing processes for electrolyser materials, cells, or stacks’ and HORIZON-JU-CLEANH2-2025-03-02 ‘Scalable innovative processes for the production of PEMFC MEAs’.

Synergies with programmes beyond Horizon Europe are also encouraged. For instance, for topic HORIZON-JU-CLEANH2-2025-05-03 ‘Knowledge transfer and training of civil servants, safety officials, and permitting staff to improve safety assessment and licensing procedures across Europe’ synergies with the Hy2Market project supported by the Interregional Innovation Investments instrument are encouraged. In addition, for topic HORIZON-JU-CLEANH2-2025-01-07 ‘Towards exploration and evaluation of European natural hydrogen potential,’ proposals are encouraged to involve European and national geological research institutes.

In addition, the Call 2025 of the JU is asking proposal submitted under Innovation Actions topics to provide elaborated exploitation plans including preliminary plans for scalability, commercialisation, and deployment indicating the possible funding sources to be potentially used including the Innovation Fund. (see section 2.2.3.2 for more details).

Synergies with Member States and regional programmes

Applicants in the Call 2025, may consider additional synergies with other Programmes (e.g. European Structural and Investment Funds, Recovery and Resilience Facility, Just Transition Fund, Connecting Europe Facility, Innovation Fund, Modernisation Fund, LIFE, etc.) and/or clustering with other projects within Horizon Europe or funded under other EU, national or regional programmes, or having loans through the EIB or other promotional or commercial banks; such synergies should be reflected in a financing structure and strategy describing the business model, including envisaged sources of co-funding/co-financing and in line with state-aid rules. This is expected for all flagship projects, which in the Call 2025 concerns proposals under the Hydrogen Valleys topics. To this end, the European Commission has published a guidance notice which explains the new possibilities for synergies with ERDF programmes and offers guidance on their practical implementation[329].

[329] Commission Notice Synergies between Horizon Europe and ERDF programmes 2022/C 421/03, C/2022/7307; https://eur-lex.europa.eu/legal-content/EN/TXT/?toc=OJ%3AC%3A2022%3A421%3AFULL&uri=uriserv%3AOJ.C_.2022.421.01.0007.01.ENG

In addition, for all Innovation Action topics, including Hydrogen Valleys, the STEP Seal (so called "Sovereignty Seal" under the STEP Regulation[330]) will be awarded to proposals exceeding all of the evaluation thresholds set out in this Annual Work Programme. The STEP Seal is a label, which aims to increase the visibility of quality projects available for funding and help attract alternative and cumulative funding, and simultaneously to provide a potential project pipeline for regional and national programmes[331]. The STEP Seal is focused on projects contributing to the development or manufacturing of critical technologies throughout the Union, or safeguarding and strengthening the respective value chains in clean and resource efficient technologies, including net-zero technologies.

In addition, synergies with the French Agency for Ecological Transition ADEME's Call for Proposals for "Hydrogen technological bricks and demonstrators" (closed in 2024) are identified, even if not included directly in the topic descriptions, for topics HORIZON-JU-CLEANH2-2025-01-01, HORIZON-JU-CLEANH2-2025-03-01 and HORIZON-JU-CLEANH2-2025-03-02.

2.2.6.2. Synergies with other programmes, agencies and partnerships at implementation level

The effective operational cooperation in 2022 between the Clean Hydrogen JU and the European Innovation Council and SMEs Executive Agency (EISMEA), and namely its flagship innovation programme to identify, develop and scale up deep-tech breakthrough technologies and game changing innovations - European Innovation Council (EIC) – has reached a high degree of commitment, formalised by the signature of a Letter of Intent in November 2022. Its objectives are to (1) Exchange content based information on selected and funded grants and beneficiaries (ongoing and ended grants/projects) as well as non-selected grants and applicants in the field of innovative hydrogen based technologies; (2) enabling effective sharing of information and reporting of EIC hydrogen related grants/projects in the Clean Hydrogen JU database (e.g. TRUST), and vice versa; (3) Aligning funding opportunities regarding hydrogen based technologies within the European institutions; and (4) Enabling pipeline synergies by considering successive funding opportunities for further uptake of results stemming from the EIC topics via the Clean Hydrogen JU annual calls – and vice versa.

On the aviation side, the Clean Hydrogen JU signed a Memorandum of Understanding (MoU) with Clean Aviation JU in March 2023. In 2025, Clean Aviation JU and Clean Hydrogen JU will continue the collaboration through exchange of information concerning newly signed grants in the field of hydrogen-technologies for aviation, as well as planning and alignment of the respective future Work Programmes and calls for proposals.

Cooperation with Zero Emission Waterborne Partnership (ZEWP) has also continued in 2024 and includes a regular update on relevant projects and current and future calls.

Further cooperation is also planned with Clean Energy Transition Partnership (CEPT) on hydrogen and renewable hydrogen related calls.

As in the past, exchanges of the Clean Hydrogen JU in 2025 will also extend to the Executive Agencies in charge of managing other parts of Horizon Europe (and related partnerships topics) and other Programmes in areas relevant to hydrogen technologies.

In particular, the Clean Hydrogen JU and the European Climate Infrastructure and Environment Executive Agency (CINEA) will continue to explore potential synergies and areas

[330] https://strategic-technologies.europa.eu/about_en#paragraph_207
[331] https://strategic-technologies.europa.eu/about_en#paragraph_207

of collaboration for the energy and transport sectors under both Horizon Europe and Connecting European Facility (CEF) Transport and Energy programmes. With Connection European Facility Transport (CEF-T) the Clean Hydrogen JU will continue facilitating the implementation of synergies between the ongoing JU project H2Accelerate TRUCKS[332] (Large scale deployment project to accelerate the uptake of Hydrogen Trucks in Europe) and (but not only) the CEF-T supported project Greater4H[333].

As needed, the Clean Hydrogen JU will also continue to collaborate with other European bodies and agencies (under the coordination of the policy Directorates-General in the EC) in view of improving the exchange of information and generating synergies between different initiatives, thus reducing the risk of duplication while increasing the impact within areas that are of common interest.

For instance, cooperation with the Innovation Fund is also envisaged, having in mind the quickest path towards exploitation of results and ramp-up of industrial capacity following successful higher TRL projects implemented under the Clean Hydrogen JU including but not limited to hydrogen valleys, waterborne applications and manufacturing projects. First cooperation was established in 2023 and it is likely to continue in 2025 in the form of workshops and round tables where project beneficiaries of JU projects can share their learnings and expectations, thus contributing to create a sustainable pipeline of projects to the Innovation Fund.

In 2023 the JU started to have dialogues with those in charge of the Marie Sklodowska Curie Action (MSCA) Staff Exchanges programme. This is expected to continue in 2025 in order to identify how the funding opportunities under the MSCA Staff Exchanges programme could benefit the organisations participating in the projects supported by the Clean Hydrogen JU.

At national level the Clean Hydrogen JU will continue working to identify opportunities for collaboration (co-funding[334] but also at programming level) with national programmes, mainly via the States Representative group - an advisory body to the Governing Board of the JU. Ad-hoc exchanges with responsible of national programmes (e.g. German NOW) will continue in 2025 (building on the good practices of former years).

2.2.6.3. Supporting regions and Member States through technical assistance and synergies

In view of setting up a structured cooperation mechanism between the JU and Managing Authorities of Member States and Regions, in 2023 the Clean Hydrogen JU initiated a Technical Assistance to Generate Synergies with Members States and Regions[335]. The technical assistance finished in 2024 by providing a comprehensive framework for future cooperation. 10 Managing Authorities were selected with whom the JU has identify concrete areas for collaboration and synergies[336]. The ten selected Managing Authorities include nine Members States/Regions and an Associated Country of Horizon Europe. First three bilateral cooperation agreements between the JU and Managing Authorities were signed in June 2024 and the following seven in the second half of 2024. In addition, lessons learnt have been

332 https://cordis.europa.eu/project/id/101101446
333 https://greater4h.com/
334 Co-funding by using transfer of funds will be one of the possibilities the JU will continue to investigate in cooperation with the European Commission services, with regard to its legal feasibility. In addition, the leveraging of national and regional funds will be fostered by awarding the Seal and STEP Seals to a number of the topics included in the Call 2025.
335 https://www.clean-hydrogen.europa.eu/get-involved/working-regions_en#synergies-with-members-states-and-regions
336 https://www.clean-hydrogen.europa.eu/media/news/evaluation-results-call-expression-interest-receiving-technical-assistance-generate-synergies-clean-2023-10-04_en

shared to benefit a wider range of Managing Authorities. In 2025, the JU will continue working with these Managing Authorities in the implementation of synergies in the areas of cooperation included in the MoC, mainly on knowledge exchange, building capacity and skills and on synergies between national/regional and EU funding programmes and financial support mechanisms.

In 2024 the Clean Hydrogen JU has continued providing Project Development Assistance (PDA) for Regions with a focus on Cohesion Countries, Outermost Regions and Islands. In 2024 the Clean Hydrogen JU launched a call for tenders aiming at setting-up and running of a 'Hydrogen Valley Facility' in order to accelerate the number of hydrogen valleys in Europe. This will be done through the provision of dedicated project development assistance for hydrogen valleys project promoters (public and private). The new contract will start beginning of 2025 and will run for a five years.

In addition, in collaboration with Mission Innovation 2.0, the Clean Hydrogen JU has continued with the activities of the Hydrogen Valley platform. The platform has seen new Hydrogen Valleys added allowing the most advanced Hydrogen Valleys around the globe to provide insights into their project development. The previous contract of Hydrogen Valley platform ended in May 2024. In 2025, the maintenance and update of the Hydrogen Valley platform will be done as part of the activities of the 'Hydrogen Valleys Facility'. It is expected that the Hydrogen Valleys Platform and the Knowledge Hub to be compatible with each other from an IT point of view.

2.2.6.4. Regulations, Codes and Standards Strategy Coordination (RCS SC)

The implementation of suitable and hydrogen-specific regulatory and enabling frameworks is crucial for the EU-wide deployment of hydrogen, fuel cells and hydrogen-based technologies to meet the goals set out in the EU Hydrogen Strategy.

As stated in the Clean Hydrogen JU SRIA (JU SRIA, section 4.3), the JU will contribute to supporting the implementation of hydrogen-specific regulatory and enabling frameworks by a strategic and coordinated approach to RCS issues within the Programme, which will mostly be implemented through PNR activities.

Whilst most of the PNR activities in the JU Programme will be implemented as part of the activities within Horizontal Activity 1: Cross-cutting Issues (JU SRIA, Section 3.6), a strategic and coordinated approach is needed at the Programme level.

To this end, in 2023, the Clean Hydrogen JU set up a Regulations, Codes, and Standards Strategy Coordination Task Force, composed of the JU members: the European Commission, Hydrogen Europe and Hydrogen Europe Research, and the Programme Office.

The main goal of the RCS SC Task Force is the definition, coordination and monitoring of the strategy related to RCS within the Programme with the ultimate goal of increasing the EU impact on RCS development in the EU and beyond, with the focus but not limited to Standards. In 2025, the RCS SC Task Force will continue prioritising the coordination of the following activities:

1. Follow up RCS development related to hydrogen, fuel cells and hydrogen technologies through a continuous global watch function with the focus but not limited to standards.

2. Assessment of RCS development needs of strategic importance in the EU. Building on the previous activity and in consultation with relevant stakeholders, the RCS SC Task Force will assess what RCS developments could most contribute to fostering a regulatory friction-less EU-wide hydrogen market while meeting the EU Hydrogen Strategy goals and the interests of the EU industry and research organisations.

3. Identification and prioritisation of the needs for research and innovation, and coordination actions to support the RCS development identified as strategic for EU and that standardisation and regulatory aspects are appropriately addressed in the Programme.

4. Follow up and support the research and innovation, and coordination actions undertaken in the Programme contributing to ensure to the best possible actual use of PNR results in RCS developments.

5. Dissemination of results. This could include collecting and effectively transferring PNR/ RCS-relevant results in regulatory and standardisation bodies, targeted communication actions, awareness workshops, etc.

Furthermore, the RCS SC Task Force will also support the Commission and the Member State organisations in its activities on international regulatory cooperation when required and will support the synergies related to RCS with other partnerships.

2.2.6.5. European Hydrogen Safety Panel (EHSP)

The European Hydrogen Safety Panel[337] initiative was launched in 2017 to support the development and deployment of inherently safer hydrogen systems and infrastructure, contributing to achieving the following vision: "hydrogen and fuel cell technologies shall be safely developed, safely introduced, and safely used in projects as well as in the wider society".

The mission of the EHSP in the Programme is twofold:

- To assist the Clean Hydrogen JU at both programme and project levels, in assuring that hydrogen safety is adequately addressed and managed, and
- To promote and disseminate a high-level hydrogen safety knowledge and culture within and beyond the Programme.

The EHSP is a multidisciplinary pool of experts grouped in ad-hoc working groups (task forces) according to the tasks to be performed and to their expertise. Collectively, the members of the EHSP have the necessary scientific competencies and expertise covering the technical domains needed to make science-based recommendations to the Clean Hydrogen JU.

In 2025, the EHSP will continue and concentrate the effort on several activities within each task force (TF), as detailed in the next sub-sections. Nevertheless, in view of the increased support expected from the EHSP in the Clean Hydrogen JU Programme in 2024 and onwards, the Clean Hydrogen JU launched in 2023 a call for tenders[338] for a single service framework contract for the provision of support for coordinating and managing the EHSP, strengthening its coordination, activities, and impact. The service framework contract was expected to be operational at the beginning of 2024, but due to external circumstances outside the remits of the JU, it will be in 2025.

<u>TF.1 Support at project level:</u> The activities in this task force aim at coordinating a package of measures to avoid any accident by integrating safety learnings, expertise, and planning into the JU-funded projects by ensuring that all projects address and incorporate state-of-the-art in hydrogen safety appropriately. In 2025, the guidance document "Safety Planning and Management in EU Hydrogen and Fuel Cells Projects"[339] will be reviewed and further

[337] https://www.clean-hydrogen.europa.eu/get-involved/european-hydrogen-safety-panel-0_en
[338] https://etendering.ted.europa.eu/cft/cft-display.html?cftId=14149
[339] https://www.clean-hydrogen.europa.eu/get-involved/european-hydrogen-safety-panel-0/reference-documents_en

developed. Furthermore, the EHSP will continue to perform Safety Plans Reviews, i.e., assessing the Safety Management of ongoing projects, and Safety Specific Sessions will be organised with projects or sets of projects with similar applications coverage when needed.

TF.2 Support at programme level: The EHSP works under this task force are intrinsically linked with the activities of the previous task force but with a broader cross-cutting dimension, focused on the Clean Hydrogen JU Programme, and how safety-related aspects can be enhanced within the overall Programme and activities. Activities within this task force in 2025 will be to provide guidance in research needs on safety along the hydrogen chain, with special attention in developing areas such as, but not limited to, heavy-duty vehicles, aviation, rail, and waterborne applications. In addition, international links with the International Association HySafe[340] (and related international activities like the International Conference on Hydrogen Safety), the International Partnership for Hydrogen and Fuel Cells in the Economy IPHE[341], and the Hydrogen Council[342] will be further strengthened. Last, the revision of the internal emergency crisis management procedure (and links with 'crisis communication'), will be also performed.

TF.3 Data collection and assessment: Activities in this task force are centred on the collection and analysis of hydrogen safety-related data to derive lessons learnt and provide further general recommendations to all stakeholders.

In 2025, the EHSP, in close cooperation with the JRC, will continue with the addition of new events in HIAD 3.0 (an updated and revamped version of the HIAD 2.0 database). The EHSP will also review and assess these events and the lessons learnt and statistics obtained from this information will be summarised in a new release of the document "Statistics, lessons learnt and recommendations from the analysis of the Hydrogen Incidents and Accidents Database"[343]. Furthermore, the EHSP will continue updating the lists of the engineering models, CFD models/tools, and risk models/tools, and will release a guidance document on "Hydrogen Safety Engineering".

TF.4 Public Outreach: This task force focuses on the broad exchange of information with relevant stakeholders, including the public. The activities in 2025 will focus on setting up a new web site for the EHSP, including a set of Frequently Asked Questions (FAQs) on hydrogen safety, updated lists of events and resources, etc. The EHSP will also deliver oral or poster presentations at relevant safety, fuel cell and/or hydrogen technology conferences, organise workshops with relevant stakeholders (either as public outreach from TF4 or targeting specific JU projects in TF1), and work in close cooperation with the Communication Team at Clean Hydrogen JU.

Altogether, the EHSP will contribute to coordinating and establishing approaches to address hydrogen safety-related matters in the EU, while contributing to promoting a high-level hydrogen safety culture and a safe hydrogen market in the EU and beyond, if possible.

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340 https://hysafe.info/
341 https://www.iphe.net/
342 https://hydrogencouncil.com/en/
343 https://www.clean-hydrogen.europa.eu/get-involved/european-hydrogen-safety-panel-0/reference-documents_en

2.2.6.6. *European Hydrogen Sustainability and Circularity Panel (EHS&CP)*

Sustainable development is at the heart of the European Green Deal[344], which along with other policies[345] has set the EU on a course to become a sustainable climate-neutral and circular economy by 2050.

Hydrogen and fuel cell technologies will play an essential role in the sustainable transition and future energy system. Nevertheless, the hydrogen technologies and their value chains need further development to become an environmentally sustainable, socially responsible and circular market value proposition.

The European Hydrogen Sustainability and Circularity Panel (EHS&CP)[346] was established as a key advisory body to the Clean Hydrogen Partnership, in alignment with its Strategic Research and Innovation Agenda (SRIA)[347]. Its purpose is to support the development of sustainable hydrogen technologies based on circular economy principles, contributing to making the EU hydrogen sector a leader in sustainable and circular hydrogen technologies and value chains, and fostering a new culture within both the Clean Hydrogen JU and the wider hydrogen community.

The EHS&CP's mission has two key objectives:

1. Sustainability integration: Ensure that the sustainability and circularity are embedded, monitored, and managed at both the programme and project levels, encompassing environmental, social, and economic dimensions.
2. Knowledge promotion: Advocate and disseminate knowledge on sustainability and circularity, promoting sustainable practices within and beyond the Programme.

Following an open call for expressions of interest launched in November 2023 and a rigorous selection procedure, 15 experts were appointed to the Panel. They have been contracted and are coordinated on behalf of the Clean Hydrogen Partnership by a consortium led by Ecorys, with TNO and Grant Thornton as partners, according to a service contract signed with Ecorys in August 2023.

The Panel's experts cover a wide range of scientific competences related to sustainability and circularity across the whole hydrogen value chain, for example: eco-design, raw materials and supply chain, manufacturing processes and scaling up, waste management and recycling, end-use applications, techno-economic, environment and life cycle assessment.

The EHS&CP kicked-off in March 2024 and is organised across four task forces[348]:

- Hydrogen production (TF1)
- Hydrogen storage and distribution (TF2)
- Hydrogen end uses (TF3)
- Cross-cutting issues (TF4)

The main activities of the EHS&CP include:

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[344] COM(2019) 640 final
[345] https://ec.europa.eu/info/strategy/international-strategies/sustainable-development-goals/eu-holistic-approach-sustainable-development_en
[346] https://www.clean-hydrogen.europa.eu/get-involved/european-hydrogen-sustainability-and-circularity-panel_en
[347] https://www.clean-hydrogen.europa.eu/about-us/key-documents/strategic-research-and-innovation-agenda_en
[348] https://www.clean-hydrogen.europa.eu/get-involved/european-hydrogen-sustainability-and-circularity-panel/members_en

- Monitoring, analysing and reporting on the advancements of the projects funded by the Clean Hydrogen Partnership and its overall programme regarding sustainability and circularity of hydrogen technologies
- Defining a comprehensive approach to help integrating sustainability and circularity aspects in future projects
- Providing recommendations and sharing lessons learnt.

In 2024, the EHS&CP focused on the implementation of the Preparatory Activities consisting of developing a common understanding of the policy framework, sustainability and circularity concepts linked to hydrogen. In particular, the Panel has examined how the Strategic Research and Innovation Agenda (SRIA) of the Clean Hydrogen JU addresses the sustainability and circularity, identifying suitable indicators for tracking the Programme's progress in sustainability dimensions, such as raw material criticality, economic, social aspects, and circularity. Each Task Force reviewed and prioritised these indicators based on the distinct hydrogen value chain stages. A holistic perspective was agreed upon, recommending a life cycle approach. A set of final indicators was then proposed for each sustainability dimension, detailing their applicability and limitations. The recycling and circularity domain was found to be underdeveloped, complicating benchmarking for project evaluations. Similar challenges were noted for social indicators. In addition, an analysis was carried out to assess the impacts of scaling up hydrogen production, examining potential barriers and opportunities in areas such as policy support, water, critical raw materials, power systems, hydrogen storage and transport, land use, education, social acceptance, and stakeholder cooperation. More specifically, TF3 was intensely involved in the policy mapping, TF1 focused on identifying and proposing the most relevant sustainability & circularity KPIs currently in use, while TF4 coordinated the analysis of the impacts of scaling up hydrogen technologies.

In addition, EHS&CP assessed how the sustainability and circularity requirements have been expressed across the call topics issued during the three major funding Programmes (i.e., FP7, Horizon 2020, Horizon Europe). Simultaneously, an initial screening of all JU funded projects (2008 to 2024) was implemented based on an extensive record of projects. The data provided, already included an initial indication of whether sustainability or circularity aspects are being managed by each project and whether an LCA is planned or has already been delivered by each project.

Two workshops took place in 2024 as part of the Panel's activities:

- 1st Workshop (11 April 2024, Brussels): Focused on regulatory and policy developments related to hydrogen, sustainability indicators, and the impact of scale-up efforts. A report is available at the JU website[349].
- 2nd Workshop (26 September 2024, Brussels): The Panel presented the outcomes of the following activities:
    - Mapping the integration and evolution of sustainability and circularity in call topics
    - Developing a screening approach for JU projects, analysing best practices in meeting sustainability requirements

[349] https://www.clean-hydrogen.europa.eu/document/download/1a2104be-e9ad-4b02-9d2b-2961ff310d7d_en?filename=EHSCP%20-%20final%20draft%20report%20on%20preliminary%20activities.pdf

- Discussions on improving project reporting and brainstorming the scope of the next Panel.

The current service contract for Panel's management finished in February 2025. The Clean Hydrogen Partnership plans to award in 2025 a new framework contract to continue the Panel's activities up to 4 years.

Overall, the EHS&CP will contribute to improving the JU approaches to ensure that the sustainability and circularity are properly embedded in the research and innovation activities and projects supported in the Programme, and across the Programme, integrating the sustainable development dimension such as the economic, social and environmental.

2.2.6.7. International Cooperation

The Communication of the European Commission on the global approach to research and innovation[350] presents the EU's new strategy on international cooperation on research and innovation. The EU aims to take a leading role in supporting international research and innovation partnerships and to deliver innovative solutions for making our societies green, digital and healthy.

The strategy builds on two principal objectives: preserving openness in international research and innovation cooperation, while promoting a level playing field and reciprocity underpinned by fundamental values.

In line with these objectives and in order to better support and European Commission to align with, facilitate and accelerate worldwide market introduction of fuel cell and hydrogen technologies, the Clean Hydrogen JU continuously tries to identify priority areas, at policy and technology level, where coordinated and collaborative international activities are of interest. Within the context of 'international cooperation' mainly to refer to cooperation with countries that are neither EU Member States (over countries and territories nor associated to Horizon Europe). For this reason, associated countries are not the focus of this section, which deals mainly with cooperation with non-associated third countries.

As the deployment of fuel cells and hydrogen technology is carried out globally and key stakeholders of the Clean Hydrogen JU are involved in these developments, establishment of links with other major FCH related programmes globally is deemed important. This is particularly valid during 2025 in research activities on Understanding emissions of PFAS and for the two topics dealing with Hydrogen Valleys.

On a more general level, the relevant international activities of interest include in particular those carried out by the IEA under the Hydrogen Technology Collaboration Program (IEA Hydrogen)[351] and the International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE)[352]. In addition, with the planned study on "Hydrogen in Ports" included in the AWP2025, it is planned to continue supporting the European Commission activities within the Global Ports Coalition under the Clean Energy Ministerial.

In 2024, the Clean Hydrogen JU supported the European Commission services dealing with international cooperation in research and innovation (e.g. India, Japan). The Clean Hydrogen JU is ready to continue with these activities in 2025.

Following the successful and close collaboration of the FCH 2 JU with EC representatives on the Mission Innovation and the setting up of the Hydrogen Valley Platform, a platform for exchanges between worldwide initiatives on hydrogen valleys, the Clean Hydrogen JU will

[350] Europe's strategy for international cooperation in a changing world, COM(2021) 252 final.
[351] http://ieahydrogen.org/
[352] http://www.iphe.net/

continue to contribute in this direction. It will maintain and further improve the Hydrogen Valleys platform through a contract that is expected to start in the beginning of 2025, while contributing also towards the other activities of Clean Hydrogen Mission under MI2.0, aiming to make clean hydrogen cost competitive to the end user by reducing end-to-end costs by 2030. In this context, the Clean Hydrogen JU will support the European Commission in its co-lead activities (see also section 2.2.5.1 (C), regarding collaboration in terms of knowledge management).

International collaboration, in particular with African Mediterranean countries, might be facilitated through the study on “Sustainable paths for the use and management of water in the hydrogen value chain” which is expected to start at the beginning of 2025.

For concrete references to international collaboration in the Call for Proposals see section 2.2.3.2 of this document.

2.3. Support to Operations of Clean Hydrogen JU for 2025

2.3.1. Communication, dissemination and exploitation

2.3.1.1. Communication

A. Communication objectives

The communication plan in 2025 will support the priorities identified in the current work-programme, and Clean Hydrogen JU's communication objectives identified in the communications strategy. Some of the yearly objectives are constant throughout the programme life (such as those related to project communication), while others are changing according to (new) priorities identified, such as for example a focus on communicating the programme as a centre of knowledge on hydrogen technologies at EU level. In addition, separate communication plans are being developed for the European Hydrogen Observatory.

The following objectives will lead the communication activities in 2025:

Goal	Objective	Messages
Position the Clean Hydrogen JU as the main EU tool for the funding of hydrogen research and technology demonstration in Europe and an important contributor to the development of the hydrogen technologies sector	Communicate about the funding opportunities offered by the Partnership and continue to attract valuable applications. Enhance project – related communication**,** including the activities and results of the projects that have kickstarted their activities in 2024. Communicate about the added value of the Join Undertakings and their role in driving EU research and innovation.	The Clean Hydrogen Partnership accelerates progress in clean hydrogen technologies**.** The projects funded by Clean Hydrogen Partnership help make hydrogen technologies more performant, more competitive, more accessible, more circular, and safer (all target groups) Launch and results of the call for proposals (foreseen in January 2025) Promotion of ongoing flagship projects in key areas relating to heavy-duty transport, shipping industry, maritime transport, aviation, as a solid foundation for the development of a hydrogen economy in EU. Promotion of key results and achievements. *Target groups: policymakers, opinion-makers, experts, industry and research, media, other partnerships)*
Establish Clean Hydrogen's reputation as a centre of knowledge on hydrogen technologies at EU level	Communicate about the European Hydrogen Observatory and the launch of Hydrogen knowledge hub and the Hydrogen Valley Platform.	Clean Hydrogen informs about the development of the technology with data grounded in robust analysis and science. How to get involved, what are these platforms offering, importance of data, who can use the data, what data we provide (objective, often unique). *Target groups: industry / SMEs, investors, academia, citizens*
Increase awareness, acceptance, and uptake of clean hydrogen	We aim to continue to create a positive narrative around clean hydrogen in media across Europe, as an important part of the solution to the current energy challenges.	The Clean Hydrogen Partnership brings innovative technologies from the laboratory to the factory floor and, ultimately, to European businesses and consumers. Target groups: industry / SMEs, investors, consumers, policymakers, opinion-makers, experts, media.

Milestone/Activity/Topic	When	Channels / tools	Target group
Launch of Call 2025	January – February 2025	Website, social media, newsletter, events (info-day), brochure	• Policymakers and authorities (EU, National, regional, local & International) • Industry • Research • Beneficiaries
Media campaign to promote the achievements of the partnership	January - June 2025 (TBC)	Articles in traditional media, social media Joint event at the EU Parliament	• Policymakers and authorities (EU, National, regional, local & International) • Industry • Research, academia, education and training organisations • Opinion formers (media, experts, NGOs, etc.) • Consumers/ citizens
Hydrogen Week	November 2025	Website, social media, newsletter	• Policymakers and authorities (EU, National, regional, local & International) • Industry • Research, academia, education and training organisations • Opinion formers (media, experts, NGOs, etc.) • Consumers/ citizens
Launch of the Hydrogen Knowledge Hub	Q1 2025	Website, social media, newsletter	• Policymakers and authorities (EU, National, regional, local & International) • Industry • Research • Opinion formers (media, experts, NGOs, etc.) • Consumers/ citizens

Target audiences

- Policymakers and authorities (EU, National, regional, local & International)
- Opinion formers (media, experts, NGOs, etc.)
- Researchers, academia, education and training organisations
- Industry, SMEs , investors
- Consumers/ citizens
- Clean Hydrogen JU Advisory bodies
- Other EU partnerships

Main channels and tools

To be able to respond to today's fast communication landscape, the tools and channels employed will be integrated as much as possible, for maximum impact. Moreover, as proposed in the chapter on guiding principles, taking into account the current social context the JU will aim to have a powerful online communication, hence following the "digital first" approach.

We are pursuing a digital-first approach that allows us to be impactful in real time with timely news and information. Achieving better digital expertise and social media integration through development of online channels and content is essential in the current context, which is characterised by an increasing flux of information and data, fast-paced (often-instant) communication and social distancing (limited physical meeting opportunities).

We are also expanding our channels to reach out regularly to a broader audience through social media, newsletters, and continuous improvement of our website. To this purpose content for online channels will be continuously developed and new channels will be explored. For example, to promote hydrogen technologies in a campaign for young people we could employ more social media channels such as Instagram.

Our goal with the development of the European Hydrogen Observatory and ultimately the Hydrogen Hub is to shift more findings online and create a hub for data and analysis, which is up-to-date, dynamic, and easy to use.

Website

Online communication will remain the preferred channel for all audiences in 2025. The website, together with the social media channels, are the main gateway to the organisation.

we will continue to address the (long term) recommendations will be identified in the audit and contribute to the optimal performance of the website.

In addition to its main website, Clean Hydrogen JU continues to oversee a series of associated digital platforms: H2V, European Hydrogen Observatory, European Hydrogen Refuelling Station Availability System (E-HRS-AS) and a mini-website dedicated to the Hydrogen Week. In addition, in 2024, new sections were added to the JU website to inform on the work of the JU with regions a well as on activities and support of the JU to Hydrogen Valleys.

Among others, the audit recommends the better integration and prominence of the Clean Hydrogen Partnership's affiliated initiatives and comes in line with the general digital approach we aim to enhance, in cooperation with DIGIT and the Knowledge management unit.

Social media

A social media plan complements each year the general media plan, to allow for a wider distribution of the content and will be built around major events and initiatives. The JU will promote content via the following channels throughout the year, by means of both paid and organic campaigns.

Channel	Audience	Content	Objective
X (former Twitter)	Journalists and Media Stakeholders	Pictures; Short videos; Links to external content (including news); Polls; Live transmission of events	Build reputation and leadership, focusing on what's new: promote news, partnerships, projects and initiatives events and activities
LinkedIn	Professionals Experts	Pictures; Short videos; links to extended content, news; articles;	Cultivate the relationships with networks of experts, get in touch with industry/business stakeholders
YouTube	Non specialist audiences	Videos; Live streaming	Build visibility and reputation with a broader public; You tube has the second-largest search engine after Google Search and its content has a long life

Through social media, the JU will disseminate a wide variety of digital content quickly, efficiently and extensively. This content includes videos (e.g. interviews with stakeholders, project stories), visuals (e.g. animated GIFs, images), short written posts, and hashtags. The choice of format will depend on the specific platform they are created for (e.g. Twitter, LinkedIn, etc.) and the information needs of the target audience.

Clean Hydrogen JU will keep in touch with its audiences every day through the social media channels, and engage with them directly, thus creating a strong, transparent and interactive relationship and nurturing the community of subscribers / followers.

In this context, the JU is looking at integrating social media advertising in its campaigns, so that it earns more followers and reach out to a more general audience. Through social media advertising, it will gain visibility and expand the audience as organic posts have more and more difficulty to stand out. Advertising can be used to: promote the new website of the JU, to announce its main events and calls for proposal and can be focused on specific countries / regions).

Newsletter

The Clean Hydrogen JU Newsletter is sent out to the subscribers' database (over 17308 subscribers), in a format based on the Newsroom template of the European Commission. It is adapted to contain both "flash news" whenever there is an important programme update / activity and a periodical edition, which summarises the latest news and includes as well policy-elements and relevant news from media and third-party sources. The focus will be always on the programme activity.

Media

Public awareness and acceptance remain a critical issue for the deployment of hydrogen and fuel cells technologies and the media plan will be adapted to include a more diverse range of media in different EU countries. A dedicated media plan comprising both organic and paid options will be implemented through a campaign continuing the efforts started in the previous years.

The Clean Hydrogen Joint Undertaking's media efforts will revolve around three general topics such as, Clean Hydrogen technology, Clean Hydrogen Joint Undertaking and Clean Hydrogen JU funding opportunities (calls for proposals and expression of interest for various topics). These three topics are strongly interconnected and will be used as a basis for content development tailored to the different target audiences, focus countries, tools and channels.

Events

The JU will organise a number of events with both online and physical presence.

In line with the SBA, the JU will convene an annual **European Clean Hydrogen Partnership Forum**.

The European Clean Hydrogen JU Forum and the EU Hydrogen Research Days come together in what has already been established as of 2020 as the "**European Hydrogen Week**". The Hydrogen Week represents already a brand in itself, which the JU wants to consolidate further, promote, and use it to differentiate the EU annual events(s) from the numerous events on hydrogen taking place in Europe, Brussels and beyond.

Following the 2024 example, the JU will also use the occasion to showcase the synergies between and with the members of the partnerships (industry and research associations and with the various European Commission services/programmes, and reflect on the entire hydrogen value chain from production, storage, to transport, distribution and utilisation.

For example, we are participating in the organisation of a Joint event at the European Parliament, which will take place in April 2025. The event will showcase the joint undertaking model as a driver for European competitiveness and sustainability.

In addition, the JU aims to work with the 2025 EU presidencies (Poland and Denmark) to organise joint event(s) (if possible, on the agendas of the respective presidencies), and participate in other events that EC / partnerships are organising – Transport Research Arena (TRA), Connecting Europe, SET-PLAN, R&I days, European Sustainable Energy Week, EU Regions week.

The JU will continue to organise events to promote its project portfolio and calls including info days and sectorial workshops:

- Call 2025 Info Day;
- EU Hydrogen Valleys Days;
- Projects events – such as demonstrations, projects visits, etc;
- Participation in major European /international exhibitions (HyVolution, Hannover Messe, World Hydrogen Summit in Rotterdam, BusWorld etc) and conferences (International Safety Conference, Conference of the Parties (COP));
- Workshops with EU and international counterparts (i.e. NEDO).

Monitoring and measuring impact of communication activities

The impact of the online communication efforts will be measured using the Europa Analytics reports for website and newsletter performance, and default social media analytics available on each of the platforms, namely Twitter, LinkedIn and YouTube.

Total outreach via all communication channels (including events, publications, social media, newsletters etc.) will be also taken into account if enough data will be accessible.

2.3.1.2. Dissemination and exploitation of projects results

All dissemination and exploitation (D&E) activities of the Clean Hydrogen JU will be in line with the European Commission strategy for dissemination and exploitation of the projects results in Horizon Europe[353]. The Horizon Dissemination & Exploitation Group will be one of the pillars (together with the Horizon Feedback to Policy Group) to coordinate implementation, according to the D&E Strategy for Horizon Europe. Clean Hydrogen JU shall continue participating and contributing in this group.

Furthermore, an ecosystem of services and tools has been established to enhance circulation of knowledge stemming from R&I projects:

- CORDIS[354]: Multilingual articles and publications that highlight research results, based on an open repository of EU project information.
- Horizon Results Platform[355]: A public platform that hosts and promotes research results, thereby widening exploitation opportunities. It helps to bridge the gap between research results and generating value for economy and society. Beneficiaries can create their own page to showcase their results, find collaboration opportunities and get inspired by the results of others;
- Innovation Radar[356]: A data-driven method focused on the identification of high-potential innovations and the key innovators behind them in EU-funded research and innovation projects;
- Horizon Dashboard[357]: An intuitive and interactive knowledge platform where one can extract statistics and data on EU research and innovation programmes – sorted by topics, countries, organisations, sectors, as well as individual projects and beneficiaries.
- Horizon Results Booster[358]: A package of tailor-made specialised services to maximise the impact of R&I public investment and further amplify the added value of the Programme, by building the capacity of projects for disseminating research results, increasing their potential for exploitation and improving access to markets;
- Horizon Standardisation Booster[359]: An initiative that supports European research and innovation projects to valorise results through standardisation, supporting them to contribute to the creation of new standards or the revision of existing standards. It responds to the main priorities (so-called urgencies) outlined in the European Strategy

[353] Dissemination & Exploitation Strategy for Horizon Europe - Towards an Integrated Dissemination & Exploitation Ecosystem, European Commission, DG-RTD, CIC, 2020
[354] https://cordis.europa.eu/en
[355] https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/horizon-results-platform
[356] https://ec.europa.eu/digital-single-market/en/innovation-radar
[357] https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/horizon-dashboard
[358] https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/d-e-booster
[359] Horizon Standardisation Booster (https://hsbooster.eu/)

on Standardisation[360].

- European Intellectual Property (IP) helpdesk[361]: A first-line service aiming to provide free-of-charge support to help beneficiaries of EU-funded research projects manage, disseminate and valorise their IP in the context of EU research and innovation programmes.
- Open Research Europe[362]: A platform that makes it easy for beneficiaries of European research and innovation projects to comply with the open access terms of their funding and offers researchers a publishing venue to share their results and insights rapidly. The new EC scientific publishing service for fast publication and open peer review for research scientific articles stemming from H2020 and Horizon Europe projects across all subject areas.
- Research and innovation success stories[363]: A collection of the most recent success stories from EU-funded research & innovation.

In particular, Innovation Radar (IR) is a prominent initiative embedded in the project workstream. Clean Hydrogen JU, following the legacy of FCH 2 JU, is supporting and participating through the on-going and new projects. This activity initiates by the project officer in collaboration with the related project beneficiaries in case an innovations is stemming out of their project activities. The process is being conducted during the project mid-term and final reviews, where possible innovative outcomes are analysed by a dedicated expert, filling out a questionnaire. The purpose is to provide information in a structured and quantified way, allowing introduction into the list of the innovations of IR. The Innovation Radar exercise has been incorporated in the eGrants Management tools, which gives the flexibility to the project officers to update existing innovations or submit questionnaires for new innovations that happen up to the final reporting; the Programme Office will assess whether this new feature can be applied successfully and effectively to flag innovations of our projects that comes later in the project lifecycle, even if without the use of experts. The identified innovations/innovators are gaining visibility and can be supported for further exploitation and dissemination by connecting with possible investors and corporates (fundraising, venture building and networking). One concrete example of this is Dealflow.eu[364], a matchmaking platform supported by the EC to help projects commercialize their innovations, by facilitating access to clients and investors and providing high-end coaching services. The service gives priority to the projects that are already analysed by the Innovation Radar. Also, during the Innovation Awards organised each year during the Hydrogen Week, the top-ranking innovations that have been filtered from the Innovation Radar are presented to the public allowing them to vote for the best one.

As part of the knowledge management activities, but also in the context of the Project Management workflow, the Programme Office will keep on checking compliance with the Horizon Europe MGA provisions in D&E, encouraging the projects not only to implement their D&E plans, to update and revise them when necessary, but also to try to benefit from the opportunities provided by the D&E ecosystem to facilitate and enhance their D&E activities during and after the end of each project, focusing especially on the exploitation efforts of the

[360] European Strategy on Standardisation aims to speed up the pace of innovation through the development of efficient Standards that might be capable to accelerate the transition towards a more resilient, green and digital economy and to protect democratic values in technology applications - https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/13099-Standardisation-strategy_en
[361] https://intellectual-property-helpdesk.ec.europa.eu/regional-helpdesks/european-ip-helpdesk_en
[362] https://open-research-europe.ec.europa.eu/
[363] https://ec.europa.eu/research-and-innovation/en/projects/success-stories
[364] https://dealflow.eu/

key exploitable results[365]. This provision is valid during and after the end of the funding cycle of the projects (for both the ongoing H2020 and the new Horizon Europe projects), as foreseen in the Model Grant Agreement (MGA), taking into account the changes introduced in Horizon Europe compared to the H2020 as regards D&E, which reinforces the D&E framework for the projects supported under the current programme. Especially after the funding period, projects will be contacted to remind the key results owners about their contractual obligations to enable dissemination and exploitation of them and on the available tools provided by the EC to help them accomplish this task.

2.3.2. Procurement and contracts

Clean Hydrogen JU allocates funds to procure the necessary services and supplies so that it reaches its objectives and adequately supports its operations and infrastructures.

To make calls for tender and contract management as effective and efficient as possible, Clean Hydrogen JU resorts extensively to EU inter-institutional calls for tenders (including the ones launched in the context of the back-office arrangements for Procurement, as mentioned below in section 2.3.4.2), and their implementation in multi-annual framework contracts. In addition, it must be noted that the Clean Hydrogen JU has also concluded several Service Level Agreements (SLAs) with other Directorate Generals of the European Commission for support to various administrative activities.

The Clean Hydrogen JU expects to either join the EU inter-institutional procurement procedures, or launch its own calls for tenders (as a result of the current framework contracts ending in 2025-2026, or seeing as the need is not already covered in another framework contract):

- Supply of office furniture, furnishings,
- Supply of domestic appliances,
- FWC for the provision of all travel agency services relating to the business trips and events of all persons travelling on behalf of or at the request of the European Commission and other institutions, bodies and agencies of the EU.

The Clean Hydrogen JU will work on further simplifying the management of procurement activities by using digital and automated procedures and processes.

As of 2024, the JU has prepared and launched all its open calls for tenders via the Public Procurement Management Tool (PPMT), while all of the calls will be managed, and will then be published on the Funding and Tenders Opportunities Portal, thus joining all EU public contracting authorities in use of the corporate suite of IT tools for the management of calls for tenders.

In 2025, the JU will gradually extend its use to other types of procedures and set up an in-house monitoring system for all of its signed contracts, until a corporate solution can be adopted (i.e. eContracts, developed by the European Commission and not yet available to the JU)

2.3.3. Other support operations

2.3.3.1. ICT management

Eight Joint Undertakings are sharing the housing location in the building “White Atrium”,

[365] D&E legal obligations for beneficiaries - extract from the D&E [pdf]

Brussels Belgium. The arrangements for the facilities are subject to a common contract for both the office space and the IT management of equipment, maintenance and help desk.

ICT provides the ICT infrastructure, tools and services to enable the staff members to work and the teams to collaborate.

The Joint Undertaking JU strategic objective in the field of ICT is to lead by example in digital transformation. This transition is clustered on the following pillars:

- paperless, streamlined procedures that use technology to remove mechanical tasks.
- improved access to and use of data to work more efficiently and be more transparent.
- staff collaborating efficiently and easily anytime, anywhere and with all stakeholders.

and will be supported in 2025 by specific objectives in the following five areas: Information and Communications Technology (ICT) governance, Information and document management, and digital transformation.

Joint Undertakings will take all opportunities to build synergies on areas of joint interest and maintain the strong partnership with DIGIT to harmonise processes and good practice (IT Legacy/Cybersecurity) and feeds into corporate decisions when possible.

ICT Governance will be further developed by renewing, extending, or creating Service Level Agreements for the common digital infrastructure to improve synergies and efficiencies among the Joint Undertakings. Ten Joint Undertakings[366] participate in the back-office arrangements [367], in which common tasks such as IT governance and shared ICT infrastructure and services have been allocated to the Clean Hydrogen JU as lead. In the context of the back-office arrangements for ICT (BOA ICT), the Joint Undertakings have adopted at the end of 2024 the common IT annual work plan for 2025.

This will also be supported by added-value interinstitutional framework contracts, in particular, the DIGIT Dynamic Purchasing System (DPS), or inter-agency joint procurements the Clean Hydrogen JU will continue joining [368]. The common procurement plan is defined in the annual work plan 2025 for the IT Governance, aligned with the common IT actions approved in December 2025, supervised by Clean Hydrogen with the support of the back-office arrangement for procurements lead by Clean Aviation Joint Undertaking.

Regarding the digital infrastructure, the JU will continue to rely on the secure pan-European networks for the Commission, executive agencies and other European institutions. The new TESTA line design shared with more agencies is operated under the new DIGIT broker model and is actually shared as best practice within the IT community. The common conference centre of the White Atrium building will be upscaled with the necessary audio-visual functions to held hybrid meetings. This will be greatly facilitated by the new Memorandum of Cooperation signed with SCIC for installation and support.

In the area of **digital transformation**, the main objective is to build a performing digital infrastructure and a fit-for-purpose Digital Workplace. Each staff member will continue to receive modern IT equipment allowing for more flexibility, but also from 2025 focusing on the

[366] The ten participating Joint Undertakings to the BOA ICT are the eight referred to in Article 13 of the Single Basic Act (namely CAJU, CBE JU, Chips JU, Clean Hydrogen JU, EU-Rail JU, Global Health EDCTP3 JU, IHI JU, SNS JU), and in addition two JUs which are not referred to in Article 13 of the Single Basic Act but showed interest in participating in the BOA ICT, namely EuroHPC JU (not established through the SBA) and SESAR 3 JU (exempted from the BOA through article 158 of the SBA)

[367] See section 2.5.1 Organisational management

[368] see section 2.3.2 Procurement and contracts

digital culture, promoting digital skills, mobile hardware and software solutions, and collaboration:

- The shared spaces specific to the Clean Hydrogen JU or transversal in the common tenant will be encouraged for collaboration;
- The cybersecurity mindsets will be required anywhere and anytime.

Other projects related to the extended use of EC tools will be carried out, such as the deployment of new modules in SysPer (MiPS for mission management– see below section 2.3.4 related to HR management), and the generalization of PPMT usage in the area of procurement [369]. A new modern contract database and management will be developed for monitoring.

The adoption of the new **Regulation on Cyber Security** in 2024 enforces the establishment of an internal cybersecurity risk management, governance and control framework that ensures an effective and prudent management of all cybersecurity risks. The requirements and implementation of the regulation will be mutualised within the Back-Office arrangement on ICT under the service group "Security and compliance management" developed in the back-office arrangements for ICT lead by the Innovative Health Initiative Joint Undertaking (IHI JU), with the ultimate objective to develop the common security framework by 2029 in the most effective way. Cybersecurity will be reinforced by the dedicated role of Cyber Security Officer to reinforce the JU's resilience to ever evolving digital security threats, establish a central point of contact with CERT-EU, and follow the developments and practical implementations by the relevant inter-institutional groups.

2.3.3.2. Document Management

The implementation and continuous improvement of the Clean Hydrogen JU **Information and Document Management System (IDMS)**, aims to simplify and streamline the management of information and documentation within the organisation. The Clean Hydrogen JU uses a portfolio of secure, state-of-the-art corporate digital solutions. The Clean Hydrogen JU will continue to use and /or adopt corporate digital solutions provided by the European Commission such as ARES, eProcurement suite, eGrants suite.

Document management at Clean Hydrogen JU is governed by several regulations. On the one hand, several regulations define the necessary registration and retention, while on the other hand the data protection regulation and the information security policy define access restrictions and deposition of documents.

Since 2018, the Clean Hydrogen JU has implemented ARES (the digital corporate tool in the European Commission for document management system) in the wake of the entry into effect of the Decision of the Executive Director on the Document Management Policy [370] establishing a new archiving and registration policy for Clean Hydrogen JU based on the European Implementing Rules of 30 November 2009 for the DECISION 2002/47/EC, ECSC, EURATOM on Document Management, and for the DECISION 2004/563/EC, EURATOM on Electronic and Digitised Documents".

[369] See section 2.3.2 Procurement and contracts

[370] Decision of the Executive Director on the adoption of a Document Management Policy Ares(2020)321462

Furthermore, the Clean Hydrogen JU has implemented SYSPER in 2019, leveraging on the existing EC infrastructure and processes for staff matters administration. See the chapter 2.3.4.2 related to HR Tools implementation.

In 2025, Clean Hydrogen JU will continue its efforts undertaken on these matters to keep awareness among staff at a high level, with procedural guidance and trainings, making use of the trainings dedicated to these applications offered via the EU-Learn platform.

Effective **record management** covers all information, both electronic and physical records, necessary to ensure evidence of Clean Hydrogen JU's activities ensuring an appropriate level of accountability, transparency, retention and public access to documents. The Commission proposed new rules on information security applicable to all EU institutions, bodies, offices and agencies [371]. It is expected that this proposal will be adopted in 2025 by the co-legislators and will become a new regulation to which the Clean Hydrogen JU will have to align.

In 2025, the Clean Hydrogen JU will further exploit the potential of data, information, knowledge and content management for running the program, communication to citizens and stakeholders and best staff engagement. New/different digital solutions available to the Joint Undertaking under the Microsoft 365 package will be further investigated in addition to those adopted after the data protection impact assessment.

Information Management has been gradually implemented in the Clean Hydrogen JU using the Microsoft 365 SaaS platform to complement the existing document management tool Hermes-ARES-NomCom provided by the European Commission. A new intranet has been released in 2024 using SharePoint to facilitate the interaction between all internal actors. In 2025 the Clean Hydrogen JU will further develop collaboration spaces in the Microsoft 365 common tenant with dedicated Teams groups, channels and libraries for the internal and external actors of the Joint Undertakings under the ICT back-office arrangement governance service provision[372].

The Clean Hydrogen JU will also identify and invest in emerging technologies such as Microsoft Power Platform, automation, AI, etc. for business optimization. The ICT will also support the modernisation of the digital platforms or applications develop for the knowledge management [373].

2.3.3.3. Data protection

Concerning the processing of personal data, the Clean Hydrogen JU is bound by Regulation (EU) 2018/1725[374] of 23 October 2018 on the protection of natural persons with regard to the processing of personal data by the Union institutions and on the free movement of such data, the Clean Hydrogen JU takes all necessary and appropriate measures to provide transparent information and communication for the exercise of the rights of the data subjects. The privacy notices for each specific processing operation are available on the Clean Hydrogen JU website[375] .

In accordance with Council Regulation (EU) 2021/2085 of 19 November 2021 establishing the Joint Undertakings under Horizon Europe, and in line with article 13 therein regarding back-office arrangements, the JU will continue to identify and foster synergies and efficiencies in

[371] https://commission.europa.eu/document/11fa0c3f-ff24-4f6b-a7a6-4e714da35432_en
[372] See sectton 2.5.1 Organisational management BOA ICT
[373] See section 2.2.5.1 Knowledge management.
[374] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32018R1725
[375] https://www.clean-hydrogen.europa.eu/about-us/privacy-policy_en.

administrative activities related to data protection in coordination with other Joint Undertakings (see section 2.3.2).

With regard to synergies with other JUs in the field of data protection, in 2024 the Clean Hydrogen JU participated in a call for tenders launched by SESAR 3 JU aimed at acquiring data protection consultancy services in support of the Data Protection Officers (DPO), which resulted in the signature of a framework contract. A joint specific contract with all JUs sharing the same IT infrastructure is planned under this framework in order to update the data protection impact assessment that was performed in 2020 with regard to the use of Microsoft services, in tandem with the review of the Inter-Institutional Licensing Agreement with Microsoft, currently under revision by the European Commission and Microsoft.

In addition, the Clean Hydrogen JU will continue to maintain a public register of all of its data processing activities via its website (services that have been secured as the result of a joint procurement procedure).

In 2025 the increase of widespread use of Artificial Intelligence applications will become a major point of attention with reference to the protection of personal data and the JU will use the contractual instruments at its disposal, as specified above, to ensure that the introduction of new IT tools with AI is done with an acceptable level of risk and hence introduce, as necessary, any new relevant processing activities in its register, also in line with the needed updates by the EDPS of the legal instruments required to tackle any new challenges in that area. Specifically, the introduction and future improvement of AI-powered features in the Microsoft 365 suite of applications will require close monitoring from the data protection point of view.

In 2025 the DPO will perform an annual data protection awareness session in order to inform and update all JU staff with every relevant news and points of attention, especially with regard to the use of AI in the daily work of the JU's Officers and its contracted experts.

With regard to reaction to the EDPS's initiatives, the JU will make use of the new open-source tool called Website Evidence Collector (WEC) to perform a review of its webpages where personal data is collected.

2.3.3.4. Logistics and facility management

In 2025 it is planned to refit the offices space for the Clean Hydrogen JU, in line with the guidelines of the Commission on working time and hybrid working, the objective of the refurbishment is to offer an open environment for staff members, that preserves an adequate welcoming of newcomers, transmission of knowledge and know-how, as well as effective teamworking in a multi-cultural context and informal collaborative exchanges as a source of creativity[376].

The new open spaces will reduce the closed atmosphere and allow light to come deep inside the working spaces. New meeting rooms will be also created to facilitate networking, supported by the relevant and up-to-date technology for hybrid meetings. This will induce a complete change of office furniture adapted to this layout, leading to a massive disposal exercise for the equipment accumulated since the creation of the Joint Undertaking. This ambitious project is the concretisation of the new ways of working adopted in 2023.

[376] Commission decision on working time and hybrid working adopted by analogy by the Governing Board at the end of 2023

2.3.4. Human Resources

2.3.4.1. HR Management

The priority objectives in the field of Human Resources are to ensure that the Staff Establishment Plan is filled, to ensure an efficient management of staff resources and to ensure an optimal working environment.

This is achieved mainly through efficient selection procedures, staff performance appraisals and reclassifications, learning and development opportunities, promotion of open communication and inter-JU cooperation, and by respecting the work life balance procedure in place.

In 2025, the following actions will be carried out in the area of HR:

- Finalisation of recruitments to fill the Staff Establishment Plan (see below in section 2.3.4.3) and onboarding of the selected staff: temporary agents for Financial Officer (assistant (AST) position) and for Knowledge Management Officer (administrator (AD) position), contract agent for Personal Assistant to the Executive Director and to the Heads of Units, Seconded National Expert (two positions); the creation of a reserve list for temporary agents for Project Officer (administrator (AD) position) will also be done,
- Ensuring that all new staff will follow a mandatory training on 'Ethics and Integrity';
- Evaluation of the implementation of the Commission decision on working time and hybrid working, adopted by the Governing Board in 2023,
- Implementation of the following HR tools:
    - Preparation and update of the job descriptions in a new JIS module in SysPer;
    - EC tool MiPS+ for missions.

In line with the EC priorities for 2019 - 2024, the Clean Hydrogen JU will continue to promote:

- Gender and geographical balance: diversity aiming at ensuring geographical balance where possible and gender balance will be important considerations in selection procedures, without compromising competency-related criteria;
- Development and Talent management: it is important for staff members to be able to follow trainings to improve their work skills, but it is as important to work on talent management, meaning that staff members can develop their skills in subjects of interest not necessarily related to the current job;
- Encourage and create synergies between JUs, in accordance with the requirements of article 13 of the SBA and following the back-office arrangement study and preparatory actions carried out in 2022 (see below).

2.3.4.2. Strategy for achieving efficiency gains and synergies

On the administrative part of the JU's processes, synergies and efficiency gains are aimed in a first instance to allow the JU to do more with the limited resources it has. Efficiency gains and synergies are achieved through three types of actions:

- The use of corporate tools and adoption of corporate processes, for instance in the financial, procurement, HR functions, and the participation to inter-institutional contracts for the acquisition of services (e.g. in the area of ICT);
- The collaboration with other JUs and/or Agencies for administrative synergies and for

reinforcing expertise, inter alia in the form of back office arrangements (see below in section 2.5.1 on Organisational management);

- The continuous improvement and streamlining of internal procedures, for which the Clean Hydrogen JU is carrying out an assessment.

2.3.4.3. Staff Establishment Plan[377]

Function group and grade	2024				2025	
	Authorised budget		Actually filled as of 31/12		Authorised budget	
	Permanent posts	Temporary posts	Permanent posts	Temporary posts	Permanent posts	Temporary posts
AD 16						
AD 15						
AD 14		1		1		1
AD 13						1
AD 12		2		2		1
AD 11						
AD 10		2		2		2
AD 9		3		2		3
AD 8		2		2		3
AD 7		5		4		4
AD 6		2		2		2
AD 5						
TOTAL AD		17		16		17
AST 11						
AST10		1		1		1
AST 9		1		1		1
AST 8		1		1		1
AST 7		1		1		1
AST 6		1		1		2
AST 5		4		4		3
AST 4						1
AST 3		1		1		
AST 2						
AST 1						
TOTAL AST		10		9		10
GRAND TOTAL	27		25		27	

[377] Adjustments to the staffing level may be decided by Corporate Management Board after considering the budgetary top-ups by third country credits and other aspects

Contract Agents	FTE corresponding to the authorised budget 2024	Executed FTE as of 31/12/2024	Headcount as of 31/12/2024	FTE corresponding to the authorised budget 2025
Function Group IV	*1*	*1*	*1*	*1*
Function Group III	*1*	*0*	*0*	*1*
Function Group II				
Function Group I				
TOTAL	*2*	*1*	*1*	*2*

Seconded National Experts	FTE corresponding to the authorised budget 2024	Executed FTE as of 31/12/2024	Headcount as of 31/12/2024	FTE corresponding to the authorised budget 2025
	3	*2*	*2*	*3*
TOTAL	*3*	*2*	*2*	*3*

Recruitment forecasts 2025 following retirement/mobility or new requested posts					
Job title in the JU	**Type of contract (Official, CA, TA)**		**TA/Official** **Function group/grade of recruitment internal (Brackets) and external (single grade) foreseen for publication**		**CA** **Recruitment Function Group (I, II, III and IV)**
	Due to foreseen retirement/ mobility	**New post requested due to additional tasks**	**Internal (brackets)**	**External (brackets)**	
Financial Officer	*1*			*AST4*	
Knowledge Management Officer	*1*			*AD6*	
Management Assistant					*1*
SNE	*1*	*1*			

2.4. Governance activities

2.4.1. Governing Board

The Governing Board (GB) is the main decision-making body of the Clean Hydrogen JU. It has overall responsibility for the strategic orientation and the operations of the Clean Hydrogen JU and shall supervise the implementation of its activities in accordance with Articles 15 and 80 of the Single Basic Act.

The GB is composed of three representatives of the European Commission on behalf of the EU, six representatives of the Industry Grouping (Hydrogen Europe) and one representative of the Research Grouping (Hydrogen Europe Research).

The GB plans to hold three meetings in 2025. The indicative key decisions of the GB in 2025, adopted by preference through written procedures in accordance with the Rules of procedure adopted in 2021, are listed below:

Key decisions in 2024	Timetable
Assessment of the Annual Activity Report for 2024	Q2
Adoption of the Governing Board opinion on the JU's 2024 Annual Accounts	Q2
Adoption of the Clean Hydrogen JU Synergies strategy	Q4
Adoption of the AWP and budget for 2026	Q4

In addition, depending on the timing of EC decisions, implementing rules on staff regulations may be submitted to the GB for adoption, by preference in the form of written procedures.

2.4.2. States Representatives Group

The States Representatives Group (SRG) is an advisory body to the GB. It consists of up to two representatives and up to two alternates from each Member State and from each country associated to the Horizon Europe Framework Programme. In total, there are 33 countries represented in the States Representatives Group. The SRG shall be consulted and, in particular, review information and provide opinions on the following matters:

a) programme progress of the Clean Hydrogen JU and achievement of its targets and expected impacts;
b) updates to the SRIA;
c) links to the Horizon Europe and other initiatives related to Hydrogen;
d) draft work programmes;
e) involvement of SMEs;
f) actions taken for dissemination and exploitation of results along the value chain;
g) annual activity report.

The SRG will hold at least two meetings in 2025. Issues to be covered include:

- opinion on the JU's Annual Activity Report for 2024,
- opinion on the JU's AWP for 2026,

Furthermore, the SRG will prepare in 2025 its annual report on national and regional policies and programmes on Hydrogen. This report is a key input to identifying potential synergies on hydrogen-related activities, between countries or regions and with the activities of the Clean Hydrogen JU.

The Chair of the SRG represents the SRG at the Clean Hydrogen Joint Undertaking's Governing Board meetings, where he has an observer status.

2.4.3. Stakeholders Group

The Stakeholders Group is the other advisory body to the GB, to be consulted on various horizontal issues or specific questions in areas relevant to the work of the Clean Hydrogen JU. Based on Recital 34 of the Single Basic Act: it requires that "With a view to ensuring that joint undertakings are aware of the positions and views of stakeholders from the entire value chain in their respective fields, joint undertakings should be able to set up their respective advisory stakeholders' groups, to be consulted on horizontal issues or specific questions, as per the needs of each joint undertaking". In accordance with the general provisions of Article 22(2) of the Single Basic Act "The stakeholders' group shall be open to all public and private stakeholders, including organised groups, active in the field of the joint undertaking, international interest groups from Member States, associated countries or other countries" In particular, for the Clean Hydrogen Joint Undertaking, Article 84(1) mentions that "The stakeholders' group shall consist of representatives of sectors which generate, distribute, store, need or use clean hydrogen across the Union, including the representatives of other relevant European partnerships, as well as representatives of the European Hydrogen Valleys Interregional Partnership and of the scientific community".

The Chairperson of the SG shall have the right to attend the meetings of the GB and take part to its deliberations without voting rights.

In 2024, the expansion of the SG was complete, after a Call of Expression of Interest opened at the end of 2023. This allowed for having additional sectors represented, including other partnerships. The five new members were appointed by decision of the Governing Board dated 7th May 2024.

The SG will hold at least two meetings in 2025. The objectives of the meetings will be to update on the activities of the Clean Hydrogen JU and the activities of the members of the SG with a view to understand the potential to enable concrete synergies between the JU and the sectors represented by the SG members, including on the AWP / Call for Proposals 2026.

2.5. Strategy and plans for the organisational management and internal control systems

2.5.1. Organisational management

No change is foreseen on the organisation structure of the Clean Hydrogen JU in 2024.

However, together with the other Joint Undertakings, the Clean Hydrogen JU will continue implementing the back-office arrangements defined since 2022. Indeed, the Single Basic Act of the Joint Undertakings establishes that the JUs shall achieve synergies and -and provide horizontal support functions via the establishment of back-office arrangements, operating in identified areas.

In continuation of the study carried out in May-July 2022 by the JUs and of the related implementing measures since then, in 2025 the implementation of back-office arrangements will continue in five areas. In the area of ICT, the common IT annual work plan identifies as main priorities the continued provision of IT infrastructure and services, the testing of the common business continuity plan (including the disaster recovery plan) and the common implementation of the Cybersecurity Regulation. In the area of HR management, eight JUs are working closely together and will reinforce their cooperation in the areas of recruitment, confidential counsellors (in continuation of the current practice where the JUs have set up a common Network of Confidential Counsellors since 2019) and HR digitalisation, under the SLA put in place in the context of the back-office arrangements with the Circular Bio-Based Europe Joint Undertaking (CBE JU) as Lead. In the area of Procurement, the back-office arrangements foresee the full implementation of the joint procurement plan for 2024 and 2025, approved in late 2023. The back-office arrangements will also continue in the area of Accounting. Furthermore, after the selection of their common building for the period from 2025 to 2031, the Joint Undertakings envisage the implementation of back-office arrangements for Facility Management Implementation of the Internal control framework

The Clean Hydrogen JU's revised Internal Control Framework was adopted by the FCH 2 JU

Governing Board in August 2018, and its applicability was transferred to the Clean Hydrogen JU via the Governing Board Decision of 17 December 2021, reference number CleanHydrogen-GB-2021-3, 'o*n the transfer of decisions of the Fuel Cells and Hydrogen 2 Joint Undertaking's Governing Board to the Clean Hydrogen Joint Undertaking'* (also referred to as the Omnibus Decision). The priority objective remains to implement and maintain an effective internal control system so that reasonable assurance can be given that (1) resources assigned to the activities are used according to the principles of sound financial management and (2) the control procedures in place give the necessary guarantees concerning the legality and regularity of transactions. For this purpose, particular emphasis will be given to the assessment of efficiency of internal control measures. Following the assessment of the internal control systems carried out in 2024, the following main actions were identified for 2025:

- Regarding the component Control Environment, there is a recommendation for ethical training for all staff at least on annual basis (to be integrated as part of the training maps). In addition, there is a recommendation for specific ethical trainings to management. Different types of trainings on this matter are available: dignity, respect, harassment, resilience, resistance, fraud, etc. For all the newcomers the induction ethical training is compulsory within 6 months of their arrival. A staff survey at the Clean Hydrogen JU will be implemented in 2025. In addition, an update of the Staff Leaving Procedure is to be finalised and fully implemented. Overall, a revision of the list of procedures is ongoing and will continue in 2025 to update, streamline the current ones and draft the missing ones.
- Regarding the component Risk Assessment, actions in accordance with new R&I anti-fraud guideline issued in June 2024 will be implemented in 2025. The Clean Hydrogen JU will continue with promoting anti-fraud trainings for majority of the staff and will continue with active participations in the FAIR meetings.
- Regarding the component Control Activities, trainings on cyber security awareness will be reinforced to cope with the increasing security threats. Following the cybersecurity regulation adopted at the end of 2023, a first assessment will be done in July 2025. Finally, to ensure a smooth transition from closed offices to open space in 2025, a business continuity plan will be put in place. This will allow that all the operations can be carried out properly during the renovation involving disposal of equipment, installation of new one, noise, dust and works while keeping professional and social connections between colleagues.

2.5.2. Financial procedures

The Clean Hydrogen JU shall fully comply with the requirements of the recast Regulation (EU, Euratom) 2024/2509 on the financial rules applicable to the general budget of the Union entering into force on 23 September 2024.

In compliance with its Article 71, the Joint Undertaking will respect the principle of sound financial management. It shall also comply with the provisions of the Financial Rules adopted in 2019. In compliance with its Article 70, any departure from this Model Financial Regulation, required for the purpose of the Joint Undertaking's specific needs, shall be subject to the Commission's prior consent.

Monitoring arrangements, including through the Union representation in the Governing Board, as well as reporting arrangements, will ensure that the Clean Hydrogen JU can meet the accountability requirements both to the College and to the Budgetary Authority.

With regard to ICT tools applied to support its financial procedures, since 2016, the JU has used ABAC Workflow. At the time of deployment of this tool, the JU adopted its financial procedures including the applicable Financial Circuits[378]. The financial procedures have been designed to guarantee a segregation of duties and to apply the four eyes principle in JU's financial transactions and describe in detail the financial circuits the JU implements per type of transactions and the roles and responsibilities of each actor involved. To a lesser extent, they also describe the basic principles on main procedures (grants & procurements).

In grant management, reporting and validation of costs for H2020 and Horizon Europe grants are done via the EC IT tools (SyGMa and COMPASS). Experts reports and validation of costs are supported by the EC IT tools (EMI and COMPASS). All payments are executed via the EC IT accounting tools (ABAC). The EC IT accounting tool ABAC LCK is used for contract management and reporting purposes.

2.5.3. Ex-ante and ex-post controls

The Clean Hydrogen JU shall fully comply with Article 74 of the recast Financial Regulation 2024/2509, that states that the Authorisation officer shall submit each transaction to ex ante controls and may, by delegation, put in place ex post controls.

Ex-ante controls

Ex-ante controls are essential to prevent errors and irregularities before the authorisation of operations, to mitigate the risks of non-achievement of the objective, and they avoid the need for ex-post corrective actions. An ex-ante control can take the form of checking grant agreements, initiating, checking and verifying invoices and cost claims, carrying out desk reviews (performed by Clean Hydrogen JU project, finance and legal officers); mid-term reviews carried out by external experts and ad-hoc technical reviews (when deemed necessary). Clean Hydrogen JU has developed elaborated procedures defining the controls to be performed by project and finance officers for every cost claim, invoice, commitment and payment taking into account risk-based and cost-effectiveness considerations.

In 2025, specific attention will be put to the following elements of ex-ante control:

- Financial webinars offered to learn and ask questions on the new Horizon Europe rules.
- Application of the feedback from ex-post audits and lessons learnt on ex-ante controls, e.g.; identification and red flags for most frequent H2020 errors identified by ex-post audits.
- Implementing the Horizon Europe ex-ante control strategy including risk fiches.
- Develop and apply a JU risk-based *ex-ante* controls methodology on Horizon Europe grant management cycles in order to prevent the error from being (re-) appearing (in the first place). The more significant the risk (detected), the higher the intensity of risk-based *ex-ante* controls.

Ex-post controls

Ex-post controls are defined as the controls executed to verify financial and operational aspects of finalised budgetary transactions in accordance with Article 19 of the JU Financial Rules.

The main objectives of the ex-post controls are to provide the individual Authorizing Officer

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with the necessary elements of assurance in a timely manner, thus allowing them to report on the budget expenditure for which they are responsible.

Ex-post controls on operational expenditure contribute in particular to:

- Assess the legality, regularity and sound financial management (economy, efficiency and effectiveness) have been respected,
- Provide an indication of the effectiveness of the related ex ante controls,
- Provide the basis for corrective and recovery activities, if necessary.

Ex post audits are performed by the common audit service (CAS) of DG RTD.

In 2025, focus will be put on the following:

- In cooperation with CAS, launch of new H2020 and Horizon Europe audits (based on analytical risk-profile review of the main beneficiaries and the JU's random sampling methodology.
- In cooperation with CAS, and in line with CAS Working Arrangements, ensure monitoring of timely completion of the audits.
- In cooperation with the CAS, implement the results of the ex-post audits on its beneficiaries.
- Provide adequate reporting through the budget discharge process.

As regards with the Horizon Europe (HE) programme, a new version of the Control Strategy for Horizon Europe was adopted in September 2023. The HE Control Strategy is characterised by a risk-based approach and details how the HE controls system will maintain a balance between economy, effectiveness and efficiency in the achievement of the HE programme goals.

2.5.4. Anti-fraud initiatives

To provide a framework for the activities related to battling fraud, the Common Audit Service (CAS), in collaboration with the Research Family, set up a Common Anti-Fraud Strategy in the Research Family (RAFS) taking into account the objectives and actions proposed in the Commission's Anti-Fraud Strategy (CAFS). In December 2023, an amended version of the RAFS was endorsed by the Horizon Europe Executive Committee.

In May 2024, the European Anti-Fraud Office (OLAF) published the "Methodology and guidance for the anti-fraud strategies of EU Decentralised Agencies and Joint Undertakings 2024", listing specific requirements.

In 2025, Clean Hydrogen JU will:

- Update the JU anti-fraud strategy in accordance with the RAFS 2023 and to OLAF 2024 methodological guidelines.
- Continue to apply harmonised preventive and detective measures for fraud detection.
- Continue to raise awareness amongst employees and participate to anti-fraud training sessions.
- Continue to participate to the Fraud and Irregularity Committee (FAIR) meetings

organised by DG R&I.

2.5.5. Audits

Internal audit service (IAS) of the Commission

Internal audits are carried out by the Internal Audit Service (IAS) of the European Commission in liaison with Internal Control and Audit Manager.

In 2024, the IAS completed the audit on operational synergies, raised two findings (one very important) and proposed several recommendations. The IAS also started the audit on the back-office arrangements (BOA)

The focus in 2025 will be to:

- Ensure that the agreed action plan regarding the audit on synergies is properly and timely implemented by the Joint Undertaking and provide assistance to the IAS in the follow up procedure.
- Provide input and assistance to the IAS in conducting the reviews of the back office arrangements (BOA).

European Court of Auditors (ECA)

As regards European Court of Auditors (ECA) audits, in 2025 the Clean Hydrogen JU will continue to :

- Liaise with the independent auditor to audit Clean Hydrogen JU accounts for 2024 as required by the Financial Rules of the Clean Hydrogen JU;
- Follow up and implement any recommendation made in the previous ECA reports on the Clean Hydrogen JU annual accounts;
- Provide the necessary information and support for ECA audit on 2024 and 2025 accounts;
- Assist and support ECA in their new horizontal audit for the JUs for 2025 (topic is still to be announced);
- Support the ECA team in their field or remote missions for Clean Hydrogen projects selected (on a sample basis) for an ex-post financial review, including follow-up with Clean Hydrogen JU beneficiaries and with the CAS.

3. BUDGET 2025

The 2025 budget covers all administrative and operational needs for the year.

It is noted that the budget of the JU shall be adapted to consider the amount of the Union contribution as laid down in the budget of the Union.

The following tables present revenues and expenditure in 2025 and a comparison with 2024 budget (as after its amendment in November 2024).

Revenues

The 2025 administrative budget will be financed by fresh appropriations under Horizon Europe, and by private members contributions.

The 2025 operational budget amounting to a total of 187 500 000 EUR will be financed by:

- Union existing commitments for completion lines (H2020).
- Horizon Europe operational appropriations will be financed by fresh appropriations of the Union and Union commitments entered in previous years.
- In addition, an amount of EUR 80,000,000 in terms of commitments and EUR 32,000,000 in terms of payments will be funded through third countries contribution and will finance additional hydrogen valleys.
- Additional third country credits for Clean Hydrogen JU of EUR 20,000,000 in terms of commitments in 2025 and EUR 15,000,000 in terms of payments.

These appropriations are complemented by reactivations of appropriations that became available in previous years and are introduced in the initial budget.

The table below provides an overview of the statement of revenues for 2025.

STATEMENT OF REVENUE										
Heading	**Title Chapter**	**Financial year 2024**				**Financial year 2025**				
		Commitment Appropriations	***% Ratio***	**Payment Appropriations**	***% Ratio***	**Commitment Appropriations**	***% Ratio***	**Payment Appropriations**	***% Ratio***	***Remarks***
EU contribution (excluding EFTA and third countries contribution)		117,777,030	55%	103,875,655	70%	88,378,873	45%	56,363,917	31%	
of which (fresh C1) Administrative (Title 1&2)		2,786,736	1%	2,786,736	2%	3,742,515	2%	3,742,515	2%	
of which frontloaded commitments (Title 1 and Title 2)	2002	790,664	0%	767,511	1%		0%		0%	
of which H2020 Operational (Title 3)	2005		0%	18,625,100	12%		0%	7,259,223	4%	
of which Horizon Europe Operational (Title 3)	2006	114,199,631	54%	81,696,308	55%	84,636,358	43%	45,362,179	25%	*In 2025 PA:54,038,002 from 2025 EC commitments, 4,187,156 from 2023 EC commitment (only HE) 28,060,858 from 2023 EC commitment (only HE) 37,089,864 from 2022 EC commitments.(HE and H2020)*
EFTA and third countries contribution		83,141,317	39%	39,572,478	27%	102,430,419	52%	48,519,519	27%	*Clean Hydrogen JU does not manage EFTA and third countries contribution directly. Therefore, EFTA lines will be added to the EU contribution as above*
of which Administrative EFTA(Title 1&2)	2002	98,650	0%	121,676	0%	102,919	0%	102,919	0%	EFTA 2025: for Horizon Europe calculated at 2.75%
of which Operational EFTA in H2020 (Title 3)	2005		0%	558,753	0%		0%	169,140	0%	EFTA 2025: for H2020 calculated at 2.33%

STATEMENT OF REVENUE										
Heading	**Title Chapter**	**Financial year 2024**				**Financial year 2025**				
		Commitment Appropriations	***% Ratio***	**Payment Appropriations**	***% Ratio***	**Commitment Appropriations**	***% Ratio***	**Payment Appropriations**	***% Ratio***	***Remarks***
of which Operational EFTA in Horizon Europe (Title 3)	2006	4,042,667	2%	2,892,049	2%	2,327,500	1%	1,247,460	1%	EFTA 2025: for Horizon Europe calculated at 2.75%
of which operational third countries excluding EFTA (Title 3)	2006	79,000,000	37%	36,000,000	24%	100,000,000	51%	47,000,000	26%	80,000,000 in CA and 32,000,000 in PA in Horizon Europe line in 2025 (RePowerEU2025) 20,000,000 in CA and 15,000,000 in PA in Horizon Europe line in 2025 (UK Contribution)
Financial Members other than the Union contribution		3,676,050	2%	3,675,923	2%	3,845,434	2%	3,845,434	2%	
Hydrogen Europe contribution to administrative costs	2003	3,161,403	1%	3,161,293	2%	3,307,073	2%	3,307,073	2%	
Hydrogen Europe Research contribution to administrative costs	2004	514,647	0%	514,629	0%	538,361	0%	538,361	0%	
Unused appropriations from previous years		7.969.743	4%	1,108,161	1%	1,819,722	1%	70,621,458	39%	
Of which administrative 2021	3021		0%	594,857	0%		0%		0%	
Of which administrative 2022	3022	404,216	0%	513,304	0%	1,283,580	1%	1,283,580	1%	
Of which operational 2022	3020	528,578	0%		0%	127,286	0%	37,089,864	21%	
Of which operational 2023	3023	7,036,949	3%		%	408,856	0%	28,060,858	16%	
Of which operational 2024	3024						0%	4,187,156	2%	
TOTAL REVENUE		**212.564.141**		**148.232.217**		**196,474,448**		**179,350,328**		

Expenditure

Overall, the administrative budget (Titles 1 and 2) will show an increase by 6% compared to 2024. In more details:

Title 1 - Staff

Title 1 (staff costs) represents 61% of the administrative budget for 2025 and will increase by 8% overall compared to 2024. It covers salaries and allowances for staff and external personnel as presented in the establishment plan under section 2.3.4.3. Title 1 also includes mission expenses, training and socio-medical costs, expenditure related to recruitment, reception, events and representational costs. External services costs include interim staff and trainees, installation allowance, daily subsistence and the costs of Paymaster Office of the European Commission (PMO) services.

Salaries and allowances for staff in the establishment plan (Temporary Agents) will show an increase by 11% compared to 2024 due to the expected salary update of +1,2% to be applied as from 1 April 2025 and +3,4% to be applied as from 1 July 2025. An additional 6% is the effect of step advancements and reclassifications as in the staff establishment plan.

Salaries and allowances for external personnel (Contract Agents and Seconded National Experts) will show an increase by 1% compared to 2024 provisions, due to salaries adjustments, as explained above.

Training costs decrease by 47% compared to 2024 provision. This reduction is primarily due to an unexpected budget increase in 2024, which was necessary to accommodate the team-building event.

External services will show a decrease by 23% compared to 2024 provision, returning to the normal level required for 2 FTAs.

Expenditure related to recruitment, mission expenses, socio-medial infrastructure and representational costs will remain at 2024 levels, as no additional needs are identified.

Title 2 - Infrastructure and operating costs

Title 2 (infrastructure and operating costs) represents 39% of the administrative budget for 2025 and will increase by 2% compared to 2024.

Rental and building costs are expected to increase by 3% as they return to normal levels following the temporary increase in 2024 due to refurbishment. Additionally, new furniture and IT equipment acquired as part of this refurbishment will result in an exceptional increase in movable property and associated costs in 2025, which will be covered by reactivating past appropriations.

IT costs will increase by 15%, as a consequence of the onboarding fees for HRT and SUMMA in 2025. The same applies for the increase by 2% in information and communication costs and meeting expenses and by 3% in current administrative expenditure.

On the other side, there will be a 22% decrease to telecommunication and postage costs as there are not expected in 2025 adjustments in telephony contracts due to inflation as it was the case in previous years.

Running costs in connection with operational activities include requirements for project technical assistants. These needs are expected to remain nearly stable in 2025, as technical assistance will be needed in support of the Horizon Europe grant agreement preparations for the whole year.

Title 3 - Operational costs

2025 budget includes:

H2020: payment appropriations for 17 payments (16 final and 1 interim) as well as procurement activities financed by this budget.

Horizon Europe: Commitment appropriations will cover for the Call of 2025, JRC collaboration as announced in section 2.2.4.3, operational procurement activities as described in section 2.2.4.1 and experts (evaluators and reviewers), the latter estimated for an amount of EUR 500,000. Commitment appropriations also include a EUR 80,000,000 provision on funding additional valleys through grants, as explained in sections 2.2.3 above and an additional funding of EUR 20,000,000 included in the Call 2025.

Payment appropriations will cover 63 payments (1 final and 62 interim) as well as procurement activities financed by this budget. In addition payment appropriations will cover for the entire pre-financings to grants expected to be signed in the beginning of 2025 (relating to the 2nd GB decision on call 2024) and Call 2025. Finally, there is a provision for pre-financing to grants expected to be signed under hydrogen valleys.

Note on Call 2025 budget:

In accordance with the General Annexes of the Horizon Europe Work Programme 2023-2024 (European Commission Decision C(2022)7550 of 6 December 2022), with regard to budget flexibility, the budgets set out in the calls and topics are indicative. Unless otherwise stated, final budgets may change following evaluation. The final figures may change by up to 20% compared to the total budget indicated in each individual part of the Work Programme. Changes within these limits will not be considered substantial within the meaning of Article 110(5) of Regulation (EU, Euratom) No 2018/1046**.**

STATEMENT OF EXPENDITURE								
Heading	Title Chapter	Financial year 2024		Financial year 2025				Remarks
		Commitment Appropriations	Payment Appropriations	Commitment Appropriations	% Ratio 2024/2023	Payment Appropriations	% Ratio 2024/ 2023	
1- Staff costs		***5,168,000***	***5,168,000***	***5,591,720***	***108%***	***5,591,720***	***108%***	
Salaries and allowances	11	4,689,000	4,689,000	5,215,000	111%	5,215,000	111%	
- Of which establishment plan posts	1101	4,303,000	4,303,000	4,825,000	112%	4,825,000	112%	Includes: Basic salaries for temporary staff and contract agents, family allowances, expatriation and foreign residence allowances, unemployment insurance, insurance against accidents and occupational disease, annual travel costs
- Of which external personnel	1102	386,000	386,000	390,000	101%	390,000	101%	Includes: Salaries, entitlements and allowances for Contract Agents and Seconded National Experts
Expenditure relating to Staff recruitment	1200	5,000	5,000	5,000	100%	5,000	100%	Miscellaneous expenditure on staff recruitment (travel expenses for interviews)
Mission expenses	1300	68,000	68,000	70,000	100%	70,000	100%	Mission claims and travel agency tickets
Socio-medical infrastructure	1401	15,000	15,000	15,000	100%	15,000	100%	Medical service and mobility costs
Training	1402	57,000	57,000	30,000	53%	30,000	53%	Training costs
External Services	1500	330,000	330,000	252,720	77%	252,720	77%	Includes: Interim staff and trainees Installation allowance, daily subsistence, resettlement allowance and removal costs for staff arriving/departing Cost of PMO provisions
Receptions, events and representation	1600	4,000	4,000	4,000	100%	4,000	100%	Representation, events and receptions
2-Infrastructure and operating		***3.330.614***	***3,925,471***	***3,382,728***	***102%***	***3,382,728***	***86%***	
Rental of buildings and associated costs	2000	480,000	830,000	494,000	103%	494,000	60%	Rent, works, insurance, common charges (water/gas/electricity), maintenance, security, and surveillance. Minor refurbishment.
Information, communication	2100	449,847	449,847	515,500	115%	515,500	115%	IT purchases, hardware and software, licences, software development

STATEMENT OF EXPENDITURE								
Heading	Title Chapter	Financial year 2024		Financial year 2025				Remarks
		Commitment Appropriations	Payment Appropriations	Commitment Appropriations	% Ratio 2024/2023	Payment Appropriations	% Ratio 2024/ 2023	
technology and data processing								
Movable property and associated costs	2200	5,000	249,857	5,000	100%	5,000	2%	Purchases and rental of office equipment, maintenance, and repair
Current administrative expenditure	2300	9,270	9,270	9,548	103%	9,548	103%	Office supplies, library, translation service, bank charges and miscellaneous office expenditure
Postage / Telecommunications	2400	8,998	8,998	7,000	78%	7,000	78%	Telephones, video conferences and postal services
Meeting expenses	2500	52,000	52,000	54,000	104%	54,000	104%	Official meetings such as SRG, Scientific Committee, Governing Board and caterings
Information and publishing	2600	786,500	786,500	800,500	102%	800,500	102%	External communication and events
Running costs in connection with operational activities	2700	1,539,000	1,539,000	1,497,180	97%	1,497,180	97%	Project technical assistance, audits, consulting activities and accounting services with DG BUDG
TOTAL ADMINISTRATIVE COSTS (1+2)		8.498.614	9,093,471	8,974,448	106%	8,974,448	99%	
3-Operational		***204,065,527***	***139.138.746***	***187,500,000***	***92%***	***170,375,880***	***122%***	
H2020	3002		19.081.415			11,478,514	60%	This appropriation shall cover the operational costs of the JU regarding H2020 grants (interim and final payments) andstudies.
HORIZON EUROPE	3003	204,065,527	120,057,331	187,500,000	92%	158,897,366	132%	This appropriation shall cover the operational costs of the JU regarding Horizon Europe grants (pre-financings), studies, JRC contribution and experts.
TOTAL EXPENDITURE		**12.564.141**	**148.232.217**	**196,474,448**	**92%**	**179,350,328**	**121%**	

4. ANNEXES

4.1. In-kind contribution for additional activities (IKAA) Plan

Hydrogen Europe Industry and Hydrogen Europe Research Members of the Clean Hydrogen Joint Undertaking - are hereby jointly submitting their Additional Activities Plan covering the period of 1 January 2025 – 31 December 2025.

The Plan includes Additional Activities for a total amount of EUR 238.96 million.

For the reporting of the annual additional activities plan annexed to the main part of the work programme, a scope of the additional activities is presented according to categories in line with the Article 78 of the COUNCIL REGULATION (EU) 2021/2085.

As required by the COUNCIL REGULATION, the additional activities included in the plan should contribute to the objectives the Clean Hydrogen Joint Undertaking. Therefore, each activity included in the annual plan is linked to one of the objectives of the Clean Hydrogen Joint Undertaking, as per Article 73.

For confidentiality purposes, only aggregated values of the additional activities are presented in the table below.

DETAILED ESTIMATED IKAA FOR 2025		
Detailed description of the AA	**Type of contributor**	**Estimated value AA for 2025 (in M€)**
A Pre-commercial trials and field tests		
A To contribute to the objectives set out in the communication from the Commission of 17 September 2020 on Stepping up Europe's 2030 climate ambition: Investing in a climate-neutral future for the benefit of our people, the European Green Deal and the European Climate Law by raising the Union's ambition on reducing greenhouse gas emissions to at least 55 % below 1990 levels by 2030, and climate neutrality at the latest by 2050	Private members	0.00
B To contribute to the implementation of the 2020 European Commission's Hydrogen Strategy for a climate neutral Europe	Private members	0.00
C To strengthen the competitiveness of the Union clean hydrogen value chain, with a view to supporting, in particular for SMEs, the acceleration of the market entry of innovative competitive clean solution	Private members	0.00
D To stimulate research and innovation on clean hydrogen production, distribution, storage and end use applications	Private members	0.04
E Improve, through research and innovation, including activities related to lower TRLs, the cost-effectiveness, efficiency, reliability, quantity and quality of clean hydrogen solutions, including production, distribution, storage and end uses developed in the Union	Private members	31.93
F Strengthen the knowledge and capacity of scientific and industrial actors along the Union's hydrogen value chain while supporting the uptake of industry-related skills	Private members	0.00
G Carry out demonstrations of clean hydrogen solutions with a view to local, regional and Union-wide deployment, aiming to involve stakeholders in all Member States and addressing renewable production, distribution, storage and use for transport and energy-intensive industries as well as other applications	Private members	0.00
SUB TOTAL (A)		**31.97**

DETAILED ESTIMATED IKAA FOR 2025		
Detailed description of the AA	**Type of contributor**	**Estimated value AA for 2025 (in M€)**
B Proof of concept		
A To contribute to the objectives set out in the communication from the Commission of 17 September 2020 on Stepping up Europe's 2030 climate ambition: Investing in a climate-neutral future for the benefit of our people, the European Green Deal and the European Climate Law by raising the Union's ambition on reducing greenhouse gas emissions to at least 55 % below 1990 levels by 2030, and climate neutrality at the latest by 2050	Private members	0.00
B To contribute to the implementation of the 2020 European Commission's Hydrogen Strategy for a climate neutral Europe	Private members	7.00
C To strengthen the competitiveness of the Union clean hydrogen value chain, with a view to supporting, in particular for SMEs, the acceleration of the market entry of innovative competitive clean solution	Private members	0.15
D To stimulate research and innovation on clean hydrogen production, distribution, storage and end use applications	Private members	1.51
E Improve, through research and innovation, including activities related to lower TRLs, the cost-effectiveness, efficiency, reliability, quantity and quality of clean hydrogen solutions, including production, distribution, storage and end uses developed in the Union	Private members	0.30
F Strengthen the knowledge and capacity of scientific and industrial actors along the Union's hydrogen value chain while supporting the uptake of industry-related skills	Private members	0.00
G Carry out demonstrations of clean hydrogen solutions with a view to local, regional and Union-wide deployment, aiming to involve stakeholders in all Member States and addressing renewable production, distribution, storage and use for transport and energy-intensive industries as well as other applications	Private members	0.10
SUB TOTAL (B)		**9.06**

DETAILED ESTIMATED IKAA FOR 2025		
Detailed description of the AA	**Type of contributor**	**Estimated value AA for 2025 (in M€)**
C Improvement of existing production lines for up-scaling		
A To contribute to the objectives set out in the communication from the Commission of 17 September 2020 on Stepping up Europe's 2030 climate ambition: Investing in a climate-neutral future for the benefit of our people, the European Green Deal and the European Climate Law by raising the Union's ambition on reducing greenhouse gas emissions to at least 55 % below 1990 levels by 2030, and climate neutrality at the latest by 2050	Private members	0.00
B To contribute to the implementation of the 2020 European Commission's Hydrogen Strategy for a climate neutral Europe	Private members	3.04
C To strengthen the competitiveness of the Union clean hydrogen value chain, with a view to supporting, in particular for SMEs, the acceleration of the market entry of innovative competitive clean solution	Private members	0.01
D To stimulate research and innovation on clean hydrogen production, distribution, storage and end use applications	Private members	0.00
E Improve, through research and innovation, including activities related to lower TRLs, the cost-effectiveness, efficiency, reliability, quantity and quality of clean hydrogen solutions, including production, distribution, storage and end uses developed in the Union	Private members	0.00
F Strengthen the knowledge and capacity of scientific and industrial actors along the Union's hydrogen value chain while supporting the uptake of industry-related skills	Private members	0.13
G Carry out demonstrations of clean hydrogen solutions with a view to local, regional and Union-wide deployment, aiming to involve stakeholders in all Member States and addressing renewable production, distribution, storage and use for transport and energy-intensive industries as well as other applications	Private members	0.00
SUB TOTAL (C)		**3.18**

DETAILED ESTIMATED IKAA FOR 2025		
Detailed description of the AA	**Type of contributor**	**Estimated value AA for 2025 (in M€)**
D Large scale case studies		
A To contribute to the objectives set out in the communication from the Commission of 17 September 2020 on Stepping up Europe's 2030 climate ambition: Investing in a climate-neutral future for the benefit of our people, the European Green Deal and the European Climate Law by raising the Union's ambition on reducing greenhouse gas emissions to at least 55 % below 1990 levels by 2030, and climate neutrality at the latest by 2050	Private members	0.00
B To contribute to the implementation of the 2020 European Commission's Hydrogen Strategy for a climate neutral Europe	Private members	0.00
C To strengthen the competitiveness of the Union clean hydrogen value chain, with a view to supporting, in particular for SMEs, the acceleration of the market entry of innovative competitive clean solution	Private members	78.20
D To stimulate research and innovation on clean hydrogen production, distribution, storage and end use applications	Private members	0.00
E Improve, through research and innovation, including activities related to lower TRLs, the cost-effectiveness, efficiency, reliability, quantity and quality of clean hydrogen solutions, including production, distribution, storage and end uses developed in the Union	Private members	0.00
F Strengthen the knowledge and capacity of scientific and industrial actors along the Union's hydrogen value chain while supporting the uptake of industry-related skills	Private members	0.08
G Carry out demonstrations of clean hydrogen solutions with a view to local, regional and Union-wide deployment, aiming to involve stakeholders in all Member States and addressing renewable production, distribution, storage and use for transport and energy-intensive industries as well as other applications	Private members	0.00
SUB TOTAL (D)		**78.28**

DETAILED ESTIMATED IKAA FOR 2025		
Detailed description of the AA	**Type of contributor**	**Estimated value AA for 2025 (in M€)**
E Awareness-raising activities on hydrogen technologies and safety measures		
A To contribute to the objectives set out in the communication from the Commission of 17 September 2020 on Stepping up Europe's 2030 climate ambition: Investing in a climate-neutral future for the benefit of our people, the European Green Deal and the European Climate Law by raising the Union's ambition on reducing greenhouse gas emissions to at least 55 % below 1990 levels by 2030, and climate neutrality at the latest by 2050	Private members	0.00
B To contribute to the implementation of the 2020 European Commission's Hydrogen Strategy for a climate neutral Europe	Private members	0.00
C To strengthen the competitiveness of the Union clean hydrogen value chain, with a view to supporting, in particular for SMEs, the acceleration of the market entry of innovative competitive clean solution	Private members	0.00
D To stimulate research and innovation on clean hydrogen production, distribution, storage and end use applications	Private members	0.00
E Improve, through research and innovation, including activities related to lower TRLs, the cost-effectiveness, efficiency, reliability, quantity and quality of clean hydrogen solutions, including production, distribution, storage and end uses developed in the Union	Private members	1.75
F Strengthen the knowledge and capacity of scientific and industrial actors along the Union's hydrogen value chain while supporting the uptake of industry-related skills	Private members	0.10
G Carry out demonstrations of clean hydrogen solutions with a view to local, regional and Union-wide deployment, aiming to involve stakeholders in all Member States and addressing renewable production, distribution, storage and use for transport and energy-intensive industries as well as other applications	Private members	0.00
SUB TOTAL (E)		**1.85**

DETAILED ESTIMATED IKAA FOR 2025		
Detailed description of the AA	**Type of contributor**	**Estimated value AA for 2025 (in M€)**
F Uptake of results from projects into products, further exploitation and activities within the research chain either at higher TRLs or in parallel strands of activity		
A To contribute to the objectives set out in the communication from the Commission of 17 September 2020 on Stepping up Europe's 2030 climate ambition: Investing in a climate-neutral future for the benefit of our people, the European Green Deal and the European Climate Law by raising the Union's ambition on reducing greenhouse gas emissions to at least 55 % below 1990 levels by 2030, and climate neutrality at the latest by 2050	Private members	0.00
B To contribute to the implementation of the 2020 European Commission's Hydrogen Strategy for a climate neutral Europe	Private members	0.00
C To strengthen the competitiveness of the Union clean hydrogen value chain, with a view to supporting, in particular for SMEs, the acceleration of the market entry of innovative competitive clean solution	Private members	9.14
D To stimulate research and innovation on clean hydrogen production, distribution, storage and end use applications	Private members	0.08
E Improve, through research and innovation, including activities related to lower TRLs, the cost-effectiveness, efficiency, reliability, quantity and quality of clean hydrogen solutions, including production, distribution, storage and end uses developed in the Union	Private members	0.53
F Strengthen the knowledge and capacity of scientific and industrial actors along the Union's hydrogen value chain while supporting the uptake of industry-related skills	Private members	0.00
G Carry out demonstrations of clean hydrogen solutions with a view to local, regional and Union-wide deployment, aiming to involve stakeholders in all Member States and addressing renewable production, distribution, storage and use for transport and energy-intensive industries as well as other applications	Private members	0.00
SUB TOTAL (F)		**9.75**

DETAILED ESTIMATED IKAA FOR 2025		
Detailed description of the AA	**Type of contributor**	**Estimated value AA for 2025 (in M€)**
G The research and innovation activities or projects with a clear link to the Strategic Research and Innovation Agenda, and co-funded under national or regional programmes within the Union		
A To contribute to the objectives set out in the communication from the Commission of 17 September 2020 on Stepping up Europe's 2030 climate ambition: Investing in a climate-neutral future for the benefit of our people, the European Green Deal and the European Climate Law by raising the Union's ambition on reducing greenhouse gas emissions to at least 55 % below 1990 levels by 2030, and climate neutrality at the latest by 2050	Private members	3.42
B To contribute to the implementation of the 2020 European Commission's Hydrogen Strategy for a climate neutral Europe	Private members	0.00
C To strengthen the competitiveness of the Union clean hydrogen value chain, with a view to supporting, in particular for SMEs, the acceleration of the market entry of innovative competitive clean solution	Private members	0.13
D To stimulate research and innovation on clean hydrogen production, distribution, storage and end use applications	Private members	33.49
E Improve, through research and innovation, including activities related to lower TRLs, the cost-effectiveness, efficiency, reliability, quantity and quality of clean hydrogen solutions, including production, distribution, storage and end uses developed in the Union	Private members	56.64
F Strengthen the knowledge and capacity of scientific and industrial actors along the Union's hydrogen value chain while supporting the uptake of industry-related skills	Private members	0.65
G Carry out demonstrations of clean hydrogen solutions with a view to local, regional and Union-wide deployment, aiming to involve stakeholders in all Member States and addressing renewable production, distribution, storage and use for transport and energy-intensive industries as well as other applications	Private members	0.08
SUB TOTAL (G)		**94.41**

DETAILED ESTIMATED IKAA FOR 2025		
Detailed description of the AA	**Type of contributor**	**Estimated value AA for 2025 (in M€)**
H Other, contributing to the JU objectives		
A To contribute to the objectives set out in the communication from the Commission of 17 September 2020 on Stepping up Europe's 2030 climate ambition: Investing in a climate-neutral future for the benefit of our people, the European Green Deal and the European Climate Law by raising the Union's ambition on reducing greenhouse gas emissions to at least 55 % below 1990 levels by 2030, and climate neutrality at the latest by 2050	Private members	0.10
B To contribute to the implementation of the 2020 European Commission's Hydrogen Strategy for a climate neutral Europe	Private members	0.00
C To strengthen the competitiveness of the Union clean hydrogen value chain, with a view to supporting, in particular for SMEs, the acceleration of the market entry of innovative competitive clean solution	Private members	10.00
D To stimulate research and innovation on clean hydrogen production, distribution, storage and end use applications	Private members	0.30
E Improve, through research and innovation, including activities related to lower TRLs, the cost-effectiveness, efficiency, reliability, quantity and quality of clean hydrogen solutions, including production, distribution, storage and end uses developed in the Union	Private members	0.03
F Strengthen the knowledge and capacity of scientific and industrial actors along the Union's hydrogen value chain while supporting the uptake of industry-related skills	Private members	0.00
G Carry out demonstrations of clean hydrogen solutions with a view to local, regional and Union-wide deployment, aiming to involve stakeholders in all Member States and addressing renewable production, distribution, storage and use for transport and energy-intensive industries as well as other applications	Private members	0.03
SUB TOTAL (H)		**10.46**

4.2. Link of Clean Hydrogen JU operational activities with its Strategy Map

Table 3. Clean Hydrogen JU Strategy Map: Actions, Outcomes and Impacts

Operational level resources and actions (Linked to the JU's objectives and additional tasks in the SBA and the strategy map)	**Action-1** Supporting climate neutral and sustainable solutions
	Action-2 Research and Innovation for hydrogen technologies
	Action-3 Supporting market uptake of clean hydrogen applications
Specific level outcomes (Linked to the JU's specific objectives in the SBA and the strategy map)	**Outcome-1** Limiting the environmental impact of hydrogen technology applications
	Outcome-2 Improving the cost-effectiveness of clean hydrogen solutions
	Outcome-3 Demonstrating clean hydrogen solutions, in synergy with other partnerships
	Outcome-4 Increasing public awareness and uptake of hydrogen technologies
	Outcome-5 Reinforcing EU scientific and industrial ecosystem, including SMEs
General Level Impacts (Linked to the general objectives in the SBA specific to the JU, the priorities of the Union and the strategy map of the JU)	**Impact-1** Action against climate change by drastically reducing greenhouse gas emissions
	Impact-2 Transition to a clean energy system with renewable hydrogen as one of its main pillars
	Impact-3 Emergence of a competitive and innovative European hydrogen value chain

Table 4. Criteria for linking Clean Hydrogen JU activities with Strategic Objectives

Strategy Map Objective	Criteria for linking Activities with Objectives
Resources (input), processes and activities	
1. Supporting sustainable solutions	The activity should target either the hard to abate sectors (industry, heavy-duty transport) or have as an objective or KPI linked to sustainability
2. R&I for hydrogen technologies	The activity should either start with TRL up to 3 or end with TRL of at least 7.
3. Supporting market uptake of clean hydrogen applications	Either activities addressing education and training, or activities related to the monitoring of technology progress, RCS or international initiatives.
Outcomes	
4. Limiting the environmental impact	The activity should have as an objective or KPI linked to sustainability
5. Improving cost-effectiveness	The activity should have as an objective or KPI linked to the reduction of CAPEX or increase of efficiency
6. Synergies with other partnerships	The activity should demonstrate synergies with other partnerships or Programmes
7. Increasing Public Awareness	The activity should have as an objective to measure or affect the awareness in relation to hydrogen technologies.
8. Reinforcing EU scientific and industrial ecosystem, including SMEs	Either activities promoting research, education and training or ones strengthening the links between various parts of hydrogen value chain and SMEs
Impacts	
9. Reducing GHG emissions	The activity should have a direct or indirect impact on the reduction of GHG emissions, e.g. through clean hydrogen production or consumption
10. Energy transition with renewable hydrogen	The activity should have a direct or indirect impact on the production or use of renewable hydrogen
11. Competitive and innovative European hydrogen value chain	The activity should have a direct or indirect impact on the reduction of cost of hydrogen (to make it more competitive), the innovation aspects of hydrogen or the strengthening of the value chain.

Table 5. Expected contribution of operational actions to Strategy Map elements[379]

Operational Activities	Operational level resources and actions			Specific level outcomes					General Level Impacts		
	Action 1	Action 2	Action 3	Outcome 1	Outcome 2	Outcome 3	Outcome 4	Outcome 5	Impact 1	Impact 2	Impact 3
Calls for Proposals											
HORIZON-JTI-CLEANH2-2025-01-01	✓	✓		✓	✓			✓		✓	✓
HORIZON-JTI-CLEANH2-2025-01-02	✓	✓		✓	✓			✓		✓	✓
HORIZON-JTI-CLEANH2-2025-01-03	✓	✓		✓	✓			✓		✓	✓
HORIZON-JTI-CLEANH2-2025-01-04	✓		✓		✓				✓	✓	✓
HORIZON-JTI-CLEANH2-2025-01-05		✓		✓	✓			✓		✓	✓
HORIZON-JTI-CLEANH2-2025-01-06	✓	✓		✓				✓	✓		
HORIZON-JTI-CLEANH2-2025-01-07		✓	✓					✓			✓
HORIZON-JTI-CLEANH2-2025-02-01		✓	✓		✓			✓			✓
HORIZON-JTI-CLEANH2-2025-02-02		✓			✓						✓
HORIZON-JTI-CLEANH2-2025-02-03		✓	✓		✓	✓				✓	✓
HORIZON-JTI-CLEANH2-2025-03-01	✓	✓	✓	✓	✓				✓	✓	
HORIZON-JTI-CLEANH2-2025-03-02		✓			✓	✓			✓		✓
HORIZON-JTI-CLEANH2-2025-03-03	✓		✓		✓	✓		✓	✓	✓	
HORIZON-JTI-CLEANH2-2025-04-01	✓	✓	✓	✓	✓		✓		✓	✓	
HORIZON-JTI-CLEANH2-2025-05-01		✓		✓	✓						✓
HORIZON-JTI-CLEANH2-2025-05-02	✓			✓							✓

[379] Based on the description of the relevant topics. Exact correspondence with KPIs to be determined based on the selected proposal for each topic.

Operational Activities	Operational level resources and actions			Specific level outcomes					General Level Impacts		
	Action 1	Action 2	Action 3	Outcome 1	Outcome 2	Outcome 3	Outcome 4	Outcome 5	Impact 1	Impact 2	Impact 3
HORIZON-JTI-CLEANH2-2025-05-03			✓					✓			✓
HORIZON-JTI-CLEANH2-2025-06-01	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓
HORIZON-JTI-CLEANH2-2025-06-02	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓
Other Activities											
Support to EU Policies			✓			✓	✓	✓			✓
Knowledge Management			✓			✓	✓	✓			✓
Collaboration with other entities			✓			✓	✓	✓			✓
RCS SC			✓				✓	✓			✓
EHSP			✓				✓	✓			✓
EHS & CP	✓		✓	✓			✓	✓			✓
International Cooperation			✓				✓	✓			✓
Communication			✓				✓	✓			✓
Dissemination & Exploitation			✓				✓	✓			✓
Procurement -01: Legal and administrative processes relevant to FC and hydrogen technologies			✓					✓			✓
Procurement -02 Hydrogen in Port Environments	✓		✓				✓	✓	✓	✓	
Procurement-03 – e-HRS Availability Study	✓		✓					✓			✓

4.3. Renewable Hydrogen Production. Objectives of the Clean Hydrogen JU addressed in the Call for Proposals 2025

The following tables indicate the contribution of each of the topics included in the Call for Proposals to the objectives of the Clean Hydrogen JU SRIA.

Where a topic addresses an objective directly this is shown with an “X”. When an objective is addressed indirectly by a topic this is show as a “O”.

Renewable Hydrogen Electrolysis	*Type of Action*	Reducing electrolyser CAPEX and OPEX	Improving dynamic operation and efficiency, with high durability and reliability, especially when operating dynamically	Increasing current density and decreasing footprint	Demonstrate the value of electrolysers for the power system through their ability to provide flexibility and allow higher integration of renewables	Ensure circularity by design for materials and for production processes, minimising the life-cycle environmental footprint of electrolysers, increasing recycling rates of critical materials and optimising the use of drinking water	Increasing the scale of deployment	Improved manufacturing for both water and steam electrolysis	Improve the efficiency and reduce the footprint of electrolyser's Balance of Plant (BoP)
HORIZON-JU-CLEANH2-2025-01-01 Improvements in lifetime and cost of low temperature electrolysers by introducing advanced materials and components in stacks and balance of plant	RIA	X		O		O			X
HORIZON-JU-CLEANH2-2025-01-02 Improved lifetime and cost of high-temperature electrolysers by introducing innovative materials and components in stacks and BoP	RIA	X				O			X
HORIZON-JU-CLEANH2-2025-01-03 Scale-up and Optimisation of manufacturing processes for electrolyser materials, cells, or stacks	RIA	O					O	X	
HORIZON-JU-CLEANH2-2025-01-04 Efficient electrolysis coupling with variable renewable electricity and/or heat integration	IA		X		X				O
HORIZON-JU-CLEANH2-2025-01-05 Innovative co-electrolysis systems and integration with downstream processes utilisation	RIA	O			X				

Renewable Hydrogen **Other routes of renewable hydrogen production**	*Type of Action*	Reducing CAPEX and OPEX	Improving the efficiency of processes	Increasing carbon yield for processes based on biomass/raw biogas (kg hydrogen / kg carbon)	Scaling up
HORIZON-JU-CLEANH2-2025-01-06 Innovative hydrogen and solid carbon production from renewable gases/biogenic waste processes	IA	O	O	X	
HORIZON-JU-CLEANH2-2025-01-07 Towards exploration and evaluation of European natural hydrogen potential	RIA	O			O

4.4. Hydrogen Storage and Distribution. Objectives of the Clean Hydrogen JU addressed in the Call for Proposals 2025

The following tables indicate the contribution of each of the topics included in the Call for Proposals to the objectives of the Clean Hydrogen JU SRIA.

Where a topic addresses an objective directly this is shown with an “X”. When an objective is addressed indirectly by a topic this is show as a “O”.

Hydrogen storage and distribution Hydrogen Storage	*Type of action*	To undertake research aimed at improving cost and efficiency of aboveground storage solutions.	To demonstrate distributed aboveground storage solutions available at a capital cost lower than 300 €/kg by 2030	To undertake research activities on underground storage to validate the performance in different geologies, to identify better and more cost effective materials and to encourage improved designs.	Demonstrate the large-scale underground storage across various media at a capital cost lower than 30 €/kg by 2030
HORIZON-JU-CLEANH2-2025-02-01 Development of mined, lined rock cavern for gaseous hydrogen storage	RIA			X	O

Hydrogen storage and distribution Hydrogen in the Natural Gas Grid	*Type of Action*	Development of technologies and materials to explore and support the transportation of H2 via the natural gas grid	Enable through research and demonstration activities the transportation of hydrogen through the natural gas grid either by blending or via repurposing to 100% hydrogen
n/a			

Hydrogen storage and distribution Liquid Hydrogen Carriers	*Type of action*	To increase the efficiency and reduce the costs of hydrogen liquefaction technologies.	To contribute to the roll-out of next generation liquefaction technology to new bulk hydrogen production plants.	To continue the research on carrier cycling performance, chemistries, catalysis and reactors which show potential for improved roundtrip efficiency and life cycle assessment.	Develop a range of hydrogen carriers that will be used commercially to transport and store hydrogen while improving their roundtrip efficiency and lowering their cost.
HORIZON-JU-CLEANH2-2025-02-03 Demonstration of scalable ammonia cracking technology	IA			X	X

Hydrogen storage and distribution Improving Existing Hydrogen Transport means	*Type of Action*	To increase the pressure and capacity for new builds of 100% hydrogen pipelines while reducing their cost.	To reduce road transport costs of compressed hydrogen by increasing the capacity of tube trailers.	To improve the efficiency of road transport of liquid hydrogen while reducing costs.	To enable scale-up of solutions for shipping of bulk liquid hydrogen and support its commercialisation.
n/a					

Hydrogen storage and distribution **Compression, Purification and Metering Solutions**	*Type of Action*	To develop more efficient compressor and purification technologies	To reduce the total cost of ownership of compression and purification technologies	To reduce the energy and consumption and increase the recovery factor of purification technologies	To increase the reliability and lifetime of compression and purification technologies	To improve metering technologies and standards, especially in terms of accuracy and protocols.
HORIZON-JU-CLEANH2-2025-02-02 Development of cost effective and high-capacity compression solutions for hydrogen	RIA	X	X		X	

Hydrogen storage and distribution **Hydrogen Refuelling Stations (HRS)**	*Type of Action*	To tackle the technical challenges associated with heavy-duty hydrogen refuelling stations in order to develop a commercial solution that conforms to the heavy-duty requirements;	To increase the reliability and availability of Hydrogen Refuelling Stations;	To support the creation of a network of Heavy-duty HRS across Europe;	To decrease the total cost of ownership of Hydrogen Refuelling Stations.
HORIZON-JU-CLEANH2-2025-06-01: Large-scale Hydrogen Valley **HORIZON-JU-CLEANH2-2025-06-02: Small-scale Hydrogen Valley**				O	

4.5. Hydrogen end uses: Transport. Objectives of the Clean Hydrogen JU addressed in the Call for Proposals 2025

The following tables indicate the contribution of each of the topics included in the Call for Proposals to the objectives of the Clean Hydrogen JU SRIA.

Where a topic addresses an objective directly this is shown with an “X”. When an objective is addressed indirectly by a topic this is show as a “O”.

Hydrogen end uses: Transport applications **Building Blocks**	*Type of Action*	Improving overall system performance for fuel cell stack technology in terms of power density, reliability and durability	Reduction or replacement of PGM loadings and development of new materials advancing the performance of on-board storage technology;	Improvements in design, health monitoring and manufacturability of core components for fuel cell stacks and on-board storage technology;	Extending the EU leadership on FC production from automotive to maritime and aviation, given the high pressure for decarbonisation of these sectors.
HORIZON-JU-CLEANH2-2025-03-01 Configurable Fuel Cell Powertrain for Non-Road Mobile Machinery	RIA	X			O
HORIZON-JU-CLEANH2-2025-03-02 Scalable innovative processes for the production of PEMFC MEAs	RIA	O	O	X	O
HORIZON-JU-CLEANH2-2025-03-03 Reliable, efficient, scalable and lower cost 1 MW-scale PEMFC system for maritime applications	RIA	O		O	X

Hydrogen end uses: Transport applications **Heavy-Duty Vehicles**	*Type of Action*	Reducing the cost of core components such as modules and stacks in order to foster the competitiveness of FC heavy-duty applications;	Improving overall system performance of FC systems in order to improve the availability and durability and meet the needs of FCH HDV end users;	Improvements in design and monitoring procedures of FC systems;	Supporting and accelerating the wide roll out of FC HDV.
HORIZON-JU-CLEANH2-2025-03-01 Configurable Fuel Cell Powertrain for Non-Road Mobile Machinery	RIA	X	X	O	X

Hydrogen end uses: Transport applications **Waterborne applications**	Type of Action	Scaling up FC designs towards commercially relevant applications	Reducing the CAPEX of PEMFC or SOFC systems for maritime applications;	Improving overall system performance for FC and stacks, especially in terms of power density, bunkering rate and operational flexibility;	Supporting the wide roll out of FC ships, by providing adequate fuel, storage and bunkering infrastructure and developing new solutions for ships based on hydrogen and its derivative fuels.
HORIZON-JU-CLEANH2-2025-03-03 Reliable, efficient, scalable and lower cost 1 MW-scale PEMFC system for maritime applications	RIA	X	X	X	

Hydrogen end uses: Transport applications **Rail Applications**	*Type of Action*	Reducing the cost of stacks;	Improving reliability and durability at stack and FC system;	Improving power output while reducing weight and dimension of the module;	Supporting the roll out of FC trains, by providing the viability of the FCH solution in the train transport segment.
n/a					

4.6. Hydrogen end uses: Clean Heat and Power. Objectives of the Clean Hydrogen JU addressed in the Call for Proposals 2025

The following tables indicate the contribution of each of the topics included in the Call for Proposals to the objectives of the Clean Hydrogen JU SRIA.

Where a topic addresses an objective directly this is shown with an “X”. When an objective is addressed indirectly by a topic this is show as a “O”.

Hydrogen end uses: Clean Heat and Power **Fuel Cells**	*Type of Action*	Reducing CAPEX and TCO of stationary fuel cells of all sizes and end use applications	Prepare and demonstrate the next generation of fuel cells for stationary applications able to run under 100% H2 and other H2-rich fuels whilst keeping high performance	Improve flexibility of systems in operation in particular with reversible fuel cells and integration with thermal storage	Reducing use of critical raw materials and recycling them for further usage	Support development of processes suitable for mass manufacturing
HORIZON-JU-CLEANH2-2025-04-01 Demonstration of stationary fuel cells in renewable energy communities	IA	X	X	X		

Hydrogen end uses: Clean Heat and Power **Turbines, boilers and burners**	*Type of Action*	Allow turbines to run on higher admixtures of H2, up to 100% whilst keeping low NO_x emissions, high efficiencies and flexible operation;	Develop concepts on safety and plant integration and demonstrate the retrofitting of turbines, boilers and burners so that they are able to run up to 100% H2.
n/a			

4.7. Cross-cutting issues. Objectives of the Clean Hydrogen JU addressed in the Call for Proposals 2025

The following tables indicate the contribution of each of the topics included in the Call for Proposals to the objectives of the Clean Hydrogen JU SRIA.

Where a topic addresses an objective directly this is shown with an “X”. When an objective is addressed indirectly by a topic this is show as a “O”.

Cross-cutting issues **Sustainability, LCSA, recycling and eco-design**	*Type of Action*	Develop life cycle thinking tools addressing the three dimensions of sustainable development: economic, social, and environmental, the latter in terms of reduction of GHG emissions and impact on water resources	Develop eco-design guidelines and eco-efficient processes.	Develop enhanced recovery processes in particular for PGMs/CRMs and per- and polyfluoroalkyl substances.
HORIZON-JU-CLEANH2-2025-05-01 Simultaneous ionomer and Iridium recycling	RIA		X	X
HORIZON-JU-CLEANH2-2025-05-02 Understanding emissions of PFAS from electrolysers and/or fuel cells under product use	RIA			O

Cross-cutting issues **Education and public Awareness**	*Type of Action*	Develop educational and training material, build training programs for professionals and students on hydrogen and fuel cells and implement pilot training programmes	Raise public awareness and trust towards hydrogen technologies and their system benefits.
HORIZON-JU-CLEANH2-2025-05-03 Knowledge transfer and training of civil servants, safety officials, and permitting staff to improve safety assessment and licensing procedures across Europe	CSA	X	O

Cross-cutting issues **Safety, Pre-Normative Research and RCS**	*Type of Action*	Increase the level of safety of hydrogen technologies and applications	Support the development of RCS for hydrogen technologies and applications, with the focus on standards
HORIZON-JU-CLEANH2-2025-02-01 Development of mined, lined rock cavern for gaseous hydrogen storage			O

4.8. Hydrogen Valleys, Supply Chain and Strategic Research Challenge. Objectives of the Clean Hydrogen JU addressed in the Call for Proposals 2025

The following tables indicate the contribution of each of the topics included in the Call for Proposals to the objectives of the Clean Hydrogen JU SRIA.

Where a topic addresses an objective directly this is shown with an "X". When an objective is addressed indirectly by a topic this is show as a "O".

Hydrogen Valleys	*Type of Action*	System integration: integrating several elements together to improve overall synergies and facilitate sector coupling System efficiency: improvement of overall energy and economic efficiency of the integrated system Improved security and resilience of the energy system, e.g. via hydrogen production using locally available renewable energy sources Market creation: demonstration of new market for hydrogen	Complementarity of hydrogen with RES , integration with other technologies, existing infrastructure Assessment of the availability and affordability of clean (pollution free) energy provision for industry and cities uses Mutualisation of production or distribution and storage, assuming decentralisation as key parameter Help set or test regulation requirements at the relevant governance level	Increase the knowledge management with assessment of the socio-economic and environmental impacts, including the concept of digital twin assuring an effective monitor and optimization strategy for the operation and further development of the valley Development of public awareness of hydrogen technologies including contributions from Social Science and Humanities if this was relevant
HORIZON-JU-CLEANH2-2025-06-01: Large-scale Hydrogen Valley	IA		X	
HORIZON-JU-CLEANH2-2025-06-02: Small-scale Hydrogen Valley	IA		X	

Supply Chain	*Type of Action*	Identification of potential vulnerabilities in EUs hydrogen supply chain;	Development of new and improved manufacturing technologies and production processes that facilitate the safe and sustainable use of non-critical (raw) materials as well as facilitate the adoption of the circular economy principles;	Reducing the use of critical (raw) materials with sustainability or environmental concerns, such as for instance those deriving from poly/perfluoroalkyls.
HORIZON-JU-CLEANH2-2025-01-03 Scale-up and Optimisation of manufacturing processes for electrolyser materials, cells, or stacks	RIA		X	
HORIZON-JU-CLEANH2-2025-03-02 Scalable innovative processes for the production of PEMFC MEAs	RIA		X	
HORIZON-JU-CLEANH2-2025-05-01 Simultaneous ionomer and Iridium recycling	RIA			X

Strategic Research Challenges	*Type of Action*	Low or free PGM catalysts (including bioinspired catalysts), reducing critical (raw) materials use in electrolysers and fuel cells, and safe and sustainable use of all material, including developing of perfluorosulfonic acid (PFAS)-free ionomers and membranes.	Advanced materials for hydrogen storage (e.g. carbon fibres, H2 carriers…)	Advanced understanding of the performance / durability mechanisms of electrolysers and fuel cells.
n/a				

4.9. Manufacturing readiness level

- MRL 1 - Manufacturing Feasibility Assessed
- MRL 2 - Manufacturing Concepts Defined
- MRL 3 - Manufacturing Concepts Developed
- MRL 4 - Laboratory Manufacturing Process Demonstration
- MRL 5 - Manufacturing Process Development
- MRL 6 - Critical Manufacturing Process Prototyped
- MRL 7 - Prototype Manufacturing System
- MRL 8 - Manufacturing Process Maturity Demonstration
- MRL 9 - Manufacturing Processes Proven
- MRL 10 - Full Rate Production demonstrated and lean production practices in place