Clean Hydrogen JOINT UNDERTAKING (Clean Hydrogen JU)

WORK PROGRAMME 2024

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
AWP	Annual Work Programme
BOA	Back Office Arrangements
BoP	Balance of Plant
CA-JU	Clean Aviation Joint Undertaking
CAS	Common Audit Centre
CAPEX	Capital Up-front Expenditure (Investment)
CCMs	Catalyst-coated membranes
CCS	Catalyst coated substrate
CEF	Connecting Europe Facility
CEF-T	Connecting Europe Facility Transport
CEM	Clean Energy Ministerial
CHP	Combined Heat and Power
CIC	Common Implementation Centre
CFD	Computational fluid dynamics
CINEA	European Climate Infrastructure and Environment Executive Agency
CO_2	Carbon Dioxide
CORDIS	
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
Doi	Digital Object Identifier
DPO	Data Protection Officer
DSS	Direct Seawater Electrolysis
EC	European Commission, sometimes also shortened to just 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
EIS	Electrochemical Impedance Spectroscopy
EMPIR	European Metrology Programme for Innovation and Research
EMRP	European Metrology Research Programme
EMS	Electrolyser Management System
EPM	European Partnership on Metrology
ePTFE	Expanded polytetrafluorethylene
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
EMPIR	European Metrology Programme for Innovation and Research
EURAMET	European Association of National Metrology Institutes
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).

[1] FCH JU was replaced by FCH 2 JU, which has taken over all rights and obligations of its predecessor. FCH 2 JU is now in turn replaced by the Clean Hydrogen Joint Undertaking.

FTE	Full-time equivalent
FWC	Framework Contract
GB	Governing Board
GDL	Gas diffusion layer
GHG	Greenhouse Gases
GO	Guarantees of Origin
GT	Gas Turbine
GT OEM	Gas Turbine Original Equipment Manufacturer
GW	Gigawatt; GW_e refers to GW electric.
HAZIZ	Hazard Identification
H_2	Hydrogen
H2020	Horizon 2020
H2V	Hydrogen Valley Platform
HD	Heavy-duty
HDV	Heavy-Duty Vehicles
HER	Hydrogen Evolution Reaction
HIAD	Hydrogen Incident and Accident Database
HR	Human Resources
HREE	Heavy rare earth materials
HRS	Hydrogen Refuelling Station
HTCP	Hydrogen Technology Collaboration Programme
IA	Innovation Actions
ICT	Information and Communications Technology
IEA	International Energy Agency
IEC	International Electrochemical Commission
IKAA	In-kind Contribution for additional activities
ILCD	International Reference Life Cycle Data System
IPHE	International Partnership for Hydrogen and Fuel Cells in the Economy
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
LCDN	Life-Cycle Data Network
LCI	Life Cycle Inventory
LDV	Light Duty Vehicles
LH_2	Liquid Hydrogen
LNG	Liquefied Natural Gas
LOHC	Liquid Organic Hydrogen Carrier
LOI	Letters of Intent
LREE	Light rare earth materials
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 Industrial Act
OCT	Overseas countries and territories
OER	Oxygen Evolution Reaction
OPEX	Operational Expenditure
PCCEL	Proton Conducting Ceramic Electrolysis

PCR	Polymerase chain reaction
PDA	Project Development Assistance
PEF	Product Environmental Footprint
PEFCR	Product Environmental Footprint Category Rules
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
PPMT	Public Procurement Management Tool
PTFE	Polytetrafluoroethylene
PTL	Porous transport layer
PV	Photovoltaic
P4P	Process for Planert
R&I	Research and Innovation
R&D	Research and Development
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
RRF	Recovery and Resilience Facility
RTO	Research and Technology Organisations
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
SLA	Service Level Agreement
SNE	Seconded National Expert
SME	Small and Medium-sized Enterprise
SoA	State-of-the-Art

SOEL	Solid Oxide Electrolysis (Cells)
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
SRU	Single repeating units
SSOs	Storage System Operators
TC	Technical Committee
TCO	Total Cost of Ownership
TEA	Techno-Economic Assessment
TEN	Trans-European Network. TEN-E refers to Electricity, while TEN-T to Transport.
TF	Task Force
TIM	Tools for Innovation Monitoring
TRL	Technology Readiness Level
UN-ECE	United Nations Economic Commission for Europe
US, USA	United States of America
WP	Work Programme
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 2024 of the Clean Hydrogen Joint Undertaking** (hereafter also Clean Hydrogen JU[2], or simply as "the JU"), outlining the scope and details of its activities for the year 2024 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 EU's funding programme for research and innovation, Horizon Europe[3], 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 FP7 and 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[4] and the policy developments in this context such as the European Green Deal[5] and REPowerEU, 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 towards climate neutrality.

[2] 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.
[3] Regulation (EU) 2021/695 establishing Horizon Europe – the Framework Programme for Research and Innovation, OJ L 170, 12.5.2021, p. 1–68.
[4] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0301
[5] https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en

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 third Annual Work Programme (AWP) of the Clean Hydrogen Joint Undertaking (Clean Hydrogen JU), outlining the scope and details of its activities for the year 2024. 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 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 production is today almost completely fossil-based, as low-carbon hydrogen is not yet cost-

[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.

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 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.

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 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 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].

[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.
[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.

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[24], requiring one hydrogen refuelling station available every 200 km along the TEN-T core network and in all urban nodes by 2030; and the FuelEU Maritime proposal[25] 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[26], 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 undue regulatory barriers. The revised gas markets and hydrogen regulation[27] and directive[28] aims 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.

The European Commission introduced also the REPowerEU Plan[29] to respond to the

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[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] Regulation on the deployment of alternative fuels infrastructure, as adopted by the European Parliament and the Council (https://data.consilium.europa.eu/doc/document/PE-25-2023-INIT/en/pdf).
[25] Regulation on the use of renewable and low-carbon fuels in maritime transport, as adopted by the European Parliament and the Council (https://data.consilium.europa.eu/doc/document/PE-26-2023-INIT/en/pdf).
[26] New EU framework to decarbonise gas markets, promote hydrogen and reduce methane emissions (https://ec.europa.eu/commission/presscorner/detail/en/ip_21_6682)
[27] 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)
[28] 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)
[29] COM/2022/230 final.

unprecedented global energy market disruption caused by Russia's invasion in Ukraine. The urgency to transform Europe's energy system by ending EU's dependence on Russian fossil fuels comes on top of the need to tackle the climate crisis. The newly created EU Energy Platform[30], supported by regional task forces, will enable voluntary common purchases of gas, LNG and hydrogen by pooling demand, optimising infrastructure use and coordinating outreach to suppliers. The Platform will also enable joint purchasing of renewable hydrogen. Also, the EU External Energy Strategy[31] will facilitate energy diversification and build long-term partnerships with suppliers, including cooperation on hydrogen or other green technologies. The strategy boosts the development of renewables and hydrogen, steps up energy diplomacy and aims to develop major hydrogen corridors in the Mediterranean and North Sea.

Hydrogen is an integral part of REPowerEU Plan: a target of 10 million tonnes of domestic renewable hydrogen production and 10 million tonnes of imports by 2030 has been set, to replace natural gas, coal and oil in hard-to-decarbonise industries and transport sectors. To support the uptake of green hydrogen by industry, the Commission will roll out carbon contracts for difference and specific financing for REPowerEU under the Innovation Fund, using emission trading revenues. In addition to this, 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.

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 delegated acts.

- The Delegated Act on a methodology for renewable fuels on non-biological origin,[32] 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[33].
- The Delegated Act establishing a minimum threshold for greenhouse gas (GHG) emissions savings of recycled carbon fuels[34] 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 hydrogen sector were introduced by the EC. The Electricity Market Reform[35] proposal introduced the option for Member States to introduce new, or adapted, market-based support schemes to promote storage and demand

[30] EU Platform established by the EC with the Member States for the common purchase of gas, LNG and hydrogen.
[31] EU external energy engagement in a changing world. SWD(2022) 152 final.
[32] Commission Delegated Regulation (EU) 2023/1184 of 10 February 2023.
[33] 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).
[34] Commission Delegated Regulation (EU) 2023/1185 of 10 February 2023.
[35] COM(2023) 148 final/14.3.2023: https://ec.europa.eu/commission/presscorner/detail/en/IP_23_1591

response, which could lead to the incentivisation of hydrogen storage for power generation.

In parallel, the EC proposed the Net-Zero Industry Act (NZIA)[36] as one of the pillars of the Green Deal Industrial Plan[37], 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, via measures to facilitate investments, incentivise demand and up- and re-skill Europe's labour force. The Critical Raw Materials Act (CRMA)[38] 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 CRMs. 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 funded by the Innovation Fund under the umbrella of the EU Hydrogen Bank[39], to be launched on 23 November 2023. The Hydrogen Bank, implemented by the European Commission, aims to unlock private investments in hydrogen 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.

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 policy agenda.

To achieve this, the Strategic Research and Innovation Agenda (SRIA)[40] 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[41];
- 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;

[36] COM(2023) 161 final/16.3.2023: https://ec.europa.eu/commission/presscorner/detail/en/IP_23_1665
[37] COM(2023) 62 final/1.2.2023: https://ec.europa.eu/commission/presscorner/detail/en/ip_23_510
[38] COM(2023) 160 final/16.3.2023https://ec.europa.eu/commission/presscorner/detail/en/ip_23_1661
[39] https://climate.ec.europa.eu/news-your-voice/news/upcoming-eu-hydrogen-bank-pilot-auction-european-commission-publishes-terms-conditions-2023-08-30_en
[40] 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).
[41] Regulations, Codes and Standards Strategy Coordination Task Force, the European Hydrogen Safety Panel and the Sustainability and Circularity Panel.

- Supporting the European Commission in the implementation of its international cooperation agenda in research and innovation.

The present Annual Work Programme 2024 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 113.5 million. Additional EUR 60 million (from the RePowerEU plan budget) will be used to support different activities (including topping-up of related call topics and a procurement to set-up and run a 'Hydrogen Valleys Facility') for increasing the number of Hydrogen Valleys across Europe. In addition, specific actions are foreseen to implement complementary activities in line with what is described in the SRIA (see section 1.3.3.).

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 the European value chain for safe and sustainable clean[42] 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.

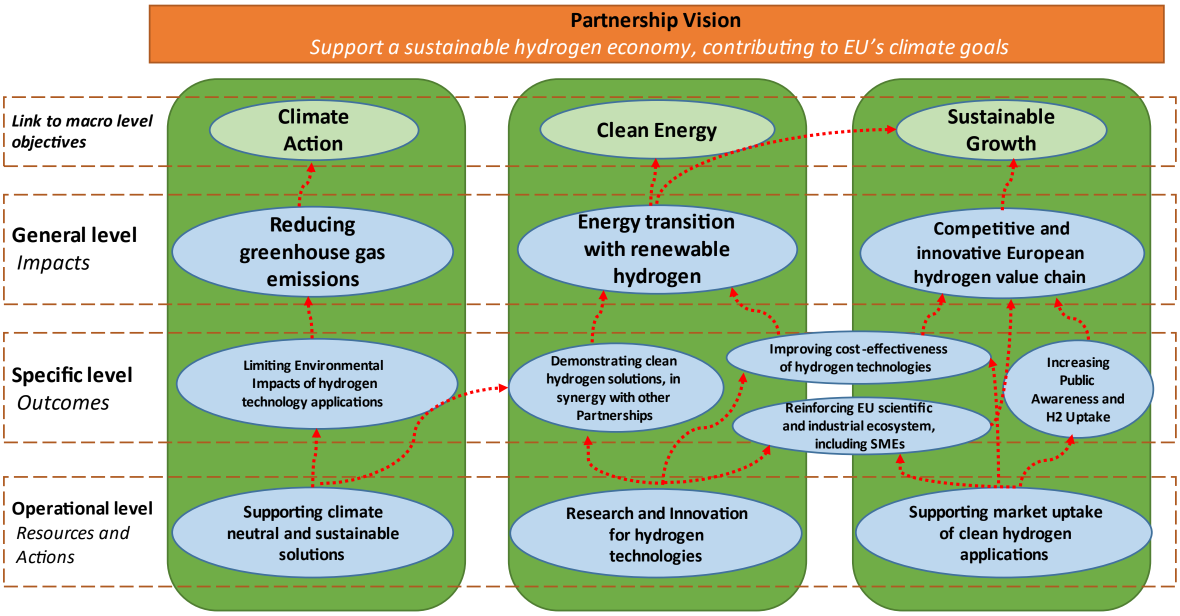
In order to prepare the implementation strategy of the Programme, the Clean Hydrogen JU prepared a Strategy Map[43] to identify this large number of (often high-level) objectives to more specific ones. This facilitated the identification of the necessary actions over the lifetime of the JU, necessary 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

[42] "clean" meaning "renewable" in agreement with the definition of the Hydrogen Strategy, the only definition available at the time of adopting the SBA
[43] See Section 7 of the Clean Hydrogen JU SRIA.

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 will be mainly implemented through open and competitive annual Calls for Proposals[44], providing financial support mainly in the form of grants to participants. The planned research and innovation actions are described in Section 0. The topics of each Call will be determined on an annual basis through extensive consultation between the three members of the JU[45] and with the support of the Programme Office. 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[46], will be a useful input in these discussions, indicating whether more action is needed in certain area.

Moreover, the Clean Hydrogen JU will undertake 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 0.

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

[44] 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.
[45] The three members of the JU are the European Commission, Hydrogen Europe and Hydrogen Europe Research.
[46] https://ec.europa.eu/research-and-innovation/en/knowledge-publications-tools-and-data/interactive-reports/performance-european-partnerships-2022

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, accompanied by a number of actions[47] 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[48]. For industrial applications, renewable hydrogen costs must reach levels between 2-3 €/kg as a feedstock[49], 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

[47] 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.
[48] See Figure 15 in SRIA-HE/HER
[49] Green Hydrogen Cost Reduction: Scaling up electrolysers to meet the 1.5°C climate Goal, IRENA 2020

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 for 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 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[50].

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,

[50] 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.

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.

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[51].

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,

[51] http://mission-innovation.net/wp-content/uploads/2022/09/Clean-Hydrogen-Mission-Action-Plan-Sept-22.pdf

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.[52] 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[53] 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 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

[52] Strengthening Strategic Value Chains for a future-ready EU Industry, EC, 2019.
[53] https://single-market-economy.ec.europa.eu/industry/strategy/industrial-alliances/european-clean-hydrogen-alliance_en

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[54] 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 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 CEM[55] and IPHE[56], 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

[54] See Articles 5(2), 17 (2), 19(4), 74, 82 and 83 of the SBA.
[55] Clean Energy Ministerial
[56] International Partnership on hydrogen and fuel cells in the economy

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. It is expected that this Panel will start working in 2023.

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 JRC and 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 2024

2.1 Executive summary 2024 and message from the Executive Director

2.1.1 Message from the Executive Director

Dear Readers

The European hydrogen funding landscape has evolved and increased significantly in recent years. In order to accelerate the development and deployment of a European Hydrogen value chain it is crucial to join efforts and to work in collaboration at European, National and Regional levels and to continue bringing together industrial, research and public sectors. We are very happy to take such a challenge on-board.

This year's Work Progammes has been carefully prepared in consultation with a large number of stakeholders, and in particular with the public and private members of the JU as well as with its advisory bodies, the States Representative Group and the Stakeholder Group. This helped us identify and include in this programme more opportunities to create synergies with other programmes and activities (both public and private).

With our activities we will continue supporting the European Union ambitions to create a consumption of 10 million tonnes of domestic renewable hydrogen in the EU by 2030. In addition, our Partnership will contribute to the objectives of the Net-Zero Industry Act by continuing to support the scale-up of hydrogen technologies and by increasing the competitiveness of the hydrogen industry in Europe .

The biggest part of the 2024 Work Programme of the Clean Hydrogen JU, is allocated to a Call for Proposals with a budget of EUR 113.5 million, to cover R&I activities across the whole hydrogen value chain. In addition, to stimulate the creation of regional hydrogen economies, in 2024, the second commitment of EUR 60 million will be allocated in this respect to Hydrogen Valleys related activities. Within these activities, a first ever "Hydrogen Valleys facility" will be supported, in order to accelerate the number of hydrogen valleys in Europe through project development assistance that supports Hydrogen Valleys at different level of maturity.

Projects funded through the 2022 Call for Proposals have started their activities and the beginning of 2024 will see the kick-off of our projects under the Call of 2023. We hope to receive many proposals in our next Call to expand the JU family of projects and count with your participation.

Enjoy the read!

Mirela Atanasiu

Executive Director ad interim

Clean Hydrogen Partnership

2.1.2 Executive Summary

The third 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 2024, one Call for Proposals for an indicative total budget of EUR 113.5 million is foreseen, plus EUR 60 million from Horizon Europe, to be directed towards Hydrogen Valleys topics according to the REPowerEU Plan. 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 20 topics will be part of the call for proposals, including 5 for Renewable Hydrogen Production, 5 for Hydrogen Storage and distribution, 4 for transport and 2 for heat and power. In addition, 2 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), 8 Innovation Actions (IA), and 1 Coordination and Support Action (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. An important novelty in the Call for Proposal 2024 is that it 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 a techno-economic, environmental and social assessment concerning the use of water in the green hydrogen value chain, assessment of the potential of natural/geologic hydrogen in Europe and a techno-economic-environmental analysis on the use of hydrogen in a RES-dominated European power generation sector. The exact budget to be allocated to these three procurements will be decided before preparing the tender specifications and will be supported by market research. According to the results of the market research, the relevance and need for each of the tenders will be revisited together with the members of the JU.

In addition, a first-ever 'Hydrogen Valleys Facility', with an estimated budget of 12.5 MEUR is planned, which will be supported wiht budget from the EUR 60 million RePowerEU plan budget included in the AWP2024. Such a facility will be implemented through a procurement aiming at accelerating the number of hydrogen valleys in Europe. The facility is expected to include project development assistance to support Hydrogen Valleys at different level of maturity. In addition, it will include activities to ensure that the knowledge gathered by and the lessons learnt from Hydrogen Valley projects are retained, collected, analysed and widely disseminated and used in a structured and efficient way. The Facility will also be used to maintain and update the Mission Innovation Hydrogen Valley Platform[57].

The Clean Hydrogen JU will continue to contribute towards the implementation of EU Policies

[57] https://h2v.eu/

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)[58] activities, to ensure synergies. To this end the outcomes of the ongoing JU study (to be delivered throughout 2024) on sustainable supply chain and industrialisation of hydrogen technologies is expected to be of relevance. 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 also continue following and contributing as necessary to the SET-Plan activities, in particular to the Implementation Working Group (IWG) on “Renewable Fuels and Bioenergy” and 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 2024 was agreed in 2023 and will be implemented in 2024. 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 2024. Following the changes in the 2023 structure of the report, adapted to the new objectives and research priorities of the Clean Hydrogen JU, the Report will again include a more complete overview of the Programme, its budget, its evolution and it’s progress. Continuing the good experience and practice, the 14th annual Programme Review Days will be organised in autumn 2024. Following the revamp of the European Hydrogen Observatory[59] (EHO) in the second half of 2023, in 2024 the data sets, reports and tools offered by EHO will be further expanded, aiming to have by end of 2024 the complete set of functionalities and resources envisaged in the related contract. In 2024, the activities of the Clean Hydrogen Knowledge Hub[60] 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.

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 2024 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 2024, the Regulations, Codes and Standards Strategy Coordination (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

[58] https://ec.europa.eu/growth/industry/policy/european-clean-hydrogen-alliance_en
[59] https://observatory.clean-hydrogen.europa.eu/
[60] https://etendering.ted.europa.eu/cft/cft-display.html?cftId=15172

regulatory friction-less hydrogen market in Europe and beyond if possible. According to the Council Regulation establishing the Joint Undertakings under Horizon Europe[61] (also referred to as Single Basic Act – SBA), the JU should also support the Commission in its work in the the CEM[62] and IPHE[63], both entities working on standardisation.

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.

The Clean Hydrogen JU will also start the activities European Hydrogen Sustainability and Circularity Panel, set-up in 2023, at the Programme level to support the Clean Hydrogen JU Programme implementation and the transition of the overall European hydrogen sector towards a sustainable and circular hydrogen economy, while also promote and disseminate the relevant knowledge and culture within and beyond the Programme.

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, 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, in particular with African Mediterranean countries, might also be facilitated through the foreseen study on “Sustainable paths for the use and management of water in the hydrogen value chain” and in the form of the project development assistance within the framework of the planned ‘Hydrogen Valley Facility’ which may be open to (but not only) to these countries.

Communication and outreach activities in 2024 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.

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.

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 2024.

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, corporate processes and procedures will continue to be simplified and

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[61] 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

[62] Clean Energy Ministerial

[63] International Partnership on hydrogen and fuel cells in the economy

improved. The Clean Hydrogen JU expects to either join the EU inter-institutional procurement procedures, or launch its own calls for tender. As of 2024, the JU will prepare and launch all of its 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.

Based on studies made in 2022 and decisions made in 2023, back-office arrangements will be implemented based on the agreed description of the target organisation model by the Executive Directors of the different Joint Undertakings. The Clean Hydrogen JU will take the lead for the organisation of ICT shared services.

Furthermore, the JU will closely monitor the implementation of its budget and its Staff Establishment Plan and will continue its close cooperation with the other Joint Undertakings in matters of common interest such as back-office arrangements, etc.

2.2 Operational activities of Clean Hydrogen JU for 2024

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 4.2.

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.[64]

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,[65] 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[66] 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[67];
- Clean Hydrogen JU KPIs, defined by the Clean Hydrogen JU[68] 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[69] 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.

[64] Articles 5.2(h), 17.2(a), 19.4(f)/(g)/(o), 36, 74(a) and 171 of the SBA.
[65] HE Regulation Art 50(1) & SBA Art 171(2)(a-c-d-e)
[66] A robust and harmonised framework for reporting and monitoring European Partnerships in Horizon Europe, 2021, RTD, https://europa.eu/!b3TBfW.
[67] https://research-and-innovation.ec.europa.eu/document/04974c33-68e6-4f20-a818-a46e4ecfaa09_en
[68] Annex I of the SRIA
[69] Annexes II-VI of the SRIA.

Table 1 Clean Hydrogen JU KPIs, monitoring the progress towards the objectives of the Strategy Map[70]

KPI Name		Unit of measurement	Baseline	Actual 2023[1]	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[2]	14%	15	30	40		On track[3]
	1b. Circular and sustainable solutions	% of JU budget	< 1[2]	4%	5	10	15		On track[3]
2. Early research projects		% of budget	10[2]	10	10	10	10		On track
3. Demonstration projects		# of projects	43[2]	12	20	40	60		On track[3]
4. Education and training		# of projects	4[2]	1	2	4	6		On track[3]
5. Monitoring technology progress		*Qualitative indicator*	N/A	AAR22[4]	N/A	N/A	N/A		On track
6. Supporting EC in H2 market uptake		*Qualitative indicator*	N/A	AAR22[4]	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[5]	N/A	75[6]	75	100	N/A[5]
	7b. Improvement in the quality of Life Cycle Assessments (LCA)	Quality of LCA submitted by projects (rating in %)	60[2]	N/A[5]	N/A	65	70	75	N/A[5]

[70] 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.

<table>
<tr><th colspan="2">KPI Name</th><th>Unit of measurement</th><th>Baseline</th><th>Actual 2023[1]</th><th>Target 2023</th><th>Target 2025</th><th>Target 2027</th><th>Ambition 2030</th><th>Status</th></tr>
<tr><td colspan="10">Resources (input), processes and activities</td></tr>
<tr><td rowspan="2">8. Capital cost of hydrogen applications</td><td>8a. Capital cost of electrolysers</td><td>% reduction across electrolyser technologies</td><td>100</td><td>N/A[5]</td><td>N/A</td><td>65</td><td>55</td><td>45</td><td>N/A[5]</td></tr>
<tr><td>8b. Capital cost of heavy-duty road applications</td><td>Cost of FC module CAPEX in €/kilowatt</td><td>1,500</td><td>N/A[5]</td><td>N/A</td><td>420</td><td>290</td><td>100</td><td>N/A[5]</td></tr>
<tr><td colspan="2">9. Research and Innovation Synergies</td><td># of projects</td><td>5[2]</td><td>7</td><td>5</td><td>10</td><td>20</td><td></td><td>On track</td></tr>
<tr><td colspan="2">10. Public perception of hydrogen</td><td>Qualitative indicator</td><td>N/A</td><td>AAR22[4], project HYPOP[7]</td><td>N/A</td><td>N/A</td><td>N/A</td><td></td><td>On track</td></tr>
<tr><td colspan="2">11. Total persons trained</td><td># of persons in thousands</td><td>5[2]</td><td>N/A[5]</td><td>N/A</td><td>110</td><td>160</td><td>240</td><td>N/A[5]</td></tr>
<tr><td colspan="2">12. Patents and publications</td><td># of patents / publications</td><td>12[2]/ 289</td><td>15/ 113</td><td>17/ 100</td><td>20/ 400</td><td>25/ 450</td><td></td><td>On track[8]</td></tr>
<tr><td colspan="2">13. Promoting cross-sectoral solutions</td><td>% of budget</td><td>15[2]</td><td>8</td><td>10</td><td>15</td><td>25</td><td></td><td>On track[3]</td></tr>
<tr><td colspan="10">Impacts*
(KPIs reporting progress of hydrogen sector at EU level, to which the JU is contributing)</td></tr>
<tr><td colspan="2">14. Expected avoided emissions</td><td>Million tonnes of CO2-eq/year</td><td>0.085</td><td>0.17[9]</td><td>N/A</td><td>N/A</td><td>N/A</td><td>223</td><td>Off track[10]</td></tr>
<tr><td colspan="2">15. Deployment of electrolysers</td><td>Gigawatt</td><td>0.077</td><td>0.129[9]</td><td>4</td><td>6</td><td>10</td><td>40</td><td>Off track[10]</td></tr>
<tr><td colspan="2">16. Market uptake of clean hydrogen</td><td>Mt of clean hydrogen consumed</td><td>0.008</td><td>0.016[9]</td><td>0.7</td><td>1</td><td>2</td><td>10</td><td>Off track[10]</td></tr>
<tr><td colspan="2">17. Total cost of producing renewable hydrogen</td><td>€/kg</td><td>8</td><td>6.89[9]</td><td>6.5</td><td>5.5</td><td>4.5</td><td>3</td><td>On track</td></tr>
<tr><td rowspan="2">18. Size of private hydrogen sector</td><td>18a. Activity in terms of companies</td><td># of companies</td><td>300</td><td>1,107[9]</td><td>1,000</td><td>1,500</td><td>2,000</td><td>-</td><td>On track</td></tr>
<tr><td>18b. Activity in terms of projects in the pipeline</td><td># of Projects</td><td>50</td><td>113[9]</td><td>200</td><td>500</td><td>800</td><td>-</td><td>On track[11]</td></tr>
</table>

KPI Name		Unit of measurement	Baseline	Actual 2023[1]	Target 2023	Target 2025	Target 2027	Ambition 2030	Status
Resources (input), processes and activities									
	(ongoing or under construction)								
	18c. Electrolyser manufacturing capacity	GW/year	1	3.11[9]	5	17.5	30	-	On track[11]

* 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.

[1] The latest values available on November 2023 are reported. For KPIs (#1-4, 9, 13) these reflect the signed grants of Call 2022. 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 on eGrants by the end of 2022 are reported, as reported in the latest Annual Activity Report of the JU (AAR 22). 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 AAR22.

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

[3] Expected to be on track after signing the grants for Call 2023 and three remaining grants from Call 2022.

[4] More information about this KPI can be found in Section 5.8 of Clean Hydrogen JU’s Annual Activity Report 2022 (published June 2023).

[5] 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.

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

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

[8] Reported figures concern 2022 coming from Annual Activity Report 2022. Current 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.

[9] Calculated from the European Hydrogen Observatory; data from 2022 for KPI-14 to KPI-17, while for KPI-18 from May 2023. KPI-17 was calculated using the methodology proposed by the Observatory contractors.

[10] 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.

[11] Expected to be on track towards the end of 2023 or beginning of 2024, based on project announcements.

2.2.1.3 Risk Assessment

An annual risk assessment exercise was conducted in October 2023 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 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 2023, the following guiding questions were asked:

- Are the risks and action plans identified in the previous year's exercise and presented in the AWP 2023 still relevant?
- Are there any significant risks to the achievement of JUs' objectives that emerged during the course of the year 2023?
- 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 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[71], high and medium risks, together with the action plans are presented below:

[71] 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 in the upcoming years, the programme office will be running two framework programmes simultaneously, H2020 in the peak of implementation, 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. Back office arrangements are helping to harmonize the working processes and have revealed that they do not represent a solution for the headcount issue.	Use of service contracts for support activities in the Operations, while increased coordination will be explored through synergies with other joint undertakings on administrative activities. 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. JU will continue to investigate further simplification opportunities, among them such as use of the lump sums as a cost model in new calls/grants implementation. JU should shorten time for recruitment for staff, including a new ED. GB 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 MS/regional funds for hydrogen technologies due to lack of strategic guidance and consequently JU proper involvement in programming activities. Additional interconnected risk could result in unbalanced funding to end-use applications of hydrogen which were originally planned to be supported by other partnerships or programmes (instead via JU funding which does focus on production and storage). As a result, Pillar 2 (after two major HE calls) remains underfunded.	The programme office continues currently to act on ad-hoc basis on the synergy efforts required by the SBA, building on the extensive experience in implementing such synergies in the predecessor FCH JU Working with the newly established Stakeholder group should be also better explored, to propose and follow-up on synergies with the Programme Office in an effective manner. JU will continue to report to the Governing Board and will continue to seek strategical guidance.

Risk Abbreviation	Risk Identified	Action Plan
Membership Data	Risk that in-kind contribution balances are significantly misstated and some JUs projects failing on eligibility criteria 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 JU reputation.	A process to ensure eligibility criteria and their continuous monitoring throughout lifetime of the projects should be put in place. 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.
Projects Execution	Risk that program objectives will not be achieved fully and timely due to delays in project execution attributed to COVID-19 and due to hydrogen market changes. There is a negative impact on duration of the projects, including FIDs ("financial investment decision") for demonstration projects as regards co-funding, and consequently on budget execution and programme reaching its objectives. Due to war in Ukraine, there is an increased disruption in a value chain and a general economic impact of the war (increase prices and scarcity of raw materials and energy resources).	Mitigating actions are in place for monitoring of any delays in the project, restructuring of the projects, if necessary, granting project extension in average of 6 months due to COVID-19 via amendment process.

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 2024.

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 (external changes, e.g. COVID-19 in 2020, conflict in Ukraine in 2022); factors 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[72] 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 2024 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 above, in 2024 the Clean Hydrogen JU will support low TRL research activities aiming at developing innovative proton conducting ceramic electrolysis cells and stacks and innovative technologies for direct seawater electrolysis. Building on the support provided in former calls, the Call 2024 will also support research to develop better performant and lower cost anion exchange membrane electrolysers for high power range applications. In addition, a topic has been included to support the development and demonstration in a relevant environment of online monitoring and diagnostic tools for electrolysers, with the objective of improving lifetime, optimise operation and eventually reduce operational costs. Support will be also provided to one Innovation Action looking at the production and integration of hydrogen in energy-intensive industries following a circular approach aiming at maximising

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

overall process efficiency and optimising the use of resources.

Also on hydrogen production, a study is foreseen to evaluate the potential of geological hydrogen 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 for 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.

On hydrogen storage, the Call 2024 will support a low TRL project to investigate the microbial interaction for underground hydrogen porous media storage. In addition, a topic is included to develop novel large-scale aboveground storage solutions for demand-optimised supply of hydrogen.

Looking at the hydrogen distribution supply chain, the Call 2024 has included several topics. One Innovation Action targets the demonstration of renewable purification and separation systems for renewable hydrogen-containing streams in industrial applications. Another topic targets the demonstration of innovative solutions for high-capacity, reliable, flexible, and sustainable hydrogen compression technologies in commercial applications. Finally, with view to support the expected increase of heavy-duty mobility applications running on hydrogen, a topic has been included to demonstrate multi-purpose hydrogen refuelling stations for different environments (ports, airports, road-transport, etc).

Scientific priority - Hydrogen end uses - transport

It is widely agreed that hydrogen will be an essential element (either as a fuel or as part of other fuels like ammonia, acting as hydrogen carriers) to decarbonise the maritime sector. In 2024, Clean Hydrogen JU will support research targeting to improve the performance and decrease costs of fuel cell systems for heavy-duty applications by optimising and scaling-up balance of plants (BoP) components. An additional topic has been included to develop the next generation on-board storage solutions with a focus on hydrogen-powered maritime applications. Finally, one Innovation Action topic is expected to deploy and demonstrate hydrogen-powered inland or short-sea shipping solution.

Scientific priority - Hydrogen end uses - clean heat and power

Hydrogen offers a unique chance also to decarbonise the power generation and heating sectors. In 2024 Clean Hydrogen JU will support fuel cells and gas/hydrogen turbines.

On fuel cells one Innovation Action topic will demonstrate portable fuel cells for backup power solutions during natural disasters. On gas turbines the Clean Hydrogen JU will continue supporting the necessary research aiming at developing the next generation of gas turbines able to run on hydrogen. The Call 2024 will complement research activities supported in former years by focusing on hydrogen combustion at high pressure. In addition, a study is foreseen to assess the role of hydrogen in Europe’s power generation sector.

Scientific priority - Cross-Cutting activities

Cross-cutting activities supported in the Call 2024 focus on Sustainability aspects. One topic will provide support for the preparation and drafting of guidelines for sustainable-by-design systems across the hydrogen value chain. Technologies at different TRLs and a range of applications from hydrogen production, storage, transport, distribution and utilisation will be addressed.

In order to address the growing environmental concerns relative to the use of polyfluorinated substances (PFAs), a second topic has been included that will research and develop non-fluorinated components for fuel cells and electrolysers.

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 2024 the Clean Hydrogen JU will continue supporting several flagship[73] Hydrogen Valleys of different scales.

In addition, in 2024, the JU will launch a call for tenders aiming at the setting-up and running a ‘Hydrogen Valley Facility’ to accelerate the number of hydrogen valleys in Europe.

[73] 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-JTI-CLEANH2-2024-01-01	Innovative proton conducting ceramic electrolysis cells and stacks for intermediate temperature hydrogen production	RIA
	HORIZON-JTI-CLEANH2-2024-01-02	Advanced anion exchange membrane electrolysers for low-cost hydrogen production for high power range applications	RIA
	HORIZON-JTI-CLEANH2-2024-01-03	Development of innovative technologies for direct seawater electrolysis	RIA
	HORIZON-JTI-CLEANH2-2024-01-04	Development and implementation of online monitoring and diagnostic tools for electrolysers	RIA
	HORIZON-JTI-CLEANH2-2025 -01-05	Hydrogen production and integration in energy-intensive or specialty chemical industries in a circular approach to maximise total process efficiency and substance utilisation	IA
Hydrogen storage and distribution	HORIZON-JTI-CLEANH2-2024 -02-01	Investigation of microbial interaction for underground hydrogen porous media storage	RIA
	HORIZON-JTI-CLEANH2-2024 -02-02	Novel large scale aboveground storage solutions for demand-optimised supply of hydrogen	RIA
	HORIZON-JTI-CLEANH2-2024 -02-03	Demonstration of hydrogen purification and separation systems for renewable hydrogen-containing streams in industrial applications	IA
	HORIZON-JTI-CLEANH2-2024-02-04	Demonstration of innovative solutions for high-capacity, reliable, flexible, and sustainable hydrogen compression technologies in commercial applications	IA
	HORIZON-JTI-CLEANH2-2024 -02-05	Demonstration and deployment of multi-purpose Hydrogen Refuelling Stations combining road and airport, railway, and/or harbour applications	IA
Hydrogen end uses: transport applications	HORIZON-JTI-CLEANH2-2024 -03-01	BoP components, architectures and operation strategies for improved PEMFC system efficiency and lifetime	RIA
	HORIZON-JTI-CLEANH2-2024 -03-02	Scaling up Balance of Plant components for efficient high-power heavy-duty applications	RIA
	HORIZON-JTI-CLEANH2-2024 -03-03	Next generation on-board storage solutions for hydrogen-powered maritime applications	RIA
	HORIZON-JTI-CLEANH2-2024 -03-03	Demonstration of hydrogen fuel cell-powered inland or short sea shipping	IA
Hydrogen end uses: clean heat and power	HORIZON-JTI-CLEANH2-2024 -04-01	Portable fuel cells for backup power during natural disasters to power critical infrastructures	IA
	HORIZON-JTI-CLEANH2-2024 -04-02	Improved characterisation, prediction and optimisation of flame stabilisation in high-pressure premixed hydrogen combustion at gas-turbine conditions	RIA

	Topic identifier	Topic Title	Type
Cross-cutting Issues	HORIZON-JTI-CLEANH2-2024-05-01	Guidelines for sustainable-by-design systems across the hydrogen value chain	CSA
	HORIZON-JTI-CLEANH2-2024 -05-02	Development of non-fluorinated components for fuel cells and electrolysers	RIA
Hydrogen Valleys	HORIZON-JTI-CLEANH2-2024 -06-01	Large-scale Hydrogen Valley	IA (flagship)
	HORIZON-JTI-CLEANH2-2024 -06-02	Small-scale Hydrogen Valley	IA (flagship)

2.2.3 Call for Proposals

2.2.3.1 Overview of the Call

The AWP 2024 includes one Call for Proposals as follows:

Call Identifier	Budget (EUR million)	Publication[74]	Deadline
HORIZON-JTI-CLEANH2-2024-1	113.5	17 January 2024	17 April 2024

The European Commission in its communication "REPowerEU Plan[75]" announced an additional investment of EUR 200 million available[76] for the Clean Hydrogen JU for doubling the Hydrogen Valleys in the EU by 2025. In that respect, an additional 60 MEUR is added to:

- support Hydrogen Valleys in the reserve list of the Call 2023
- support Hydrogen Valleys in the reserve list of the Call 2024
- set-up and running of a 'Hydrogen Valley facility' aiming at accelerating the deployment of Hydrogen Valleys across Europe. This will be implemented through a service contract (see section 2.2.4.1).

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.

[74] The Executive Director may decide to open the call up to one month prior to or after the envisaged date of publication.
[75] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2022%3A230%3AFIN&qid=1653033742483
[76] Allocated as follows: 60 MEUR Call 2023, 60 MEUR Call 2024 and 80 MEUR Call 2025.

HORIZON-JTI-CLEANH2-2024-01-01: Innovative proton conducting ceramic electrolysis cells and stacks for intermediate temperature hydrogen production

Specific conditions	
Expected EU contribution per project	The JU estimates that an EU contribution of maximum EUR 3.00 million would allow these outcomes to be addressed appropriately.
Indicative budget	The total indicative budget for the topic is EUR 3.00 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)[77].

Expected Outcome

To realise the potential of hydrogen as an energy vector in the decarbonised economy it needs to be produced sustainably on a mass scale. Steam electrolysis based on proton conducting ceramic electrolysis cells (PCCEL) is a promising technology for directly producing dry hydrogen, and achieving high electrical stack efficiency and low degradation rate due to its operation at intermediate temperature, typically between 450°C and 700°C. PCCEL stack technology in Europe is currently based on tubular cells integrating Ni-cermet electrodes, $BaZr_{1-x-y}Ce_xY_yO_{3-\delta}$ based electrolytes, and composite electrodes containing Cobalt (Co) and various rare earth elements. The intermediate operating temperature of this technology can be leveraged to replace these materials by e.g. cheaper steel-based components to reduce reliance on critical raw materials and strategic raw materials (CSRM) such as Co, rare earth elements, Nickel (Ni) etc. It will furthermore contribute to increasing lifetime by reducing thermally activated degradation and improving Faradaic efficiency. This calls for a new design approach of PCCEL cell and stack, ensuring the development of high-performance cell and stack with reduced amount of CRM and CSRM. This will further contribute to significant reduction of CAPEX of the technology.

The outcome of this topic will be an innovative low-cost cell and stack concept with improved current density than State-of-the-Art (SOA), which can be operated at intermediate temperatures (≤600ºC) and exhibiting longer lifetime than SOA for energy efficient hydrogen production.

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

[77] 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/ls-decision_he_en.pdf

- Novel cells and stacks designed for operational temperatures ≤ 600°C and faradaic efficiency above 90%.
- Cells and stacks produced by scalable manufacturing techniques with potential for later integration and automation into a pilot line.
- Strengthened European value chain on electrolyser components with decreased reliability of critical and strategic raw materials from international imports.
- European leadership for renewable hydrogen production based on PCCEL electrolysers.

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

- Demonstrate successful start-up of the stack with a hot idle ramp time of 240s and cold start ramp time of 6h;
- Increase current density of cells above or equal to 0.75 A/cm^2 at thermal neutral voltage at temperatures ≤ 600°C;
- Demonstrate short stack based on 5 single repeating units (SRU) with minimum total stack active area of 250 cm^2 operated under representative conditions over > 2000 h targeting a degradation rate < 0.5 % / 1000h;
- Establish a roadmap for defining technological pathways enabling to reach CAPEX of 1400€/(kg/d) and OPEX of 85 €/(kg/d)/y.

Scope

PCCEL stack technology in Europe is largely based on tubular cell design enabling pressurised operation up to 10 bar at 600°C, as demonstrated in the WINNER[78] and GAMER[79] projects, while recent work published in the literature also addresses planar cell and stack development. The state-of-the-art cells consist of traditional Ni-cermet electrode, $BaZr_{1-x-y}Ce_xY_yO_{3-\delta}$ based electrolyte, and composite electrodes containing Co and various rare earth elements, exhibiting current density peaking at 0.3 A/cm^2 at 600°C at thermoneutral voltage. The topic focuses on the development of new cell and stack designs aiming at improving the performance and flexibility of operation, while reducing costly ceramic-based components and critical raw materials and strategic raw materials (e.g. light and heavy rare earth materials, LREE and HREE, Ni, Co)[80]. Improved thermal and load cycling capabilities (faster and higher number of thermal cycles) should be ensured by designing new cells and/or stacks, e.g. electrode or metal supported cells/stacks, cells with integrated interconnect/current collector/electrode, metal-based monolith cells/stacks, etc. This can be sought by nano-engineering and/or self-assembly of interfaces, integrating several functionalities in single components and/or by developing thinner layers to reduce material consumption and ohmic losses.

The new sustainable-by-design electrolysers will operate at temperature ≤ 600°C to minimise thermally induced degradation and promote efficient thermal management.

Proposals should address the following requirements:

- Design of new cells and/or stacks e.g. metal or electrode supported cells/stacks, cells with integrated interconnect/current collector/electrode and/or metal-based monolith

[78] https://cordis.europa.eu/project/id/101007165
[79] https://cordis.europa.eu/project/id/779486
[80] https://www.crmalliance.eu/hrees

cells/stacks and/or intrinsically more robust cell/stack design/assembly, and validation on single cell and short stack level;

- Dedicated test protocols at cell and/or short stack level will be developed to establish performance and degradation rate of the cell/short stack under variable load profiles. Accelerated stress tests could be applied for shortening the testing time for degradation evaluation. This task will also contribute to evaluate the flexibility of operation of the devices;
- The stack design shall be assisted by fluid dynamics and multi-physics modelling to determine the optimal cell and stack architectures considering the specific electrochemistry and the thermal management within the stack, as well as to define optimal operating conditions of the stack;
- Increased current density of the cells should be obtained by e.g., designing thinner electrolytes and/or new electrodes with improved materials/architectures;
- Increased Faradaic efficiency shall be obtained by implementing materials solutions and/or by optimising operating strategy;
- Corrosion stability of the metal-based components should be validated in relevant operating conditions, in particular for the steam side of the electrolyser, and if needed, improved by development of protective coatings;
- Degradation mechanisms of the stack components should be identified with respect to temperature, steam content and utilisation, and pressure (for pressurised solution);
- The cell and stack manufacturing methods should be based on processes with potential for later upscaling, automation and mass-manufacturing;
- Techno-economic evaluation of the steam electrolyser integrated in given application(s) and considering economy of scale will provide the Levelised Cost of Hydrogen (LCOH) and will be used to provide insights into relevant business models. The CAPEX and OPEX of the novel stack concept will be evaluated;
- Proposals are expected to address sustainability aspects via Life Cycle Assessment (LCA) by reducing the use of critical raw materials compared to state-of-art cells and/or stacks and/or their recycling.

Consortia are expected to build on the expertise from the European research and industrial community to ensure broad impact by addressing several of the aforementioned items.

Proposals should demonstrate how they go beyond the ambition of projects WINNER[81], GAMER[82], PROTOSTACK[83], METPROCELL[84] and DAICHI[85] European projects and be complementary to them.

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[86] (see section 2.2.4.3 "Collaboration with JRC"), in order to support EU-wide harmonisation. Test activities should adopt the already published EU

[81] https://cordis.europa.eu/project/id/101007165
[82] https://cordis.europa.eu/project/id/779486
[83] https://cordis.europa.eu/project/id/101101504
[84] https://cordis.europa.eu/project/id/277916
[85] https://prosjektbanken.forskningsradet.no/en/project/FORISS/284289?Kilde=FORISS&distribution=Ar&chart=bar&calcType=funding&Sprak=no&sortBy=date&sortOrder=desc&resultCount=30&offset=120&TemaEmne.2=Avanserte+materialer&source=FORISS&projectId=283773
[86] https://www.clean-hydrogen.europa.eu/knowledge-management/collaboration-jrc-0_en

harmonised testing protocols[87] to benchmark performance and quantify progress at programme level.

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

HORIZON-JTI-CLEANH2-2024-01-02: Advanced anion exchange membrane electrolysers for low-cost hydrogen production for high power range applications

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)[88].

Expected Outcome

Anion Exchange Membrane-water electrolyser (AEMEL) is a promising technology as it has the advantage of reducing hydrogen production costs and fulfilling the requirements of limited resources. In comparison to low-temperature Proton Exchange Membrane Water Electrolysis (PEMEL) there is no need for electrocatalysts comprising platinum-group elements. AEMEL are typically fed with alkaline water, limiting the selection of materials for the various components; however, the production of stable materials, the development of polyfluoroalkyl substances (PFAS)-free membranes and suitable electrocatalysts can be ramped up more easily to satisfy demand than for PEMEL electrocatalysts-materials.

Currently, Europe is leading research and development for AEMELs. As such, it is of crucial importance to maintain this lead and develop new AEMEL stacks enabling the production of pressurised hydrogen. It can be expected to produce hydrogen at 50 bar with future AEMEL stacks at an overall input current density of >1.5 A/cm^2, with reduced alkaline concentration of <1 mol/L and 0 mg/W of critical raw materials as catalysts as stated in the targets for 2030 in the SRIA of the Clean Hydrogen Partnership. The electricity consumption should not exceed 48 kWh/kg(H_2) by 2030 while the capital costs should be as low as 300 €/kW and 600 €/(kg/d) by 2030.

The project should build on the outcomes of previous findings on previous and ongoing EU

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

[88] 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/ls-decision_he_en.pdf

projects (ANIONE[89], NEWELY[90], CHANNEL[91], HERAQCLES[92] and HYScale[93]).

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

- Strengthening the European leadership in anion exchange membrane water electrolyser;
- (AEMEL) development, manufacturing and deployment for pressurised hydrogen production;
- Novel short-stack layouts with high power for pressurised AEMEL by 2027 and development of manufacturing processes to produce electrolysers for the upcoming demand;
- Development and implementation in developed stack of next-generation AEMEL materials (Anion exchange membranes, ionomers, electrocatalysts, bipolar plates, porous transport layers, *etc.*) to achieve higher stability, efficiency and recyclability;
- Increased membrane stability and decreased gas crossover.

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

- Reducing electrolyser CAPEX and OPEX and thus the cost per kg $H_{2,}$ especially by reducing the amount of Critical Raw Materials (0 mg/W; *e.g*. Co, Ir, Pt) use as electrocatalyst;
- Increasing current density and durability for AEMEL and decreasing footprint;
- Proof of the technology with long test(s) (3,000 h);
- Business model for the scale-up and industrialisation.

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

- Electricity consumption @ nominal capacity: 48 kWh/kg (2030);
- Capital cost: 600 €/(kg/d) (2030);
- Degradation: below 0.5 %/1,000h (2030);
- Current density: 1.5 A/cm^2 (2030);
- Use of critical raw materials as catalyst: 0.0 mg/W (2030).

Scope

The scope of this topic is to develop the next generation of anion exchange membrane electrolyser stack layout delivering hydrogen at a pressure suitable for industrial end-uses.

It is expected that electrocatalysts will be highly active, with a low-loading of critical raw materials < 0.1 mg/W and used to demonstrate operation at current densities > 1.0 A/cm^2 at cell potentials below 1.8 V, with alkaline concentrations of <1 mol/l and an electricity consumption below 50 kWh/kg. The temperature at which the applied membrane material properly functions is expected to be lower than 90 ºC. To achieve the targets, all components

[89] https://cordis.europa.eu/project/id/875024
[90] https://cordis.europa.eu/project/id/875118
[91] https://cordis.europa.eu/project/id/875088
[92] https://cordis.europa.eu/project/id/101111784
[93] https://cordis.europa.eu/project/id/101112055

have to be optimised in terms of pressure, chemical and corrosion stability as well as their performance and durability. In particular, new AEMs, low-loading of critical raw materials electrocatalysts and porous transport layer (PTL) structures should be developed, and their implementation in catalyst coated substrate (CCS), catalyst-coated membranes (CCMs) and membrane electrode assemblies (MEA) is expected to be studied.

Targeted prototype scale and cell size should be appropriate for targeted applications and future scale-up. The proposal should target at the end of the project the construction of a stack of minimum 50 kWel with an active area of at least 500 cm^2 and designed to operate at >50 bars of output pressure. The short stack should exhibit a minimum operation performance of current densities > 1.0 A/cm^2 at cell potentials below 1.8 V with alkaline concentrations of <1 mol/l. Under these, conditions degradation rates of <0.7 %/1000 h should be demonstrated for a period of at least >3,000 h with the designed stack layout under the stated parameters.

Studies on possible corrosion effects and on degradation mechanism of AEM, anode and cathode electrocatalysts and PTLs should be conducted through EU harmonised testing protocols in order to be able to further predict their lifetime and identify degradation effects.

Proposals are expected to address sustainability, circularity and recycling aspects when choosing AEMs, catalysts, PTL and cell-materials, including bipolar plates. Proposals are expected to perform complete techno-economic and life cycle assessments.

Proposals should show how the developed concepts should be applied in a laboratory setting at a first step, and in a second step how they should be optimised considering the important relevant design and operating parameters (TRL5).

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[94] (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[95] to benchmark performance and quantify progress at programme level.

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

HORIZON-JTI-CLEANH2-2024-01-03: Development of innovative technologies for direct seawater electrolysis

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 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:

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

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

	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)[96].

Expected Outcome

Electrolytic hydrogen production and its various uses are leading to new types of energy and chemical industry systems which allow linking of sectors such as transport, as well as, hard to abate industrial sectors, electricity production and energy storage. In line with EU policies (EU Hydrogen strategy and REPowerEU Plan) a massive deployment of electrolytic systems with a scale up to multi-MW is expected. This implies maintaining performances and efficiency as well as optimising them, by reducing the use of critical raw materials, improving purification systems for the feedwater and complex balance of plant alongside the need to extend the durability against transient, dynamic or harsh conditions as well as, the overall lifetime of the system.

Some issues experienced have been, to some extent, overcome in the case of big industrial installations. Despite of that, the progress in all, and especially local, remote, and distributed, electrolytic systems can easily be fostered by leaving aside the water purification step as well as the use of low Platinum group metals (PGM)-based catalysts maintaining reasonable trade-off between cost and durability, as well as, other advanced materials and components such as membranes, ionomers, coatings, Porous Transport Layer (PTLs), bipolar plates etc.).

On the other hand, the offshore and onshore generation of 'green' electricity, and related prospective hydrogen manufacturing potential, yields in an interest in the direct electrolysis of sea water. All these issues are at the moment addressed separately by various planned or ongoing research and innovative projects. The novel outcome expected for this topic relies on the development of solutions addressing more than one of them.

The solutions provided should contribute to the possible future development of a technology allowing for sustainable production of green hydrogen in remote (delocalised) and/or offshore locations using seawater as a feedstock. Under the highly delocalised premise of the availability of "cheap electrons" from renewable electricity, the electrolytic production of hydrogen faces new challenges as in numerous geographic regions deprived of freshwater reservoirs, sea/ocean water is regarded as the preferred feed choice for future environment-friendly electrolytic applications.

Seawater is usually being targeted in the areas characterised with deficits of fresh water. While technically this is not the only possible source, due to its global abundance and the global scale of the required hydrogen production development of electrolytic systems, accomplishment of seawater into electrolysis can in future yield in further integration of hydrogen into local economies of various European and non-European locations especially if it does not require desalination.

The innovative technology developed should overcome limitations of direct electrolysis of seawater addressing among others the stabilisation of pH fluctuations, physical blockages from solid impurities, precipitates and microbial contamination, materials and components corrosion, low activity, selectivity, and durability (together with the relevant recycling and reuse

[96] 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/ls-decision_he_en.pdf

strategies) of the Hydrogen Evolution Reaction (HER) and Oxygen Evolution Reaction (OER) catalysts. It should also propose innovative materials/components structures/compositions and membrane/ionomer (when applies) to reach effective high-performing and corrosion-resistant, and thus durable, seawater electrolysis systems. The proof of concept of the innovative technology should enable direct electrochemical seawater splitting as well as brine use for energy efficient hydrogen production contributing to the overall objectives of the Clean Hydrogen JU SRIA.

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

- Target applications based on renewable hydrogen production from seawater through its direct electrolysis coupled to renewable intermittent energy sources;
- Combining electrolysis with recovery/reuse of salts and compounds from seawater brine for other applications;
- Identify the maximum concentration of contaminants (inorganic, organic, as well as, biological) allowed to operate efficiently a direct seawater electrolysers;
- Techno-Economic, Environmental and Social Analysis of the proposed technology (e.g. TEA combined with LCA, LCCA, LCSA);
- Comparison of the technology proposed proving its potential advantages against conventional approach based on desalination and freshwater electrolysis based solutions;
- Proof of principle/concept of cell/stack able to work with seawater as a direct feedstock, including especially also bivalent cations and anions;
- Development of materials/components such as separators, electrodes and catalytic materials exhibiting stability in salinity conditions characteristic for seawater;, as well as, characterised by improved reuse/recyclability features targeting the fully circular industrial environment.
- Evaluate the trade-offs between the use of critical raw materials and resulting performance of the future electrochemical device of interest or the development of innovative catalysts, free of critical raw materials;
- Estimation of the correlation of the salinity, chemical composition and microbial related factors of sea water to the efficiency, degradation, etc. of the electrolyser and its materials.
- Providing the solutions for future effective direct electrolysis of sea water for various chemical compositions and salinity range of at least 3,3 to 3,9 % (characteristic to e.g. Mediterranean Sea).

Project results are expected to contribute to the following objectives and KPIs of the Clean

Hydrogen JU SRIA by the end of the project: :

- Energy consumption @ nominal load: 53 kWh_e/kg for low temperature EL and <40 kWh_e/kg + <10 kWh_{th}/kg for high temperature EL.
- Current density for nominal operation: ≥ 0,5 A/cm^2.
- Degradation: ≤ 5 %/500h.
- Operational flexibility: 20 to 100 % of nominal load.
- Minimal capacity of the electrolyser 20 gH_2/h.

- PGM electrode load: < 0.4 mg/W.

The achieved purity of hydrogen should be of at least 99%.

Scope

The expectations stemming from the aforementioned expected outcomes create a set of challenges to be overcome in order to produce electrolysers of various scale of power for distributed hydrogen production, performed without other than basic mechanical filtration or purification of seawater. In order to understand and tune reaction mechanisms describing the desired catalytic activities and the overall stability and selectivity, special attention needs to be paid to in-depth experimental, computational and theoretical insight into the mechanistic pathways and properties of the electrode-electrolyte interface under operating conditions. The major effort should, therefore, focus on one hand on the improvement of the hydrogen electrode to work in this harsh environment and on the other hand on the improvement of the selectivity towards the oxygen evolution at the anode electrode, as well as, to the durability issues stemming from both corrosion processes and catalyst (and membrane when applies) poisoning.

The project should consider the following requirements:

- Identify and develop suitable materials (catalysts, membrane when implemented, coatings, Porous Transport Layers, Bipolar Plates, sealings), as well as electrolyser design options and operating conditions relevant to the seawater composition of interest in correlation with electrolyser cell performance and selectivity.
- Experimental and model-based studies on the durability of materials, components and resulting prototype in harsh environment.
- Optimise advanced cost effective and limited CRM use electrocatalysts concerning activity, durability, and selectivity for the HER and OER with high tolerance to poisoning caused by chlorides, salts, and various contaminants (including ammonia and organic contaminants) present in seawater.
- Reduce the experimental efforts by means of the application of computer modelling tools including computational material science-based simulation approach.
- Integrate and test corrosion resistant new cost effective and available components into a prototype short stack (> 5cells) operated under dynamic mode simulating the intermittent behaviour of solar or wind power sources (RES).
- Identify the correlations between the durability of the component/system under development and its cyclic operating conditions.
- Operate the stack under representative conditions (to evaluate its performance and durability for at least 2000 h of cumulative operation and a minimum of 1500 cycles from idle to nominal operating conditions to simulate the dynamic electricity input from fluctuating renewable sources). The degradation rates should be measured during this time and reported in %/1000 h.
- Identify, define, and test a safe operating window in terms of durability based on the typical characteristics (e.g. salinities) of at least two types of sea feedwater corresponding to the prospective areas of application – relevant synthetic seawater according to the above identified geographic regions can be considered at some stages of long-term testing while final tests should consider the use of the natural water samples.

- Assess the circularity and techno-economic and environmental feasibility of the proposed technology, including the CRM cost – system durability tradeoff and evaluation of the brine as a source of extractable raw materials.

Consortia are encouraged to explore synergies with relevant ongoing projects funded by the European Innovation Council (EIC) Pathfinder Challenge 2021[97] as relevant.

Proposals are encouraged to explore synergies with projects within the metrology research programme run under the EURAMET research programmes EMPIR[98] and EMRP[99] (in particular on metrology for standardised seawater pHT measurements[100] and metrology for ocean salinity and acidity[101].

Activities related to test protocols and procedures for the performance and durability assessment of water electrolysers fed with low grade water should foresee a collaboration with JRC[102] (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[103] to benchmark performance and quantify progress at programme level.

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

HORIZON-JTI-CLEANH2-2024-01-04: Development and implementation of online monitoring and diagnostic tools for electrolysers

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 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)[104].

[97] EIC Pathfinder Challenges 2021 (HORIZON-EIC-2021-PATHFINDERCHALLENGES-01), https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/horizon-eic-2021-pathfinderchallenges-01-04?tenders=false&callIdentifier=HORIZON-EIC-2021-PATHFINDERCHALLENGES-01

[98] https://www.euramet.org/research-innovation/research-empir

[99] https://www.euramet.org/research-innovation/emrp

[100] https://projects.lne.eu/jrp-saphties/

[101] https://www.euramet.org/research-innovation/search-research-projects/details/project/metrology-for-ocean-salinity-and-acidity

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

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

[104] 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/ls-decision_he_en.pdf

Expected Outcome

The implementation of GW-scale hydrogen production through water electrolysis is being planned within the next decade. Coupling of these installations with fluctuating renewable energy sources (RES) is increasingly attracting interest due to the imminent decarbonisation of the electrical energy system. To ensure long lifetime even during transient operation, and hence low cost of ownership, tools for monitoring, diagnostics, and control are needed to optimise operation and detect fault conditions at an early stage. Such tools have been demonstrated in research labs and have been part of several EU projects paving the way for the implementation of new methodologies within commercial systems embedding high-temperature (DESIGN, DIAMOND[105], INSIGHT[106], REACTT[107], a.o.) and low-temperature systems (D-CODE[108], SAPPHIRE[109], INSIDE[110], HEALTH-CODE[111], RUBY[112], a.o.). All of these projects focused on fuel cells with the exception of INSIDE and REACTT which looked at electrolysers, and these systems have not yet been demonstrated and integrated into electrolyser systems of industrially relevant scale (> 100 kW). In addition, robust methodologies for interpretation need to be developed and validated specifically for electrolysis, both in a representative embedded hardware for the algorithms and monitoring, and in a representative industrial system.

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

- Providing new product ideas and solutions addressing monitoring and diagnostics of electrolysis systems, including hardware and software.
- Contributing to securing safe operation of large-scale systems such as AEL, PEMEL, SOEL, and AEMEL[113] and reduce the cost of ownership.
- Contributing to extending the lifetime of electrolysers, namely under fluctuating electricity input conditions.

Project results are expected to contribute to the following objectives of the Clean

Hydrogen JU SRIA:

- Reducing electrolyser OPEX;
- Improving dynamic operation and efficiency, with high durability and reliability, especially when operating dynamically;
- Demonstrate the value of electrolysers for the power system through their ability to provide flexibility and allow higher integration of renewables;
- Increasing the scale of deployment;
- Develop tools and methods for monitoring, diagnostics and control of electrolyser systems.

KPIs that should be addressed by this topic:

[105] https://cordis.europa.eu/project/id/621208
[106] https://cordis.europa.eu/project/id/735918
[107] https://cordis.europa.eu/project/id/101007175
[108] https://cordis.europa.eu/project/id/256673
[109] https://cordis.europa.eu/project/id/325275
[110] https://cordis.europa.eu/project/id/621237
[111] https://cordis.europa.eu/project/id/671486
[112] https://cordis.europa.eu/project/id/875047
[113] AEL: alkaline electrolyser, PEMEL: Proton exchange membrane electrolyser, SOEL: solid oxide electrolyser, AEMEL: Anion Exchange Membrane Electrolyser

- Prediction of higher than 95% of fault detection and isolation (FDI).
- Cost of monitoring and diagnostic system should be limited no more than 3% of system cost:
    - AEL: €24/(kgH2/d) or €12/kW
    - PEMEL: €30/(kgH2/d) or €15/kW
    - SOEL: €24/(kgH2/d) or €15,6/kW
    - AEMEL: €18/(kgH2/d) or €9/kW
- Contribute to reduce degradation:
    - AEL: 0.10%/1000 hrs
    - PEMEL: 0.12%/1000 hrs
    - SOEL: 0.50%/1000 hrs
    - AEMEL: 0.50%/1000hrs
- Improve reliability towards the target of 99%

Scope

In previous projects[114], proof of concepts of smart sensing technologies and functionalities have been integrated into the Management System. The main objective is, thus, focused on the development of monitoring tools and diagnostic techniques integrated in an Electrolyser Management System (EMS) that can range from processing conventional signals to advanced techniques including Electrochemical Impedance Spectroscopy (EIS). Physical and virtual sensor development should be addressed in the advanced solutions to be developed.

The scope of this topic is to further develop methods and tools for monitoring and diagnostics of electrolyser systems and demonstrate these at an industrially relevant scale (> 100 kW) on one electrolyser type. Such tools would help reduce OPEX by making dynamic operation more durable and reliable, reducing degradation on the system, and increasing the system efficiency. The commercial utilisation and exploitation should be clearly considered in the project.

Proposals should address the following:

- Develop a generic open-access monitoring and diagnostic platform that enables interoperability and thus allow for its utilisation by different electrolyser technologies;
- Identify suitable cell, stack and system level monitoring parameters which indicate a possible critical state of the cell/stack/module within the system;
- Develop reliable diagnostic algorithms to determine the remaining useful lifetime depending on the state of health of the cell components/cell/stack/module. Both physical model-based approaches and data-driven approaches are eligible;
- Develop the hardware for the implementation of these advanced Monitoring, Diagnostic and Lifetime Prediction tools that is able to interact with common control units and power electronics of the electrolyser system to trigger counter actions;
- Validate the diagnostic approach and the developed hardware for monitoring and lifetime prediction on at least two technologies (PEMEL, AEL, AEMEL or SOEL) in

[114] See detailed list in the expected outcome section

laboratory scale;

- Develop and propose strategies to sustain performance and improve durability of cells, stacks and systems for each tested technology. Demonstrate the effectiveness of the proposed strategy on short stack level or larger;
- Demonstrate functionality and resilience of the devices on electrolysers of power > 100 kW operated in representative or real conditions on at least one technology (PEM, AEL or SOEL), including fluctuating RES electricity input. Any demonstrator used in the proof-of-concept phase should already exist or be funded by other projects (TRL 6);
- Provide the prospect to integrate the tool for real time simultaneous monitoring of multiple stack and module key parameters and indicators. The EMS will receive output data in real-time from physical/virtual sensors of the EMS;

Proposals may address the following:

- Establish database of the measured experimental data to help future efforts into the development of new electrolyser operation schemes.
- Ensure the efficiency of the monitoring system in all kinds of environments.

Proposals are encouraged to explore synergies with projects within the metrology research programme run under the EURAMET research programmes EMPIR[115] and EMRP[116] (in particular on metrology for standardised seawater pHT measurements[117] and metrology for ocean salinity and acidity[118].

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[119] (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[120] (including Accelerated Stress Testing protocols) to benchmark performance and quantify progress at programme level.

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

HORIZON-JTI-CLEANH2-2024-01-05: Hydrogen production and integration in energy-intensive or specialty chemical industries in a circular approach to maximise total process efficiency and substance utilisation

Specific conditions	
Expected EU contribution per project	The JU estimates that an EU contribution of maximum EUR 10.00 million would allow these outcomes to be addressed appropriately.
Indicative budget	The total indicative budget for the topic is EUR 10.00 million.
Type of Action	Innovation Action
Technology	Activities are expected to start at TRL 5 and achieve TRL 7 by the end of the

[115] https://www.euramet.org/research-innovation/research-empir
[116] https://www.euramet.org/research-innovation/emrp
[117] https://projects.lne.eu/jrp-saphties/

[118] https://www.euramet.org/researchinnovation/search-research-projects/details/project/metrology-for-ocean-salinity-andacidity
[119] https://www.clean-hydrogen.europa.eu/knowledge-management/collaboration-jrc-0_en
[120] https://www.clean-hydrogen.europa.eu/knowledge-management/collaboration-jrc-0/clean-hydrogen-ju-jrc-deliverables_en

Readiness Level	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 10.00 million – proposals requesting Clean Hydrogen JU contributions above this amount will not be evaluated.
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)[121]. 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 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.

Expected Outcome

Energy Intensive and Specialty Chemical Industries consumes about a quarter of energy in Europe and significantly emits GHG. Most processes are powered with fossil fuels, and the role that clean hydrogen can play in decarbonising these sectors is widely recognised, together with circularity and efficiency through demand-side management and digitisation, as per illustrated in the Masterplan for a Competitive Transformation of EU EIIs. Early demonstrators, acting as de-risking initiatives, can pave the way towards industrial-scale demonstrations, where the impact in terms of GHG emission reduction is massive. It is a key opportunity to generate highly qualified jobs as well while addressing the ambitious targets set by the European Commission in its EU H2 strategy and REPowerEU plan.

This topic focuses on the production of clean hydrogen and its integration into those industries, within a circular approach. The long-term target (proposals should contribute to it) is to ensure continuous supply of clean hydrogen to those industries, at competitive costs compared to incumbent technologies. It is open to any production technology, and even combination of production technologies, as long as they operate from renewable input. This topic is suitable,

[121] 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/ls-decision_he_en.pdf

but not limited to, a further expansion of a successful smaller project, a demonstration into a sector not yet covered by on-going initiatives, or an innovative demonstration of clean hydrogen production technology (or combination of technologies). Proposals should build on and avoid overlaps with past and on-going projects supported by the Clean Hydrogen Partnership and its predecessor the FCH2-JU, the Processes4Planet (P4P) partnership and the Innovation Fund.

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

- Contribution to the ambitious targets set by the European Commission within REpowerEU;
- Contribution to initiatives launched by the European Commission pertaining to industries, decarbonisation, circularity, sustainability, and energy efficiency;
- Contribution to viable business cases for the clean hydrogen produced and integration of by-products from hydrogen production and/or transformation of waste into feedstock within those industries;
- An outline of a continuation plan for greater expansion, ultimately linked to a viable business case placing industrial circularity at the heart of the concept;
- Potential for integration into a hydrogen valley;
- High visibility and dissemination of lessons learnt;
- Development of skills and creation/conversion of jobs.

The topic is open to any renewable hydrogen production route. Accordingly, projects are expected to address the following objectives and related KPIs:

- the KPIs should be in line with the 2030 KPIs stated in the Clean Hydrogen JU SRIA for the relevant technologies. It could be necessary to include additional KPIs according to the renewable hydrogen production route/s addressed.

Scope

The scope of this topic is to demonstrate the integration of clean hydrogen production and supply to Energy Intensive and/or Specialty Chemical Industries for any combined applications (e.g. feedstock, heat and power generation, amalgamation with CO2, CO or N2 to generate synthetic fuels or hydrogen carriers, etc.) within a prism where circularity and sustainability are central, thereby considering transformation of waste into feedstock and/or capture and integration of any by-products from hydrogen production.

Proposals should cover the following aspects:

- Full-scale demonstration of one or more renewable hydrogen[122,123] production technologies;
- A supply of clean hydrogen (from technologies that will have been integrated within the scope of this topic and in line with relevant regulations' thresholds) in the range of at minimum 100 kg/h, over a minimum of 2 years of operations or 5000 cumulative working hours; Operational KPIs like availability and quantity of hydrogen integrated into the process should be included in the proposal;
- Implementation of comprehensive energy management system covering inputs,

[122] As defined in the SRIA of the Clean Hydrogen JU, clean hydrogen refers to renewable hydrogen
[123] Renewable hydrogen is hydrogen produced using renewable energy (Renewable Energy Directive 2018/2001/EU)

processes, and outputs;

- The development and validation of a comprehensive Energy Management System (including electrical energy and substances) as an optimisation tool capable of blending industry demand-side management with the maximisation of economic benefit and lifespan of hydrogen production technology, utilising advanced control methodologies like predictive approaches and real-time optimisation; related KPIs like optimization of renewable energy usage, reduction of H2 production cost by optimized energy management, reduction of CO2 footprint of H2/O2 and following products could be added;
- In addition to the hydrogen produced, transformation of at least one by-product into a feedstock and/or integration of at least one by-product from hydrogen production;
- Demonstration of the enhancements achieved in the hydrogen production and in the total process efficiency through techno-economic and life-cycle assessment, underlining the socio-economic and environmental benefits of the proposed circular approach, with attention to water management.
- Analyse and incorporate best practices on holistic sustainability from other sectors

Proposals should demonstrate how the circularity approach (e.g. use of by-products, transformation of a waste into a feedstock) is tackled, together with sustainability aspects such as, but not limited to, water management. The use of artificial intelligence and any other digital tools aiming at increasing safety and optimisation of operations is encouraged. Performance should be measured mainly against energy savings and GHG emission avoidance.

Costs for the development and integration of clean hydrogen technologies allowing supply of hydrogen/oxygen/by-products/ etc to the industries targeted are in the scope of the topic and may be funded. Any upstream (such as renewable energy technologies) or downstream processes (such as production of e-fuels, ammonia, chemicals) are in the scope of the topic within the circularity approach but will not be funded. For the downstream processes applicants are encouraged to seek synergies with the Processes4Planet (P4Planet) Partnership or other programmes.

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

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.

This topic is expected to contribute to EU competitiveness and industrial leadership by supporting a European value chain for hydrogen and fuel cell systems and components.

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[124]).

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[125] (see section 2.2.4.3 "Collaboration with JRC"), in order

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

to support EU-wide harmonisation. Test activities should adopt the already published EU harmonised testing protocols[126] to benchmark performance and quantify progress at programme level.

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

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

HYDROGEN STORAGE AND DISTRIBUTION

HORIZON-JTI-CLEANH2-2024-02-01: Investigation of microbial interaction for underground hydrogen porous media storage

Specific conditions	
Expected EU contribution per project	The JU estimates that an EU contribution of maximum EUR 3.00 million would allow these outcomes to be addressed appropriately.
Indicative budget	The total indicative budget for the topic is EUR 3.00 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)[127].

Expected Outcome

In a fully developed hydrogen economy large-scale hydrogen storage is expected to play a crucial role to balance supply and demand of hydrogen, even more so if the hydrogen is produced from renewable energy sources that are usually highly intermittent. To date, the most cost-effective technical solutions identified for storing large quantities of hydrogen is in underground geological formations, in particular in salt caverns and porous reservoirs (e.g. gas depleted field, aquifers), or artificial caverns. While different pilot projects already demonstrate(d) salts caverns as a large-scale hydrogen storage solution, the feasibility of storing hydrogen in porous reservoirs is not yet proven. In particular, the impact of hydrogen-consuming microbial activity needs more research in order to identify the potential risks associated with naturally present microbial communities in reservoirs. It is necessary to identify, characterise and determine site-specific microbial activities across different European sites for specific operational conditions. As well dedicated standards and guidelines are missing, representing a critical gap for the development of a European hydrogen ecosystem. The project results and findings obtained should contribute to overcome these normative gaps.

Artificial caverns for large-scale H2 storage also need more studies and pilots for demonstrating this solution industrially, however they are out of the scope of this project.

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

- Generate multidisciplinary knowledge that leads to microbiome-based understanding as needed by the industry and associated actors;

[127] 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/ls-decision_he_en.pdf

- Make industrially available large-scale hydrogen storage systems that can reduce the cost and improve the efficiency of hydrogen supply across the European landscape;
- Facilitate international collaborations to generate and apply knowledge that can improve underground hydrogen storage operations that contribute to hydrogen sustainability and reduce associated costs;
- Foster sustainable and safe design guidelines for operators of underground storage systems for long-lasting management solutions;
- Contributing to keep European leadership for large-scale hydrogen storage solutions, with particular focus on assessing the potential risks associated with biogeochemical processes.
- Definition of a risk matrix and European guidelines to support SSOs (Storage System Operators) in the identification and management of microbial risk associated with the storage of hydrogen in porous reservoirs;
- Replication 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.

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

- 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, with the focus on standards, for assessing the risks associated with the storage of hydrogen and microbial activities in porous reservoirs;
- Organising safety, Pre-Normative research (PNR) and RCS workshops;
- Providing inputs for developing Standards, Technical Specifications, or Technical Reports.

Scope

Different studies and projects (e.g. HYUSPRE[128], HYSTORIES[129]) have assessed the feasibility of storing hydrogen in porous media geological formations. However, a comprehensive assessment of the risks (eg. production of certain corrosives compounds and other impurities) associated with the different groups of microorganisms in specific underground formations needs to be studied in detail, considering the boundary conditions specific of each site (e.g., temperature, pressure, pH, rock's chemical composition, salinity, etc.). Related impact on rock properties (porosity, permeability, mechanical properties) driven for example by dissolution and precipitation mechanisms needs also to be investigated.

To overcome the gaps above and building also on the results of previous studies, projects and analysis, proposals should address the following:

- Taxonomic and functional characterisation of indigenous microbial populations present in the different European porous media geological formations. Relate growth rate and hydrogen-related enzymatic functions to different boundary conditions (e.g.

[128] https://cordis.europa.eu/project/id/101006632
[129] https://cordis.europa.eu/project/id/101007176

temperature, pressure, rock's chemical composition, salinity, etc.) should also be considered in the inventory. An interdisciplinary approach is highly recommended. Molecular tools should be applied to profile in terms of microbial taxonomic composition, relative abundances and functional characterisation the indigenous microbial populations present in the different European porous media geological formations (e.g. targeted Polymerase chain reaction (PCR) amplification and high-throughput sequencing of 16S rRNA; analysis of functional genes as molecular biomarker).

- Assess the microbial and geochemical reactions and their interactions between the two to clearly distinguish the reactions of hydrogen (and eventually considering also the impurities due to conversion of depleted natural gas storage to hydrogen storage) within each specific site. The results of the analysis considering multiple geological environments should be reported in order to improve the knowledge regarding the conditions in which reactions take place;
- Development of site-specific bio-chemical modelling. Modelling key microbial activities (i.e., H_2S production, methanogenesis, etc) should allow to understand how physical, chemical, and biological processes are coupled in an underground hydrogen storage;
- Development of standardisable and transferable methodologies for sampling autochthonous microbial populations of underground geological formations, including a reliable system to distinguish possible exogenous contamination;
- Development of laboratory methodologies for the processing and analysis of different types of samples collected from the underground storage sites (e.g. liquids, rocks, drilling mud, etc.). The methodologies developed should be described in sufficient detail to allow reliability and reproducibility of the obtained results among different laboratories;
- Application of the methodologies previously indicated for different sites, assuring an exhaustive coverage of the different European sites' peculiarities. The methodologies should be applied in different laboratories, considering different site samples. Microbial activity should also be observed during different testing periods, possibly up to six months, and in different batch/reactor operation volumes. Different levels of experiment together with modelling will be necessary to reproduce underground storage conditions and enable upscaling to the reservoir scale.
- Definition of guidelines/protocols to support SSOs in the identification and management of risk associated to the storage of H2 in porous media geological formations, as well as future standardisation activities. The guidelines should also propose a fast-track procedure which 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.

In order to ensure an exhaustive coverage of the different European sites' peculiarities, the consortium should include a large panel of SSOs from different EU Member States, whose operated storage infrastructures represent the variety of EU porous media geological formations. The knowledge and differences in the national underground storage facilities can be very significant, therefore the EU wide coverage should guarantee full usability of results for EU companies.

Building on the results of the previous activities, the proposals should, as relevant, provide recommendations and dissemination for updating and/or development of new standards at the EU and International levels.

Proposals are encouraged to explore synergies with projects within the metrology research programme run under the EURAMET research programmes EMPIR[130] and the European Partnership on Metrology (in particular projects MetroHyVe2[131] , Met4H2[132] and MefhySto[133]).

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

HORIZON-JTI-CLEANH2-2024-02-02: Novel large-scale aboveground storage solutions for demand-optimised supply of hydrogen

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)[134].

Expected Outcome

Future hydrogen related infrastructure components need to store significant amounts of hydrogen and deliver it according to the specific amounts, frequencies, and rates of hydrogen demand:

- Heavy-duty Refuelling stations:
    - Trucks:
        - Expected H_2 turnover: 5-10 tons/day;
        - Expected H_2 capacity: 10-50 tons.
    - Trains:
        - Expected H_2 turnover: 10-50 tons/day;
        - Expected H_2 capacity: 20-250 tons.
    - Ships:
        - Expected H_2 turnover: 50-500 tons/day;
        - Expected H_2 capacity: 100-2500 tons.
    - Temporary Refuelling Stations (e.g. in road construction or mining):

[130] https://www.euramet.org/research-innovation/research-empir
[131] https://www.sintef.no/projectweb/metrohyve-2/
[132] https://met4h2.eu/
[133] https://mefhysto.eu/
[134] 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/ls-decision_he_en.pdf

    - Expected H_2 turnover: 1-10 tons/day;
    - Expected H_2 capacity: 1-10 tons.
- Residential quarters, off-grid communities, industrial processes (metals or glass processing), import terminals, on-shore buffer storages: large variations in daily, weekly or monthly hydrogen storage and delivery are to be expected.

Currently, mainly compressed and liquefied hydrogen storage are used as aboveground options. They have several shortcomings: operation conditions (pressure, temperature), volume and geometrical footprint, potential for sudden release of large amounts of hydrogen, limited perspectives for further lowering cost. Research on novel hydrogen storage solutions is expected to overcome these deficits.

Project results are expected to contribute to all following outcomes:

- Advancing the maturity of aboveground hydrogen storage solutions based on novel gaseous, on novel solid or liquid hydrogen carrier, or on novel hybrid storage solutions;
- Decrease cost and energy consumption for delivery of hydrogen and, thus, increase the competitiveness of hydrogen technologies;
- Minimising impacts on the environment and maximising the safety of large scale aboveground hydrogen storage to significantly strengthen the European value chain of hydrogen delivery;
- Foster the establishment of new business cases for manufacturers of hydrogen storage system solutions by contributing to the implementation of regulations, codes, and standards for large scale aboveground storage systems for the abovementioned applications;
- Promoting the role that hydrogen can play for reaching the climate goals by validating its safe and cost-effective large scale aboveground storage in an application relevant environment.

Project results are expected to contribute to the following objectives and KPIs of the Clean Hydrogen JU as reflected in the SRIA 2021-2027:

- Undertake research and develop novel solutions for lowering cost and improving efficiency of aboveground storage solutions in some or all of the applications mentioned above.
- Showcase in this RIA the potential to decrease the cost and energy demand of hydrogen delivery by validating installations of a novel storage technology at the hundred kg H_2 module scale at TRL5 by 2027, allowing for implementation above the 20 ton H_2 scale by 2030 (SRIA, KPI Table 11);
- Validate the requirements for distributed aboveground storage solutions at TRL5 with the target, to achieve by 2030 a CAPEX lower than 600 €/kg H_2 on the 20 ton H_2 scale (SRIA, KPI Table 11).
- Validate a density of at least 40 kg H_2/m^3 on storage container level

Further expected outcomes under this topic:

- Novel safety solutions and features of the proposed storage technology, in order to reduce safety distances or store hydrogen at locations not being allowed at present for state-of-the-art compressed or liquid hydrogen storage, e.g. in buildings or shallow below surface;

- Reduction of the geometrical footprint and volume for relevant applications (e.g., hydrogen storage in HRS in inner urban areas or inside of buildings) and, thus, decrease the cost of ground in comparison to state-of-the-art compressed or liquid hydrogen storage;
- Progress in lowering the environmental impact and global warming potential of hydrogen storage, shown by a comprehensive Life Cycle Analysis (LCA). Potentials for recycling of materials used for building and operation of the storage system should be included.

Scope

Research activities under this topic should focus on novel safe, low-cost bulk storage solutions with the potential to enable demand- and application-optimised supply of H_2 on the (multi-) tons range for the various applications mentioned above.

Additionally, bulk hydrogen storage in urban industrial or residential environments faces special challenges: high cost for ground calls for an as low as possible geometrical footprint, and installation in the public domain should fulfil highest safety requirements. In contrast to mobile storage systems, requirements on weight and rate of H_2 loading are however more relaxed. Some applications would benefit from placing the storage system even inside of buildings or up to 10 metres underground (which is considered in this topic still as “aboveground” storage in contrast to storage in underground caverns or porous rock formations), which is currently not feasible due to safety regulations. Therefore, research activities should have a focus on minimising the geometrical footprint and volume of the storage system, as well as on safely preventing the accidental release of large amounts of H_2 by developing inherently safe storage solutions.

Furthermore, to reduce OPEX and contribute to Europe’s target on reducing total energy demand, the energy efficiency of the whole conversion chain from H_2 production, transport and storage up to its final use, has to be maximised while minimising the scope and frequency of maintenance activities. Consequently, research activities under this topic should also develop high efficiency storage systems, optimally integrated into the respective application with minimal energy requirements, e.g., profiting from waste energy (heat), and with minimised requirements for operational maintenance.

The proposed novel storage solution should be validated in line with the following requirements:

- Proposed storage technologies should internally operate in the temperature range between -40°C and +120°C. This requirement does not apply to any reactors for hydrogen loading or release that may be necessary, but only to the storage containers themselves. But ambient temperature solutions are preferred also for these reactors.
- Release of only hydrogen from the storage system. The physical state and degree of purity of the released hydrogen should fit to potential applications of the proposed novel storage technology and should be listed together with those applications.
- Proposed storage system may be single or modular. The validation system should have a capacity of at least 100 kg H_2 in total. It may consist of storage modules loaded off-site with hydrogen or a hydrogen carrier and transported to the validation site or modules loaded on-site. Proposals should elaborate on the option used to supply hydrogen to the storage system.
- Proposals should describe a roadmap for scale-up of the proposed technology for storage of 20 tons of H_2 or more for the applications envisaged by the proposed

technology, by 2030

- Projects should validate the potential to reduce OPEX (energy, water, heating/cooling, maintenance, replacement of parts, recertification, …) to a level of < 1 €/delivered kg of H_2 in 2030 on the ton to 20 ton/day delivery scale;
- The safety of the storage system and boundary conditions for its implementation should be defined, since further development of already existing or the establishment of new technical rules, codes and standards for novel storage solutions is a prerequisite for the establishment of future market opportunities and business cases. The safety analysis should deliver required conditions of operation of the storage system with respect to amounts and rates of unintended possible release of hydrogen, necessary ventilation, and safety distances to neighbouring installations.
- Projects may include a work package on simulation of effects of failure and unintended hydrogen release of the proposed storage technology, validating the progress beyond the state of the art.
- Projects may implement in-situ techniques for H_2 filling level and state of health monitoring to extrapolate lifetime of the storage system.
- As far as possible, critical raw materials[135] as well as "forever chemicals"[136] in the production chain should be avoided, favouring circular economy approaches and use of chemicals and materials with minimum environmental impact. Use of recycled raw materials for construction and operation is preferred. The necessary consumption of raw materials and their resources for building and operation of the proposed storage technology should be described in the proposal.
- A broader range of applicability of the proposed technology would be a plus. Proposals may identify and provide numbers on specific business cases.
- If one, some or all of the following are necessary for envisaged applications - a hydrogenation unit, a dehydrogenation unit, a cracker, a purification, a compression device – these, as well as all necessary auxiliaries (e.g., internal and external heat management) should be included for calculation of total system storage density, footprint, CAPEX, OPEX, etc. Hydrogenation or hydrogen processing units for loading have to be included in the system envelope only if they are necessary on-site for the storage process. E.g., a hydrogenation unit for a novel type of hydrogen carrier, operated at a different site than that of the novel storage system, does not have to be included, but may be described for clarification of advantages of the proposed storage technology.
- Progress with respect to state-of-the-art in CAPEX and OPEX, considering additional cost advantages like low footprint / cost of ground or use of industrial waste heat lowering energy cost, should be assessed in a Life Cycle Cost assessment (LCCA) of potential use cases.

Liquid hydrogen storage technologies are out scope of this topic.

Proposals are encouraged to explore synergies with the Zero Emission Waterborne Transport (ZEWT) partnership and Clean Aviation Joint Undertaking (CA-JU) as this topic has the potential for providing the large scale hydrogen storage facilities that ports and airports

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135 https://ec.europa.eu/growth/sectors/raw-materials/specific-interest/critical_en

136 e.g. https://www.consilium.europa.eu/en/press/press-releases/2022/10/24/council-formally-adopts-further-restrictions-to-forever-chemicals-in-waste/

will require.

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

HORIZON-JTI-CLEANH2-2024-02-03: Demonstration of hydrogen purification and separation systems for renewable hydrogen-containing streams in industrial applications

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.
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)[137]. 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): purification prototype/s and related components, costs may exceptionally be declared as full capitalised costs.

Expected Outcome

Lowering the cost of purification is crucial for making hydrogen a competitive option in various

[137] 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/ls-decision_he_en.pdf

industries. Efficient technologies are already available to purify hydrogen from different hydrogen containing mixtures. For example, FCH2JU projects (HyGrid, HIGGS) are currently assessing performance of such technologies at laboratory or small scale. However, they have not proven yet their potential under real industrial conditions, which are adding constraints, such as high flows, complex gas composition, etc.

In addition, other innovative technologies are also emerging and may offer very interesting perspectives for hydrogen purification in the future if their performances are confirmed in operational industrial conditions.

This context shows the importance to go further with the demonstration in real industrial application conditions and optimisation of technologies regarding the efficiency of the overall system to reduce the cost of recovered hydrogen.

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

- Contributing to improving energy efficiency, reliability, and durability of purification systems in different applications;
- Contributing to lower the cost of hydrogen purification;
- Contributing to increase the lifespan of purification units and reduce maintenance requirements, making the technology more attractive for commercial deployment.

Project results are expected to contribute to the following objectives and KPIs:

- The technology should produce hydrogen with a decrease of at least 25% in Energy use and at least 30% CAPEX compared with standard technologies used for similar separations. The total energy consumption should be <3.5 kWh/kg;
- Reach a levelized cost of hydrogen separation/purification < 1euro/kg;
- Reduction (>50%) of the use of critical raw materials compared to SoA technologies.
- Aim at hydrogen recovery, higher than 90% with a purity of higher than 95% (up to ISO mobility requirements).

Scope

Current commercial purification techniques remain costly. Novel methods to purify hydrogen with higher efficiency and at lower cost would improve the overall hydrogen supply chain. A range of new membrane, electrochemical and thermochemical techniques are being developed and have shown promise to improve processes for purification of hydrogen. The natural progression towards commercialisation of next-level purification technologies is to expose them to real industrial conditions and to observe the hydrogen purity according to globally recognised standards.

Proposals for this topic should therefore cover the following elements:

- investigate the type of streams containing hydrogen that need purification, as example, mixtures with < 20% hydrogen or “almost pure” hydrogen (> 98%). Different pressure levels of the hydrogen containing mixture could be considered. Should demonstrate applicability on 2 types of streams; Hydrogen de-blending from Natural Gas lines is excluded;
- include a review of the existing industrial streams where hydrogen purification is needed, highlighting the gas composition and operational conditions of these outlet flows;

- demonstrate in a representative industrial application (at TRL7) for the operation of 3000 hours, cost effective concepts for hydrogen purification of renewable hydrogen containing streams; concepts should target > 100 kg/day pure hydrogen output. Coupling different technologies towards a more efficient system may be considered;
- offer and demonstrate an operational capacity to regulate the purity of the output flows from a fluctuating concentration in the industrial stream;
- conduct a techno-economic analysis and an optional life-cycle assessment, comparing the different technologies available on the market;
- analyse the impact of production scaling-up for purification systems.
- consider hydrogen safety issues associated to this process with thorough knowledge of the hazards.
- develop accelerated protocols to assess the lifetime of the components/systems.

Proposals are encouraged to explore synergies with projects within the metrology research programme run under the EURAMET research programmes EMPIR[138] and the EMP,European Partnership on Metrology (in particular projects MetroHyVe2[139] , Met4H2[140] and MefhySto[141]).

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

HORIZON-JTI-CLEANH2-2024-02-04: Demonstration of innovative solutions for high-capacity, reliable, flexible, and sustainable hydrogen compression technologies in commercial applications

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 8 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.

[138] https://www.euramet.org/research-innovation/research-empir
[139] https://www.euramet.org/european-metrology-networks/energy-gases/activities-impact/projects/project-details/project/metrology-for-hydrogen-vehicles-2
[140] https://www.euramet.org/european-metrology-networks/energy-gases/activities-impact/projects/project-details/project/metrology-for-the-hydrogen-supply-chain
[141] https://www.euramet.org/european-metrology-networks/energy-gases/activities-impact/projects/project-details/project/metrology-for-advanced-hydrogen-storage-solutions

	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.
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)[142]. 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): compression prototype/s and related components, costs may exceptionally be declared as full capitalised costs., costs may exceptionally be declared as full capitalised costs.

Expected Outcome

In order to accelerate the European green transition and achieve the targets set in the European Green Deal and the European Climate Law, the scale of hydrogen projects has been increasing rapidly in recent years. There is a clear shift of focus from small, decentralised H2 production units, towards large scale supply chains with centralised multi-megawatt electrolysers and large filling centers for gaseous hydrogen distribution. In addition, fleets of busses, transport trucks, garbage trucks, and other HDV are being deployed around Europe, necessitating the expansion and reinforcement of today's infrastructure with high capacity HRS to ensure fast, safe, reliable and sustainable delivery of large quantities of hydrogen.

The outlet pressure of green hydrogen production systems is generally not more than 30 bar, and a compressor is necessary for most applications (large-scale filling center, high capacity HRS, gas-pipeline injection) to reach the target pressure (minimum 500 bar for filling center, up to 1000 bar for HRS, up to 200 bar for pipelines). These compressors are subject to challenging requirements and are one of the main obstacles to achieving an economical and energy-efficient hydrogen infrastructure.

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

- Contributing to strengthening European leadership in the H2 value chain infrastructure solutions, based on compression technologies that will be applicable for H2 mobility, power-to-gas and industrial use of H2
- 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;
- Contributions to at least 1 full scale demonstrator of breakthrough and game-changing hydrogen compressor by 2027, with a focus on safety and reliability;
- Foster the replication of the solutions demonstrated in the project in at least 5 additional

[142] 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/ls-decision_he_en.pdf

locations by 2030

- 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 of the Clean Hydrogen JU as reflected in the SRIA 2021-2027:

- Improve through research and innovation, including activities related to lower Technology Readiness Levels (TRL), the cost-effectiveness, reliability, quantity and quality of clean hydrogen solutions; including production, distribution, storage and end uses developed in the Union;
- Carry out demonstrations of clean hydrogen solutions with the view to local, regional and Union-wide deployment; addressing renewable production, distribution, storage, and use for transport and energy-intensive industries as well as other applications.

More specifically the above will be achieved by contributing to the following SRIA compression-specific objectives:

- To develop more efficient compressor technologies
- To reduce the total cost of ownership of compression and purification technologies
- To increase the reliability and lifetime of compression and purification technologies

The demonstration is expected to contribute to the following KPIs of the Clean Hydrogen JU SRIA:

- Technical lifetime of the compressor: 14 years immediately, with potential to reach 20 years in 2030
- Electrical energy consumption per kg hydrogen:
    - from 5 to 900 bar: 4 kWh/kg immediately, with potential to reach 3 kWh in 2030
    - from 30 to 200 bar: 2.5 kWh/kg immediately, with potential to reach 2 kWh in 2030
- Mean time between failures (MTBF): 40,000 h immediately, with potential to reach 60,000 h in 2030
- OPEX:
    - For HRS and filling center, including auxiliaries: 0.07 €/kg immediately, with potential to reach 0.03 €/kg in 2030
    - For pipeline, including auxiliaries: 0.03 €/kg immediately, with potential to reach 0.01 €/kg in 2030
- CAPEX:
    - For HRS compressor: 933 €/(kg*day) immediately, with potential to reach 438 €/(kg*day) in 2030
    - For pipeline compressor: 167 €/(kg*day) immediately, with potential to reach 108 €/(kg*day) in 2030
- At least 90 % availability throughout the demonstration phase
- Peak noise emissions of maximum 60 dB measured at 5m distance

Scope

Today's mechanical compressors have significant drawbacks in terms of CAPEX, OPEX, maintenance, electricity consumption and noise, leading to a weakness in this area. Innovative non-mechanical compression solutions do exist and have been developed & demonstrated in previous EU-funded projects (PHAEDRUS[143], Don Quichote[144], H2Ref[145], H2Ref-DEMO[146], COSMHYC[147], COSMHYC XL[148], COSMHYC DEMO[149]) over the past few years and have increased in TRL. However, these solutions require further experience in their deployment to overcome safety and administrative regulatory challenges for the permitting of these installations. It is also necessary to perform long-term demonstration, to confirm the low O&M costs and the feasibility of an acceptable life-time, and thereby enable a rapid market introduction. In addition, the versatility of these innovative solutions still needs to be increased, by enhancing the output pressure (up to 950 bar), proving the ability of the technology to operate under challenging conditions corresponding to emerging H2 use cases (offshore platforms, cold/hot climatic zones, remote sites…) and improving the resistance of innovative technologies to low purity hydrogen.

This topic aims at further supporting the deployment of critical components in the hydrogen value chain, with demonstration in a real-life application, to increase confidence in and familiarity with hydrogen technologies. It involves dimensioning, manufacturing, installing and demonstrating a compression solution at a client site, including all related safety considerations and regulatory challenges with local authorities. The demonstration site should be a fully commercial site subject to all regulatory requirements of the country in which is deployed, and should be representative site for replication use-cases.

The demonstration campaign should include 24-month demonstration of the compression solution in a full-scale commercial setting, with direct coupling to a renewable energy source for either the hydrogen production system, the power supply of the compressor, or both.

Furthermore, the site should include some challenging aspects, such as environmental challenges (heat, marine conditions, high altitude, urban, etc…). The applicant will need to describe in the proposal which particular challenges it intends to address, their negative impact on the compressor operations and the technical solution proposed to overcome them. The power supply for the compressor and/or the power supply for the electrolyser should be directly provided by a sustainable/renewable energy source to prove the suitability of the compressor for RES, e.g. by demonstrating the ability to deal with energy peaks and intermittent hydrogen/electricity supply in an efficient way. Finally, the sustainability aspects of the solution in terms of circulatory, upcycling, second life and end of life concepts should be addressed in the project.

The compression solution should consist of either an innovative, non-mechanical, compression solution, or a combination of different solutions including at least one innovative, non-mechanical, technology (in which case the non-mechanical compressor should be the main focus of the project, and the mechanical compressor should show highly innovative aspects and advantages), and have a representative scale:

- HRS & Filling Center use-case: at least 2.5 tonnes per day from maximum 30 bar to

[143] https://cordis.europa.eu/project/id/303418
[144] https://cordis.europa.eu/project/id/303411
[145] https://cordis.europa.eu/project/id/671463
[146] https://cordis.europa.eu/project/id/101101517
[147] https://cordis.europa.eu/project/id/736122
[148] https://cordis.europa.eu/project/id/826182
[149] https://cordis.europa.eu/project/id/101007173

500 - 1000 bar (depending on application);

- Gas Pipeline use-case: at least 5 tonnes per day from maximum 30 bar to minimum 100 bar.

The reliability and advantages of the compressor should be demonstrated in terms of availability, performance, compatibility with RES, maintenance, scalability, safety, compliance and a robust business case. The compressor should be demonstrated in a commercial setting for at least two years, to show the maintenance requirements and reliability under different seasonal conditions.

A suitable demonstration site should be secured ahead of the proposal submission and convincingly described. The infrastructure directly surrounding the compressor (e.g. HRS or filling center) and other activities necessary for the project launch (e.g.: civil works, safety studies…) as well as specific manufacturing equipment required to build the compressor may be funded.

A real (not simulated) RES-profile-following power consumption of the electrolyser or compressor is a requirement of the demonstration. While the COSMHYC & H2Ref series of projects focused on hydrogen refueling stations, the project should develop a versatile technology which can also be used in the following applications: filling centers, industrial use cases or injection into a gas pipeline.

The project should provide a convincing and detailed roadmap towards large-scale manufacturing of the commercial compressor in the European Union. This should include realistic funding plans for a factory, quantitative details of the required infrastructure and plant operation needs, potential sites and their requisites, including permitting and administrative constraints, and a timeline for industrialisation. The compressor should be designed for a standardised and large-scale production process, optimising the manufacturing methods and lowering per-unit production costs and time.

In addition to the technical feasibility of the compression solution, the following aspects are to be addressed in the scope of the project:

- Special attention should be paid to the safety measures specifically linked to the compressor;
- Planning the safety concept of the whole demonstration site beyond the system limits of the compressor;
- Flexibility of the solution for several use-cases:
  - Wide range of inlet pressures (from 1 bar to 200 bar, depending on application);
  - Intermittent operation in line with the RES considered in the project;
  - Functionality as baseload compressor, as well as for receptacle filing (dynamic outlet pressure);
  - Reliable operation in challenging conditions (e.g.: hot/cold climates, marine environment, high altitude, remote).
- Sustainability, recyclability, and circularity aspects, especially if critical raw materials are used (for example Platinum Group Metals);
- Permitting and regulatory challenges at the demonstration site on a national and European level, including making recommendations for future regulation framework;
- Demonstrating economy of scale and TCO, including a detailed roadmap to

industrialisation;

- Any noise disturbance and vibrations coming from the compressor should be quantified and the consequences on the surrounding infrastructure clearly explained and mitigated;
- The adaptability of the solution for different green hydrogen sources should be addressed, including low quality gas, very low inlet pressure, high inlet pressure from transmission pipeline and intermittent production;
- State of health and degradation aspects should be analysed in-situ and quantified;
- How the compressor deals with lower quality hydrogen (either as supplied gas, or for use-cases with less strict requirements) should be addressed;
- In the case of waste energy valorisation, the associated costs (CAPEX & OPEX) of integrating this energy source;
- The OPEX for different scenarios and different modes of operation, for example for a compressor not working at full capacity, should also be addressed and described, in order to get a realistic idea of the “real-life” energy consumption to be expected in a real application (where the compressor will not always run on nominal load);
- End-of-life concepts or second life/upcycling concepts.

This topic is expected to contribute to EU competitiveness and industrial leadership by supporting a European value chain for hydrogen and fuel cell systems and components.

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-JTI-CLEANH2-2024-02-05: Demonstration and deployment of multi-purpose Hydrogen Refuelling Stations combining road and airport, railway, and/or harbour applications

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 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 8.00 million – proposals requesting Clean Hydrogen JU contributions above this amount will not be evaluated.
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)[150]. 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): HRS and related components, costs may exceptionally be declared as full capitalised costs.

Expected Outcome

Hydrogen Refueling Stations are an essential element of the future hydrogen mobility. For widespread hydrogen mobility to be viable, it will be essential to provide a nationwide network of publicly accessible HRS for passenger cars, trucks, buses, vans, etc. all over the EU. Furthermore, larger heavy duty fueling applications such as trains, harbours, and airports will require very reliable, high-capacity stations capable of delivering many tons each day in a safe manner.

Thus, it is fundamental to develop and optimise HRS (especially for trains, marine and airport applications), situated on depots, with corresponding captive demand for large-scale hydrogen. This concept assumes the provision of pressurised gaseous and/or liquid hydrogen together with the development of appropriate and reliable systems for lifetime prediction. Combining multi-mobility ecosystems (railway, maritime and airports) within the same HRS may reduce refuelling costs and supply chain costs. For example, at an airport, hydrogen is supplied for aviation systems (aircraft, ground support equipment, etc.) while hydrogen is available for heavy duty cargo transport vehicles. The project has to be commissioned and tested in order to measure if the technical requirement are met.

The project results are expected to contribute to the following outcomes:

- The deployment of hydrogen refuelling facilities for vehicles (ground support equipment and heavy-duty vehicles fleets) and captive fleets (buses, trains, etc.);
- High public visibility with a growing number of trial and demonstration projects;
- Full integration into the broader energy ecosystem;
- The underpinning of Europe's leadership in the supply of HRS solutions worldwide;
- The development of new services and the HRS delivery platform;
- The creation of an EU map of hydrogen refuelling stations;

[150] 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/ls-decision_he_en.pdf

- Improved understanding of common failures at HRS;
- Improved interoperability of HRS;

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

- Reduction of CAPEX: 1.5–4k€/(kg/d) (700bars), 0.65-2.5k€/(kg/d) (350bars), 1.5-4k€/(kg/d) (LH2);
- Increased availability: 98% (700bars), 98% (350bars), 97% (LH2);
- Hydrogen price: 3€/kg (700bars), 2€/kg (350bars), 3€/kg (LH2);
- Annual maintenance cost: 0.5€/kg (700bars), 0.35€/kg (350bars), 0.5€/kg (LH2) ;
- Increased reliability (mean time between failures): 72 days (700 bars), 144 days (350 bars), 216 days (LH2).

Scope

The aim of this topic is to demonstrate a multipurpose HRS able to supply a combination of aviation, rail and/or heavy-duty road applications.

Combining these mobility ecosystems will stimulate the development of a regional hydrogen economy, creating a synergy with public and private actors across the hydrogen value chain (production, distribution, storage, and end-use).

Currently station costs, both CAPEX and OPEX, are high, thus challenging the development of a refuelling station business model, particularly in the early years when utilisation is comparatively low.

Reliability is also low, creating difficulties for customers who cannot rely on their hydrogen supply.

In addition, the approvals and construction processes for hydrogen stations are too slow, while their design is heavily influenced by the respective fuelling protocols developed by each manufacturer, which are not yet fully understood and optimised.

Proposals should respond to the following technical requirements:

- Develop high throughput stations for heavy duty vehicles fleets (trains, buses or trucks, aircrafts, maritime vessels, and associated ground support equipment), including 1,000 to 3,000kg/day capacity and individual fills of more than 200 kg expected in less than 20 minutes; more generally the station capacity should depend on filling station profile (e.g. hourly peak demand is usually around 7% of the daily mass dispensed (for trucks);
- Develop digital models that capture refuelling data in aim to anticipate load curves in the HRS;
- Reduce CAPEX and OPEX by implementing innovative technological components (e.g., compressors, cooling systems, dispensers) and optimising their integration into the design and operation of the HRS;
- The interaction between the HRS and other fleet-specific processes on site or nearby can also be investigated. The control strategy will reduce the energy consumption of the HRS and allow safe and optimised refuelling of the vehicles and will adapt/develop appropriate fuelling protocols;
- Reduce OPEX and increase reliability by developing and testing of condition-based

maintenance approaches for key HRS components;

- Facilitate the use of locally produced green hydrogen, e.g., by enabling low inlet pressure and flexible operation for intermittent renewable energies, or production by electrolysis or biomass;
- Develop a pressurised and/or liquid hydrogen supply strategy;
- Implementing appropriate protocols depending on different supply strategies e.g., the development of swap tank containers for distribution and storage;
- Analysis and identification of standardised primary performance metrics of HRS and input to standardisation premiums in order to enable comparison of different HRS;
- Aim to standardise and industrialise HRS equipment and components while developing protocols for safe and reliable refuelling in partnership with OEMs and distributors;
- Include specific targets (beyond the State-of-the-Art) for improved reliability, safety and availability of HRS equipment and infrastructure;
- Address technical certification and levels of education and awareness amongst regulators and other stakeholders;
- Support improved efficiency, with the goal of zero boil-off for LH2 and losses during hydrogen transfer, distribution, and, ultimately, across the whole hydrogen supply chain;
- Provide refuelling of support vehicles within the respective area of use, demonstrating global platform autonomy;
- Develop an understanding of common failures at HRS;
- Quantify the costs incurred when operating an HRS.

Proposals are encouraged to explore synergies with projects within the metrology research programme run under the EURAMET research programmes EMPIR[151] and the the European Partnership on Metrology (in particular projects MetroHyVe2[152] , Met4H2[153] and MefhySto[154], MetHyInfra[155] and MetHyTrucks[156]).

Proposals are encouraged to explore synergies with the Zero Emission Waterborne Transport (ZEWT) partnership and Clean Aviation Joint Undertaking (CA-JU) as this topic has the potential for providing operational and technical solutions for hydrogen refuelling infrastructure in ports and airports.

This topic is expected to contribute to EU competitiveness and industrial leadership by supporting a European value chain for hydrogen and fuel cell systems and components.

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

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[151] https://www.euramet.org/research-innovation/research-empir
[152] https://www.euramet.org/european-metrology-networks/energy-gases/activities-impact/projects/project-details/project/metrology-for-hydrogen-vehicles-2
[153] https://www.euramet.org/european-metrology-networks/energy-gases/activities-impact/projects/project-details/project/metrology-for-the-hydrogen-supply-chain
[154] https://www.euramet.org/european-metrology-networks/energy-gases/activities-impact/projects/project-details/project/metrology-for-advanced-hydrogen-storage-solutions
[155] https://www.euramet.org/european-metrology-networks/energy-gases/activities-impact/projects/project-details/project/metrology-infrastructure-for-high-pressure-gas-and-liquified-hydrogen-flows
[156] https://www.euramet.org/european-metrology-networks/energy-gases/activities-impact/projects/project-details/project/metrology-to-support-standardisation-of-hydrogen-fuel-sampling-for-heavy-duty-hydrogen-transport

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-JTI-CLEANH2-2024-03-01: Balance of plant components, architectures and operation strategies for improved PEMFC system efficiency and lifetime

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)[157].

Expected Outcome

To achieve the ambitious goal of the European Green Deal (at least 90% reduction in transport emissions by 2050 to be consistent with climate neutrality), reducing CO2 emissions attributed to transport (around 30% of EU total) is a key, particularly when taking into account the constant expansion of high-power means of transportation on road, by rail, air and water. Improvements on fuel cells technology building blocks applicable across a range of different applications will contribute by tackling basic issues related to efficiency and lifetime which are currently preventing competitive deployment of hydrogen-based transport. The motivation of this topic is to achieve the overall improvement of the PEMFC[158]-based systems by addressing the Balance of Plant (BoP) as the remaining system technology building block, thereby ensuring successful implementation of outcomes from R&I actions currently dedicated to improving fuel cells technology for transport by addressing components from core materials to stack level, in parallel to hydrogen storage on-board.

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

- Solutions for improving efficiency and durability of the PEMFC system (at least 100 kW, as aimed for Heavy-duty (HD) road application), applicable for integration / implementation in a prototype for at least one HD transport mean by 2030*;*
- PEMFC systems integrating new optimised architecture or new hybridisation strategies ready to be adopted and implemented by developers of powertrains for heavy-duty high-power means of transport;

[157] 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/ls-decision_he_en.pdf

[158] PEMFC: proton exchange membrane fuel cell

- New modular BoP elements based on appropriate combination of components / devices / strategies addressing fuel or air supply (and cooling) and fulfilling expectations of fuel cell powertrains suppliers and end-users;
- Flexible tools for adapting/optimising PEMFC BoP operation strategies to improve reliability and durability of wide range of Fuel Cell Hydrogen-based means of transport;
- Support the development of the PEMFC technology for cost competitive next generation of commercial/industrial scale FC systems from EU suppliers of primarily heavy-duty vehicles and potentially other applications;
- Consolidate European leadership on understanding and optimisation of BoP architectures for specific technology cases addressing all transport applications, including support to developments conducted in topic “HORIZON-JTI-CLEANH2-2024-03-02: Scaling-up Balance of Plant components for efficient high power heavy duty applications” and other BoP topic dedicated to new solutions specifically adapted for new generation higher-power applications.

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

- Proving efficiency and applicability of Hydrogen Fuel Cell based solutions in the transport sector thanks to necessary improvements gained at system level, with validation of the new solutions on at least one module (defined by the project StaSHH[159] as the stack plus the BoP) for a heavy-duty-road case and demonstrated applicability for another case from a different transport mode;
- Improved building blocks for heavy-duty applications, with higher power density, efficiency, reliability and durability, thanks to better performing BoPs, with redesigned architectures and optimised strategies, integrating at least one newly developed BoP component (or sub-system);
- Objectives and KPIs are targeted at module or system scale with improvements in design or health monitoring: they should be validated on the leading selected heavy-duty-road application, then highlighting spillover benefits for other applications;
- FC module CAPEX <300 €/kW;
- FC module durability > 25,000 h. End of life is corresponding to 10% loss in performance;
- FC system electric efficiency of 60% with state of art PEMFC stack achieving SRIA KPIs in terms of initial performance (areal power density between 1 and 1.2 W/cm² @ 0.675V).

Scope

Heavy duty high-power transport applications put stringent lifetime expectations for the entire Fuel Cell System (FCS). The FCS should achieve the same lifetime expectations as the Fuel Cell stack if not longer. Balance of plant (BoP) components (such as devices to improve air, fuel and cooling subsystems, like particularly innovative air compressor/turbocharger, air humidifier, hydrogen recirculation features, and devices to support control, monitoring or safety, like high-voltage components, electronic converters, sensors...) and stack/system interactions management (diagnostic strategies, algorithms, methodologies) also require focused innovation and development. Even if stack design and core components have the

[159] https://cordis.europa.eu/project/id/101005934

most significant impact on the PEMFC performance and durability, optimising PEMFC system operation strategies and architectures is essential to achieve the targets expected for 2030 allowing efficient FC systems integration into transport means.

The link between performance losses and degradation mechanisms occurring in stacks is extensively investigated, as are the operational situations that promote them. Mitigation strategies and novel architectures can be proposed on system and BoP level but breakthrough efforts are needed to assess and moreover quantify their benefit. The eventual optimisation will allow for stability improvement towards all the specified usage modes and conditions (idle, high and low power, load cycles, cold start, start-up, shunt down, reactants, cooling).

This topic focuses on:

- developments to ensure improved system performance combined with its extended lifetime by addressing BoP components, including new developments on BoP sub-systems, and module/system interactions with respect to efficiency, reliability, durability and cost. The improvement is expected from a combined approach addressing the architecture and operation strategies of a system both supported by the development or redesign of at least one BoP component preventing optimized efficiency at beginning of life and over the long term. Moreover, primary focus will be on heavy-duty road applications, within the boundaries of STaSHH definitions for the actual validation of results, even though spillover benefits in other transport modes shall be highlighted.
- 100 to 220 kW modules, the range identified by the StaSHH[160] project for the heavy-duty-on-road cases, which is identified as the leading field of application to be considered here. Scalability by implementing several modules towards very large power when needed as well as spillover effects of new BoP solutions to other transport modes will be considered in the further exploitation of results, as additional outputs.

R&I activities to be addressed should consistently include the following to achieve the expected results:

- Understanding and assessment of irreversible and reversible degradations attributed to system operation conditions specified for the targeted application, following a coupled experimental / modelling approach (e.g., analysing and quantifying issues associated with the different usage modes, specific situations or conditions, transients);
- Development of solutions to mitigate irreversible and regenerate reversible degradation by acting on the PEMFC system strategies or redesigning BoP architectures. This could include identifying requirements for BoP-components to perform robust start-up, shut-down in nominal or extreme conditions, and plans for demonstration of identified solutions;
- Pursue BoP behaviour analysis and diagnostics for appropriate BoP and system state of health monitoring, (development of specific measuring tools, procedures, real and virtual sensors, algorithms, and prognostic based methodology; as well as digital twin approach could be considered for effective control over the long-term);
- Identifying within the BoP architecture, individual or combined elements affecting the performance likely to reduce reliability and durability. This could include issues related to materials used (for example risk of emissions causing contamination) or functional

[160] https://cordis.europa.eu/project/id/101005934

requirements (for example dynamics);

- Carrying out required development and optimisation of identified less robust BoP component(s) (ground-up redesign of at least one component or one sub-system);
- Developing solutions for optimised assembly of the selected items, also linking the approach with the best suited sub-system or system management (on this item modular multi scale architectures could be a viable approach);
- Assessing BoP components (or subsystems) managing the fuel or the air supply: feeding sources and modes (compression, circulation, purges etc) and operating conditions profiles (like pressure, flow, relative humidity) along with the devices used to control them, could be particularly relevant for improving performance stability at module management scale;
- Validation of improvement (at system/module or BoP component level) of the overall system reliability and serviceability thanks to optimised Fuel Cell System management
- Assessing manufacturability aspects for the ground-up redesigned BoP components to meet system cost targets (techno-economic assessment regarding impact on BoP improvements and manufacturing of the newly developed components).
- Carrying out a techno-economic assessment to demonstrate the progress toward reducing the CAPEX of fuel cells, associated to the work in BoP development, including manufacturing aspects regarding newly developed BoP components;

The final aim of the topic is to demonstrate efficiency and durability improvements for selected specifications, at representative scale in a real or emulated system environment.

The validation of performance improvement should be done on one real module for at least one case of heavy-duty road application, against a reference described in the proposal and presenting at least 2022 state of the art performance.

In addition, the modularity or adaptability of the solutions developed should be proven based on a feasibility study considering another power level or another heavy-duty transport mode.

Referring to StaSHH outcomes in terms of integration boundaries, developed solutions should be implementable in harmonised PEMFC modules for systems of power level of at least 100 kW (range of StaSHH standards 110 to 220kW identified for heavy-duty-road modules) and operated, for their validation, in representative conditions according to the road transport applications selected.

Proposals should include a description on how KPIs will be assessed and reached, by justifying assessment and validation procedures regarding the applications targeted.

Consortia are expected to build on the expertise from the European research and industrial community to ensure impact by addressing several of the aforementioned items. End-users should be involved, at least in an advisory board, while at least one Fuel Cell manufacturer should be included in the consortium.

Proposals should demonstrate its ability to address appropriately different heavy-duty transport means. In particular, it should be demonstrated how spill over effects in other transport modes, besides heavy-duty-on-road, will be achieved in terms of exploitation of results.. At least one partner should be involved focusing on the development of a new BoP component or sub-system.

The developments on the FC stack or stack components are not in the scope of this topic.

HORIZON-JTI-CLEANH2-2024-03-01 and HORIZON-JTI-CLEANH2-2024-03-02 topics are highly complementary; liaison between successful proposals in these two topics 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 encouraged to explore synergies with the Zero Emission Waterborne Transport (ZEWT) Partnership and 2ZERO Partnership as the outputs of the projects supported under this topics should be of direct interest to companies in the road and port-maritime sector (e.g. trucks, pilot boats, cargo port handling equipment, etc).

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

HORIZON-JTI-CLEANH2-2024-03-02: Scaling-up Balance of Plant components for efficient high power heavy duty applications

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)[161].

Expected Outcome

Development of highly durable 250-500 kW PEMFC stacks for heavy duty applications (aviation, maritime, on-/off-road transport) is ongoing. However, today balance of plant (BoP) components are developed and industrialised for 100-200 kW systems. PEMFC stacks need BoP components for the system to operate under changing environmental conditions, to safely start-/stop and recondition the fuel cells and to comply with the requirements for variable power output. Such BoP need to be developed and validated for the new generation of high power 250 to 500 kW PEMFC systems suitable for various transport related end use applications.

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

- Consolidate European industry's leadership and competitiveness in development and implementation of hydrogen powered fuel cell systems in line with Fit for 55 targets;
- Contribute to establishing a complete European based supply chain for fuel cell systems, including BoP components, thereby ensuring value creation and creation of

[161] 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/ls-decision_he_en.pdf

jobs;

- Advancements and validations in the following areas, in order to create a technology demonstrator (TRL7) within aviation, maritime or heavy-duty road transport applications, scheduled from 2027 onwards:
    - Lighter weight BoP components compared to off-the-shelf components;
    - More efficient BoP operation in design and off-design conditions compared to using off-the-shelf components;
    - Operations under application relevant changing environmental conditions (ambient pressure, -humidity and -temperature);
    - Robust fuel cell stack start-/stop- and reconditioning procedures using cryogenic stored hydrogen;
    - Built in functionalities to enable safe and robust power system start and shutdown at sub-zero ambient conditions.
- To consider tailored operational strategies relevant to the up-scaled BoP components, such as those developed in topic HORIZON-JTI-CLEANH2-2024-03-01: Balance of plant components, architectures and operation strategies for improved PEMFC system efficiency and lifetime, topic dedicated to combining optimized strategies with redesigned architectures and selected component particularly for improved performance of modules for heavy-duty road applications

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

- Simplification of the FC system design (in particular for heavy-duty applications) in order to reduce the number of parts and foster the emergence of standard components, interfaces and system configurations hence improving their manufacturability;
- Achieving performance KPIs related to system power or system efficiency specific targets as appropriate for the application targeted by the proposal:
    - FC power rating of 6 MW for ships.
    - FC system gravimetric index of 1.5 kW/kg, or > 2kW/kg thanks to the development of light weight BoP components, for aircraft.
    - FC system electric efficiency > 50% for all applications.
- Achieving higher durability and maintainability with more than 25,000 hours of operation time for both HD vehicles and aircraft or 60,000 hours for ships and possibilities to recondition the fuel cell system with specialised BoP components to ensure this goal.
- Achieving BoP components which can be coupled to HD fuel cell stacks or to multiple stacks;
- Durability of up scaled BoP components meet the requirements of application relevant load cycles.
- Contributing to reducing cost for reaching targets expected in 2030 in line with SRIA. Impact of manufacturing aspects shall be considered for scaled-up BoP components.

Scope

This topic aims at development and validation of the new generation of high-power BoP components sized for ≥250 kW heavy duty fuel cell systems containing one single fuel cell stack or multiples of stacks. The developed BoP components should be compatible with upscaling to multi-MW propulsion systems. The following components and sub-system are of high relevance:

- Air humidifiers are considered a component that contributes to improving the gravimetric power index, if the component becomes more integrated and more light weight.
- Anode gas recirculation components enable high utilisation of hydrogen and are therefore to be developed and optimised for the aforementioned requirements. The possibilities of fuel cell reconditioning measures are to be considered.
- To reliably operate fuel cell drivetrains gas sensors need to measure mass flow, humidity, temperature, pressure and gas compositions accurately. These sensors need to be operational under changing environmental conditions and need to be robust against gas impurities and water phase.

Proposals are expected to build on demonstration-level high power installations or pre-study designs by addressing the identified knowledge gaps and scaling up and improving key BoP components suitable for high power HD applications.

Increasing the fuel cell system gravimetric power index above 2.5 kW/kg requires the development of light weight and compact BoP components as well as novel and innovative system architectures. In particular, proposals should address the following:

- Re-design of BoP component(s) and enhanced system architectures for a minimum of 250 kW PEM fuel cell platform compatible with reaching the multi-MW scale and with end-user requirements (system power output, voltage level, weight, volume …);
- Investigations to simplify architectures by e.g., removing components such as gas sensors, the anode gas recirculation machine, water separators, the humidifier bypass and/or the humidifier itself;
- Analyses of the trade-offs between system efficiency, operational bandwidth and system complexity for waste heat recovery from fuel cell system components e.g., stack(s), power electronics and motors;
- Design and validation of the electric power supply architecture for BoP components used for heavy duty fuel cell systems containing one single fuel cell stack or multiples of stacks;
- Design and validation of the thermal integration of the waste heat management of the BoP components into the overall thermal system of the heavy-duty fuel cell system;
- Evaluation of auxiliary functions performed by the up-scaled BoP components e.g., for cold start and fuel cell stack reconditioning operations;
- Assessments to ensure a scalable, modular and multi modal product family that allows the usage in a wide range of HD applications (aviation, maritime, rail and road transport);
- Development, testing and validation of selected, up-scaled BoP components (PEMFC stack may be emulated);
- Implementation and testing of control strategies to validate the improved system performance, efficiency and reliability.

Original equipment manufacturers (OEMs), end users and research institutes should indicate how product relevant R&D activities lead to improved components and achieve the required system level functionality.

HORIZON-JTI-CLEANH2-2024-03-01 and HORIZON-JTI-CLEANH2-2024-03-02 topics are highly complementary; liaison between successful proposals in these two topics 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 encouraged to explore synergies with the Zero Emission Waterborne Transport (ZEWT) Partnership and 2ZERO Partnership as the outputs of the projects supported under this topic have the potential to be of direct interest to companies in the road and port-maritime sector (e.g. trucks, pilot boats, cargo port handling equipment, etc).

Proposals should demonstrate how they go beyond the ambition of FASTERH2[162], BRAVA[163], SMR-ACAP[164] and other relevant European projects and be complementary to them.

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

HORIZON-JTI-CLEANH2-2024-03-03: Next generation on-board storage solutions for hydrogen-powered maritime applications

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)[165].

<u>*Expected Outcome*</u>

The storage of hydrogen onboard maritime vessels represents a big challenge for the decarbonisation of the long-haul transport sector since the discussion around the best suited alternatives to replace fossil fuels is still undecided. It is not even sure that a single fuel will replace oil derivatives since different applications show different critical issues with logistics,

[162] https://cordis.europa.eu/project/id/101101978
[163] https://brava-project.eu/project/#facts
[164] https://cordis.europa.eu/project/id/101101955
[165] 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/ls-decision_he_en.pdf

storage volume and overall efficiency of the supply chain, thus making the decision on fuel choice a complex one for end users operating both at local and global levels.

It is difficult to categorise heavy duty maritime transport modes, ranging for instance from point-to-point routes travelled by sea ferries up to long distance maritime logistics which induces quite different requirements for fuel storage volume, distribution logistics, and bunkering/refuelling networks.

Bunkering and refuelling strategies affect the selection of fuels and the type of on-board storage. Novel solutions to onboard storage need to be studied without limitations concerning the type of fuels or its physical state. Issues to also address are the safety characteristics, including fire and explosion hazard, measures to cope with toxicity, as well as environmental impact and supply chain energy efficiency.

This topic centres around maritime transport, with a view on a spill-over to rail and road applications of similar energy storage needs (resulting from power by trajectory length). The candidate technology and fuel(s) for supplying pure hydrogen (5.0 fuel cell grade) on board of maritime vessels are expected to contribute to all of the following expected outcomes:

- Contribute to the selection of most appropriate fuels for maritime transport across the widely differing operation requirements from short to deep sea shipping, thereby consolidating Europe's leading role in decarbonising maritime transport;
- Ease the end-users' challenge of selecting the most suitable fuel for their new and retrofitted ships so that they can take well-informed decisions in the green energy (and fuel) transition.
- Define optimal fields of application of the proposed storage technology considering the logistics and the mission of each category of maritime transport by the end of the project; additionally, the pathways to spill-over to heavy-duty rail and road transport systems should be elaborated;
- Improve the operational capacity of storage systems to achieve performance according to the KPIs listed below;
- Deployment of cost-effective hydrogen or hydrogen carrier fuel storage system for maritime, and if applicable, also other heavy-duty applications by 2030.

Project results are expected to contribute to the following objectives and KPIs of the Clean Hydrogen JU SRIA (on a basis of the amount of hydrogen delivered to the energy conversion technology):

- Hydrogen bunkering rate: 20 tonH2/h in 2030;
- Tank volumetric Capacity system: 45 gH2/L (system) in 2030;
- Tank CAPEX lower than 245 €/kgH2 in 2030.

Scope

The scope of the topic is to provide a full conceptual study of the proposed solution to storing hydrogen or a hydrogen carrier below deck of a vessel with high power propulsion needs (>500 kW) and high frequency operation. The scope further entails building a reference prototype for validating the concept, or several concepts in comparison, under real-world operating conditions.

Proposals should propose a storage technology which will be able to go beyond the state of art for on-board hydrogen storage with respect to the amount of energy stored, the space occupied per MWh of stored chemical energy, and the reduced shipping space (passengers/vehicles/containers), moving closer to current fuels properties and bunkering rates.

Proposals are expected to focus on below-deck innovative inland and sea waterborne transport hydrogen storage systems beyond the State-of-the-Art in any of the well-established physical states and chemical compositions (CH2, LH2, NH3, LOHC, solid state carriers) as well as potential novel hydrogen carriers or combinations of technologies with the following characteristics:

- Supply of pure hydrogen (5 point) to the propulsion system;
- Vessel propulsion and auxiliary power systems requiring a hydrogen supply flow of minimum 30 kgH2/h with a modular approach capable of achieving MW scale capacities;
- Bunkering/refuelling expected during adequate and suitable timeslots within daily operation or at the beginning or end of daily service;
- Below-deck, integrated onboard tanks to be filled directly (excluding exchangeable mobile tank systems (i.e., tank swapping)). The whole bunkering system needs to be addressed which means that the system boundary is on one side the feeding pipe for refuelling and on the other one the pure hydrogen output to the conversion unit. Thus, everything in between is part of the system to be designed and trialled (i.e., LOHC+ and LOHC- tanks).

A complete fuel infrastructure should be described, including solutions to refuelling logistics, but not including the supply of hydrogen itself, nor taking into account whether the hydrogen supplied is used in fuel cells of different types, internal combustion engines, or gas turbines.

Proposals should also:

- Provide a realistic design study for storage tank integration into a marine or inland waterway vessel;
- Provide the design of a potential hydrogen supply chain for at least one real operational case of fossil fuel replacement, such as one or more daily ferry routes (mainland to islands or mainland to mainland), or one point to point transport line, or one multi point ferry or transport route (serviced daily or weekly);
- Provide cost estimates of the levelised cost of fuel supply, including cost of fuel storage;
- Provide cost estimates of the fuel infrastructure and storage CAPEX, and the operations OPEX (excluding the cost of hydrogen purchase);
- Provide an energy balance and LCA of the total fuel system (excluding hydrogen production), including potential uses of hydrogen in different propulsion systems;
- Address any safety measures and mitigation strategies;
- Provide an Approval in Principle by a certification body;
- Describe the scale-up to larger marine vessels, as well as the spill-over to road, off-road and rail applications (including scale-down, if applicable).

Energy performance results and/or LCA of the full supply chain well to tank and tank to motion should be clearly presented and include all aspects from fuel storage at the refuelling system, fuel distribution, to refuelling.

The mechanical design should be compatible with all requirements typical of the vessel/vehicle industry in terms of durability, exposure to harsh environments, vibrations, accelerations, safety, and exceptional loads e.g., fire. The validation of concepts shall occur through an experimental programme backed up by simulation activities, that will allow to validate the concept under a wider range of constraints.

Proposals should elaborate on potential technology spillovers to other heavy duty means of transportation (road, trains, special vehicles, etc.), through scaling and/or adapting the proposed solutions or using parts (modules) of the larger system.

Projects should provide supporting evidence concerning:

- Measures to deal with fuel spills and safety (fire, explosion, toxicity);
- Energy efficiency and fossil carbon footprint from total fuel supply concept (well to hydrogen supply) based on the chosen hydrogen carrier and on-board storage solution;
- The HAZID analysis as input to an Approval in Principle.

The following activities are out of scope for this topic:

- Technology and design developments concerning tank swap and mobile tank concepts;
- compression and liquefaction technologies;
- technologies which produce the hydrogen, such as electrolysers or ammonia synthesis;
- technologies that use the hydrogen, such as fuel cells, gas turbines, or internal combustion engines;
- technologies only aimed at terrestrial heavy-duty utilisation.

Proposals are encouraged to explore synergies with the activities and projects supported under the Zero Emission Waterborne Transport (ZEWT) Partnership, in view of the provision of storage solutions for hydrogen fuelled vessels.

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

HORIZON-JTI-CLEANH2-2024-03-04: Demonstration of hydrogen fuel cell-powered inland or short sea shipping

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.
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)[166]. 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): vessels, fuel cell system, on-board hydrogen storage and other components needed in a hydrogen fuel cell hydrogen vessel, costs may exceptionally be declared as full capitalised costs.

Expected Outcome

To date the shipping industry when compared to country-based emissions is the 6th largest emitter of CO_2, with a total yield in the range of 900 million tons of CO_2 per year. It was, as well, estimated that without action the global share of shipping's greenhouse gas (GHG) emissions may reach 17 % by 2050. The International Maritime Organisation (IMO) adopted an initial GHG reduction strategy in 2018 with the revision planned for July 2023. The IMO initially set a target to reduce CO_2 emissions by at least 50% in 2050. Upon revision, the goals were enhanced to reach the reduction levels of 20% and striving for 30% by 2030 and 70% and striving for 80% by 2040 when compared to 2008 emissions (50 % of reduction in terms of the expected sector growth). In parallel to this the EU objective of climate neutrality by 2050 will also require innovations in shipping, including the supply and use of sustainable climate neutral marine fuels as well as the associated port, storage and bunkering infrastructures. As ships in short sea shipping have generally an age of 30 years and the average age of inland ships is above 40 years[167] the waterborne transport industry faces the enormous task of implementing urgent actions needed to achieve these goals in time.

To achieve the aforementioned goals, it is important to change the mean of powering vessels, using renewable-based fuels such as hydrogen or its carriers. The consideration of various alternatives is inherent as they entail individual advantages and challenges regarding safety, handling, efficiency, volumetric energy density and cost-efficient storage.

To cope with this endeavour, innovative solutions that offer adequate vessel autonomy while

[166] 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/ls-decision_he_en.pdf

[167] https://cordis.europa.eu/project/id/285405,https://www.forschungsinformationssystem.de/servlet/is/123471/

minimising the risks and the challenges pertaining to its storage and transportation are needed. Such solutions should address bunkering, on-board storage, power conversion and propulsion and as well consider, the current industrial standards in manufacturing, transportation, storing and safe handling of hydrogen or the hydrogen carrier involved.

- Project results are expected to contribute to all of the following expected outcomes: Reducing GHG and local emissions from waterborne transport in line with prevailing targets;
- Enabling and facilitate further deployment in hydrogen-powered shipping, ensuring safety underpinned by the necessary onshore norms and regulations (protocols and standards);
- Developing pertinent technical standards and methods for the validation of hydrogen or its carriers' equipment and system;
- Developing a European supply chain and thereby consolidating the European industry's competitiveness in zero emission waterborne transport;
- Increasing public awareness and acceptance of hydrogen technologies;
- Developing the use of hydrogen (and its carriers) for waterborne transport applications according to the pillars hydrogen distribution and Hydrogen End uses of the SRIA of the Clean Hydrogen Partnership;
- Involving a wider range of stakeholders (e.g., ship designers, ship builders, ship owners, port authorities, classification societies, etc.), to accelerate the transition to zero emission shipping.

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

- In-ship system CAPEX [€/kW]: 2,000 in 2024 and 1,500 in 2030;
- Expected system lifetime [h]: 40,000 in 2024 and 80,000 in 2030;
- NO_x emissions not exceeding 25 ppm of the exhaust gas stream and 30 $mgNO_x/MJ_{fuel;}$

Scope

This topic aims at demonstrating, in an operational environment, fuel cell hydrogen based waterborne transport ecosystem, showing the feasibility and benefits of integrating hydrogen and hydrogen carriers into this hard to abate sector. The overarching goal is to address the ability to safely bunker hydrogen (pure or in terms of a hydrogen carrier), to store it on board and to consume it for propulsion in a waterborne environment.

Proposals should address the demonstration of fuel cell hydrogen powered inland or short sea vessels. Internal combustion engines are excluded.

In addition, proposals should address the following:

- Development and demonstration of a hydrogen ecosystem with at least one port including hydrogen (carrier) logistics, and suitable integrated refuelling/bunkering solution;
- Provision of zero-carbon fuels (hydrogen or its carriers), shore-based infrastructures;
- Assessment of the health hazards and other risks associated with the use of the respective fuel in vessels;

- Selection of a suitable ship segment and technical concept for the demonstration activity, including an adequate propulsion power level for the application;
- Integration and design activities for using the chosen combination of power conversion and storage technologies (e.g., fuel cells and batteries) including hybrid solutions and smart energy/power management systems;
- Assessing and describing how the selected concept represents a modular architecture of the power system, validating the compatibility for scaling up of the power rating to MW scale;
- Development of respective novel BoP configurations encountering various hydrogen carriers, as well as possible on-board carrier-dehydrogenation/generation options;
- Integrate the FC powertrain and the hydrogen / hydrogen-based storage on-board a vessel;
- Integration of the chosen on-board storage solutions below the vessel deck, or swappable fuel tank containers on deck appropriate for a scale of several hundred of kilos to tons.
- Minimal on-board energy storage for operational autonomy of 48h (2 days);
- Operate the vessel under realistic end-user conditions for a duration of at least 1.000 hours;
- Ensuring safe vessel operation and contributing to further develop the regulatory framework;
- Secure the port(s) approval processes for hydrogen / hydrogen-based fuels bunkering and construct the bunkering infrastructure solution;
- Establish the technical and economic feasibility for replication and scale up in European ports.
- Enable standardisation & regulation of the technology on vessels and within ports to create the right regulation framework for the investment in vessels and infrastructure;
- Provide instrumentation and generate detailed open access data for all relevant operations including hydrogen storage, bunkering, sailing etc. for development of new generation of modelling tools and protocols.
- Assessment and quantification of the environmental impact of the demonstration itself (in terms of reduction on GHG emissions during demonstration) as well as the potential GHG emission reduction in Europe upon a full deployment of the solution in the selected maritime transport segment. Such issues shall already be covered in the proposal phase, to facilitate a fair and adequate evaluation.

Proposals are encouraged to consider, for the vessels to be demonstrated, system prototypes developed in previous project related to the application of FC modules to heavy duty applications such as e.g. Standard-Sized Heavy-duty Hydrogen (StaSHH).

Proposals should build on and develop synergies with former EU-funded projects such as RH2IWER[168], FLAGSHIPS[169], H2Ports[170] or EVERYWH2ERE[171], as well as with relevant Zero

[168] https://cordis.europa.eu/project/id/101101358
[169] https://cordis.europa.eu/project/id/826215
[170] https://cordis.europa.eu/project/id/826339
[171] https://cordis.europa.eu/project/id/779606

Emission Waterborne Transport Partnership (ZEWT) activities, focusing on remaining gaps not covered in these projects. In particular, duplication with the activities in the RH2IWER[172] project should be avoided.

Proposals are encouraged to explore synergies with the Zero Emission Waterborne Transport (ZEWT) Partnership, specially on the activities regarding the integration of the FC powertrain and the hydrogen / hydrogen-based storage on-board a vessel. Moreover, applicants are encouraged to explore synergies with other programmes, especially with funding from CEF-T[173]

This topic is expected to contribute to EU competitiveness and industrial leadership by supporting a European value chain for hydrogen and fuel cell systems and components.

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[174]).

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.

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[172] https://cordis.europa.eu/project/id/101101358

[173] The Connecting Europe Facility (CEF) for Transport (CEF-T) https://single-market-economy.ec.europa.eu/industry/strategy/hydrogen/funding-guide/eu-programmes-funds/connecting-europe-facility-transport_en

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

HORIZON-JTI-CLEANH2-2024-04-01: Portable fuel cells for backup power during natural disasters to power critical infrastructures

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.
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)[175]. 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 components needed in the portable fuel cell system , costs may exceptionally be declared as full capitalised costs.

Expected Outcome

A critical infrastructure is defined as the body of systems, networks and assets that are so essential that their continued operation is required to ensure the security of a given nation, its

[175] 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/ls-decision_he_en.pdf

economy, and the public's health and/or safety its operational safety even in extremities such as natural or human caused disasters (earthquakes, floods, volcanoes eruption, massive fires, as well as sabotage or assault resulting emergencies). As such, it is an essential element of society, with specific needs, whose functioning should be preserved, even under exceptional circumstances such as natural disasters.

Currently these needs can be realised by means of portable gensets and/or battery packs. Therefore, it should be ensured that critical infrastructures can be powered using clean alternative energy solutions such as multifuel capable fuel cells, able to reliably provide clean electricity for a sufficiently long timeframe and with highest efficiency.

The demanding operational conditions of systems targeted by the topic will act as a chance for fuel cells-based energy generating systems significantly rising their maturity level and allowing for their further deployment in other areas of the hydrogen economy. Thus, it is necessary to find the means to use the portable robust and long-term autonomous systems based on fuel cells, which, in general, will be quickly integrated into the power system of a critical user and will provide backup power service in an uninterruptible manner. Moreover, as it should also be emphasised that these systems may be spread over, for example, in an area of a disaster affected city, and powering various facilities of different energy needs, the said approach will, as well, stem in the creation of advanced smart management algorithms for distributed microgrids.

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

- A certified, interoperation-ready (including datalink, powerlink and load prioritisation schemes), system of transportable power generator consisting of at least one generator module and a fuel tank brought in two separate containers;
- Solutions developed proven in conditions closely resembling these encountered during natural disasters and with real load profiles of exemplary units of critical infrastructure considered;
- Readiness towards commercialisation of the solution covering possible up-scaling in terms of both repeatable modules (up to min. 10), as well as, systems (min. 5);
- New services, and service models available for national and international rescue teams compliant with Integrated Situational Awareness and Analysis (ISAA);
- Breakthrough technology converting the nowadays diesel-based portable power generation to a novel fuel cell-based solution;
- Contributing to keep European leadership in disaster fighting.

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

- Improve flexibility of systems in operation in extreme conditions of natural disasters;
- Prepare and demonstrate the next generation of fuel cells for stationary applications able to run under 100% H_2 and other H_2-rich fuels whilst keeping high performance;
- Support units using other hydrogen rich fuels of the likes of ammonia, methanol, chemical hydride or liquid organic hydrogen carriers;
- Support selected fuel cell demos for proving adequate uptime and availabilities.

Furthermore, project results are expected to contribute to the KPIs for fuel cell technology for stationary sector of the Clean Hydrogen JU SRIA:

- Availability of the system should be no less than 99%;
- Warm start time should be maximum 10 minutes since the connection;
- Cold start time should be maximum 90 minutes since the installation (cold start time for the whole system, which can be hybrid solution containing fuel cell and start up battery).

Additional requirements to be competitive to already commercially available gensets and batteries:

- The fuel cell system is expected to be efficient enough to allow at least 20% increase of the operation time at the same power/load profile as compared to genset of the same volume and weight of fuel;
- At least 100% increase of the longer operation time at the same power/load profile as the best battery-based portable containerised and commercially available solution using the same volume and weight.

Scope

The topic focuses on the development and demonstration at an operational environment of a lightweight, robust, containerised and modular zero-emission transportable of at least 50 kW_e fuel cell system to power critical infrastructures in the event of a natural disaster. The system should include all balance of plant components needed for operation

The demonstration campaign should include the transportation of the fuel cell system, its installation and test at end-user site for at least 2000 hours of cumulative operation epitomising the real load profiles.

The fuel cell system should:

- be easily transported, installed and started
- sustain vibrations and low (-30°C) and high (+50°C) ambient temperature
- be able to operate with air at low ambient pressure typical for mountain regions and other extreme environmental conditions.
- be compatible with the specific requirements and norms for transport and operation under relevant harsh environment conditions .

Proposals should address the following:

- Compact and lightweight containerised contraption including the fuel cell stack and balance of plant components, which can be transported by air, road and sea;
- Storage of enough fuel to sustain its operations during the emergency state (at least two weeks);
- Easy refuelling with fast exchange of the fuel storing modules;
- Simplified plug-and-play approach to minimise the interconnection and installation time;
- Ability of operation on green hydrogen and at least one other available or easily transportable fuel;
- Fulfillment of requirements (incl. certification aspects) needed for transport;
- Modular design with stackable and lifetime prognosis and degradation interoperable

10-50 kW_e single modules;

- Include State of Health analysis at least after operation;
- Relevance to the respective standards of operation and safety;

This project should continue the efforts concerning the development, certification and industrialization of fuel cells in other projects funded by such us, but not limited to, the Clean Hydrogen JU projects RoRePower[176] and EVERYWH2ERE[177]. The advancements in the current state of the art have to be clearly demonstrated e.g. by proving the interoperability of the modules designed, including the multifuel option, developing a quick refueling capability, as well as, design targeted for highly robust environments.

The consortium should include fuel cell system providers, partners with expertise on power engineering in distributed grids, standards and requirements needed for shipment for containerised operation-ready solutions and at least one end-user for on-site testing and demonstration performed by a tailored combination of hardware, software and virtual reality tools.

When defining the systems architecture proposals should consider that each of particular critical systems of interest is characterised with its own level of embedded uninterruptible power supplies during start-up and transitional operation phases (like switch to another fuel etc.), various energy consumption for balance of plant components, as well as, differing level of losses related to the lack of the continuity of operation.

Proposals should include the development of a strategy for the installation and operation of singular fuel cell systems in a (micro)grid utilising locally existing power supply units. The fuel cell system should be equipped with effective and highly central infrastructure independent tools for digital communication and localisation. In addition to location monitoring, the monitoring of such parameters as the amount of the fuel in the tank, the potential remaining service time (calculated real-time), and electrical parameters such as power, voltage of the system connection system, and the calculated real-time amount of supplied electricity should be considered.

This topic is expected to contribute to EU competitiveness and industrial leadership by supporting a European value chain for hydrogen and fuel cell systems and components.

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-JTI-CLEANH2-2024-04-02: Improved characterisation, prediction and optimisation of flame stabilisation in high-pressure premixed hydrogen combustion at gas-turbine conditions

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

[176] https://cordis.europa.eu/project/id/824953
[177] https://cordis.europa.eu/project/id/779606

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)[178].

Expected Outcome

Hydrogen-fired gas turbines can potentially produce electric power (or mechanical work) at unmatched scale with zero carbon emissions. Furthermore, they will yield this potential at high cycle efficiency and with virtually zero emissions of atmospheric pollutants once advanced Dry Low Emission (DLE) combustion systems, able to robustly and reliably stabilise premixed hydrogen flames at high pressures, are successfully developed.

However, the development of such advanced DLE combustion systems is presently hampered by the existence of knowledge gaps about premixed hydrogen combustion at high pressure. More specifically, a crucial lack of knowledge concerns the pressure dependence of the turbulent burning rate in premixed hydrogen flames. This is due to the fundamental combustion characteristics of premixed hydrogen flames, largely deviating from those of natural gas and other more conventional hydrocarbons and affects our ability to accurately predict the stability limits of these flames.

These knowledge gaps need to be closed through fundamental research in order to facilitate, in the short and medium term, the adaptation of existing DLE combustion systems to operate with various hydrogen-enriched fuel blends that will constitute the principal energy carrier in the upcoming transition period. In the longer term, once large quantities of hydrogen become widely available, the knowledge acquired will play a crucial role in enabling the development of advanced combustion systems based on novel fuel injection and staging strategies that are able to burn pure hydrogen without incurring in the penalties related to steam/water injection or nitrogen dilution of the fuel.

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

- Development of breakthrough technologies for DLE combustion systems able to burn 100% hydrogen at the most demanding operating conditions for the gas turbine (full-load);
- Maintaining European leadership in the field of combustion dynamics control and facilitating the implementation of mitigation measures for thermo-acoustic instabilities in DLE combustion systems burning 100% hydrogen across the gas turbine load range (idling to full-load);
- Development of game-changing technologies for truly fuel-flexible operation of gas turbines, contributing to establish a crucial competitive edge to European gas turbine manufacturers and end-users in a future market for low-carbon chemical energy

[178] 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/ls-decision_he_en.pdf

carriers dominated by uncertainty.

Attainment of the three project outcomes listed above will have positive impact to the gas turbine industry in maximising of the gas turbine cycle efficiency and positively impact mitigation measures targeting NO_x emissions, in compliance with strictly regulated emissions limits.

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

- Increase hydrogen percentage in the fuel (100% by 2030);
- Minimise cycle efficiency reduction during hydrogen operation (max 2%);
- Maintain low NOx emissions (<24 NOx mg/MJ fuel @100% vol H2 by 2030).

Scope

The research scope involves acquisition of fundamental knowledge, development of modelling and analytical tools, optimisation of advanced fuel injection concepts and/or combustion staging strategies to increase the robustness of operation and the fuel flexibility of gas turbines, while conserving their cycle efficiency and emissions performance. More specifically, proposals should:

- Establish accurate experimental data and reliable model estimates about the burning rate and the boundaries of static flame stabilisation (flashback and blow-out avoidance) in turbulent premixed combustion of hydrogen-enriched fuel blends (up to 100% H2) from atmospheric to high-pressure conditions (up to 10 bar, at least).
- Accurately predict the thermo-acoustic response and the boundaries of dynamic flame stabilisation (combustion dynamics control) in turbulent premixed combustion of hydrogen-enriched fuel blends (up to 100% H2) from atmospheric to high-pressure conditions (up to 10 bar, at least).

The above-mentioned two points can be achieved by exploiting a combination of first-principle numerical simulations, to minimize the modelling assumption, and advanced optical measurements, to obtain an accurate characterization of the flames across the pressure range investigated. Furthermore, it is of crucial importance to seek the widest generality and applicability of the results. This objective can be conveniently pursued by the adoption of *canonical turbulent premixed flames* configurations (e.g. Bunsen, bluff-body, transverse jets or swirl-stabilised) for the proposed work.

- Establish the optimal combustion process and combustion system layout, fuel injection and fuel staging strategies that simultaneously achieve the most robust flame stabilisation and the best low-NOx performance for different hydrogen-enriched fuel blends (e.g. with ammonia or natural gas) at high-pressure conditions. This can be achieved by developing numerical modelling and experimental testing of advanced, less generic and more specialized, combustion systems at laboratory scale (TRL 3-5), featuring novel fuel injection concepts and combustion staging strategies, with downscaled prototypes simulated and tested in laboratory facilities spanning atmospheric to high-pressure conditions (up to 10 bar, at least). Flame stability and emissions performance should be compared between alternative designs based on different fuel injection and staging strategies.

Although not strictly required to develop fuel-flexible combustion system layouts and innovative solutions, the involvement of a Gas Turbine Original Equipment Manufacturer (GT OEM) in the relevant research activities should be considered of crucial importance to significantly strengthen the industrial relevance of the research and its applicability and transferability to gas turbine applications.

The numerical and experimental methodologies should be selected to achieve a clear analytical differentiation between concurrently occurring and tightly interconnected processes, i.e. the increase in bulk Reynolds number and thermo-diffusive instabilities with pressure with the variation in chemical reactivity. In order to ensure that the principal rate-controlling processes and their trends are correctly and accurately captured at relevant conditions, laboratory experiments and numerical modelling efforts should target a pressure range covering a significant portion of the range relevant in gas turbine operation. Therefore, as a minimum requirement, the pressure range comprised between 1 and 10 bar should be investigated using state-of-the-art numerical modelling and experimental measuring techniques, i.e. featuring detailed optical diagnostics of the flame geometrical characteristics, of its stabilisation, structure and response to acoustic forcing.

Proposals are expected to collaborate and explore synergies with the following:

- projects FLEX4H2[179] and HELIOS[180] supported under the topic "HORIZON-JTI-CLEANH2-2022-04-04: Dry Low NOx combustion of hydrogen-enriched fuels at high-pressure conditions for gas turbine applications";
- project supported under the topics "HORIZON-JTI-CLEANH2-2023-04-02: Research on fundamental combustion physics, flame velocity and structure, pathways of emissions formation for hydrogen and variable blends of hydrogen, including ammonia" and "HORIZON-JTI-CLEANH2-2023-04-03: Retrofitting of existing industrial sector natural gas turbomachinery cogeneration systems for hydrogen combustion".
- projects HYDEA[181] and CAVENDISH[182] supported by the Clean Aviation JU (CA-JU)

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.

[179] https://cordis.europa.eu/project/id/101101427
[180] https://cordis.europa.eu/project/id/101101462
[181] https://cordis.europa.eu/project/id/101102019
[182] https://cordis.europa.eu/project/id/101102000

HORIZON-JTI-CLEANH2-2024-05-01: Guidelines for sustainable-by-design systems across the hydrogen value chain

Specific conditions	
Expected EU contribution per project	The JU estimates that an EU contribution of maximum EUR 1.50 million would allow these outcomes to be addressed appropriately.
Indicative budget	The total indicative budget for the topic is EUR 1.50 million.
Type of Action	Coordination and Support Action
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].

<u>*Expected Outcome*</u>

Safety and sustainability of FCH systems[184] are key requirements in the path towards a hydrogen economy, with important effects on strategic sectors. FCH systems enable considerable amounts of low-carbon energy sources to be integrated into the industrial, transport, and residential energy supply, which are the hardest sectors to decarbonise. In this regard, it is essential that the design, manufacture, operation, scale-up, maintenance, and end-of-life management of FCH systems strive to minimise negative impacts to human health and the environment, while enhancing the safety and economic and social performance of FCH technologies. This can be achieved by taking into account principles such as safety, circularity, raw materials criticality, and sustainability in the FCH systems design phase. This is in line with EU strategies and activities such as the EU Green Deal[185], the EU taxonomy[186], on sustainable products[187] or the Safe and sustainable by design chemicals and materials framework[188] to name but a few. In this regard, the design of FCH systems from a safe and sustainable perspective has become a crucial need.

Life Cycle Assessment (LCA) and Life Cycle Sustainability Assessment (LCSA) methodologies as well as guidelines for the eco-design of FCH systems have already been developed within the scope of previous JU-funded projects (e.g. eGHOST[189], FC-HyGuide[190],

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[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/ls-decision_he_en.pdf

[184] FCH systems are understood to mean products, components thereof or processes, related to or containing one or more FCH technologies.

[185] https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en

[186] https://finance.ec.europa.eu/sustainable-finance/tools-and-standards/eu-taxonomy-sustainable-activities_en

[187] https://commission.europa.eu/energy-climate-change-environment/standards-tools-and-labels/products-labelling-rules-and-requirements/sustainable-products_en

[188] https://op.europa.eu/en/publication-detail/-/publication/eb0a62f3-031b-11ed-acce-01aa75ed71a1/language-en

[189] https://cordis.europa.eu/project/id/101007166

[190] https://cordis.europa.eu/project/id/256328

BEST4Hy[191], HyTechCycling[192], SH2E[193]). However, it is essential to have a larger number of design guidelines for FCH systems that comprehensively address all sustainability aspects (i.e. not only the environment) and encompasses also safety aspects. In this regard, safe and sustainable-by-design (SSbD) guidelines are crucial in enhancing the performances of FCH systems throughout their life cycle, including the entire supply chain and the end-of-life. These SSbD guidelines should extend the eco-design guidelines by considering aspects such as minimising the use of critical raw materials, implementing green supply management[194] principles, enhancing the circularity of the materials used while guaranteeing the safety of the processes, chemicals and materials. Furthermore, they should also incorporate social and economic considerations..

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

- Contributing to the promotion of safe and sustainability in the design and development of FCH systems, considering also the aspects of circularity and material criticality;
- Contributing to the sustainability of the EU hydrogen strategy by including life cycle thinking approaches addressing the three dimensions of sustainability: economic, social, and environmental across the hydrogen value chain;
- Contributing to the EU strategy of safety design since safety is an inherent element of both environmental (pollution) and social (health) aspects of sustainability, and it has an economic component as well;
- Fostering the development of environmentally sustainable and socially-responsible strategies for supporting industries involved in FCH design and manufacturing;
- Contributing to the positioning of FCH products and technologies in the EU taxonomy, EU Green Deal, Eco-design Directive, and 'safe and sustainable by design' (SSbD) framework;
- Increasing the number of available safe and sustainable-by-design guidelines for FCH systems across the hydrogen value chain;
- Contributing to the development of safe and sustainability-oriented design of FCH system across the hydrogen value chain.

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

- Develop life cycle thinking tools addressing the three dimensions of sustainable development: economic, social, and environmental;
- Develop eco-design guidelines and eco-efficient processes.

Moreover, the topic will impact all objectives related to all FCH systems costs because of the important impact of safe and eco-design on the economic performances (use of raw materials, production processes, certifications, etc.).

Finally, guidelines have to be developed considering the KPIs on recycling processes as defined in the JU SRIA.

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[191] https://cordis.europa.eu/project/id/101007216
[192] https://cordis.europa.eu/project/id/700190
[193] https://cordis.europa.eu/project/id/101007163
[194] Green Management (GM) is the integration of environmental thinking into Supply Chain Management, including sustainable product design, low-carbon material sourcing and selection, green manufacturing processes, short-route delivery of the final products as well as end-of-life management and reverse logistics of the products at the end of their lifespan.

Scope

This topic addresses the development of sustainable-by-design guidelines, including reference criteria and prioritisation of actions, for a selection of FCH systems in the joint field of safe and sustainability assessment and eco-design. These guidelines should comprehensively address both the sustainability and safety aspects of systems pertaining to the primary applications of hydrogen and fuel cell technologies.

The project should encompass the following items:

- Development of at least three safe and sustainable-by-design guidelines for systems across the hydrogen value chain providing criteria for the system selected. It is expected that the systems will be selected covering different TRLs levels and different application from hydrogen production, storage, transport, distribution and utilisation;
- Integrate the sustainability guidelines developed by eGHOST[195] project with safety aspects so to obtain SSbD guidelines of at least five FCH systems (2 from eGHOST project + at least 3 from this call);
- Providing guidance, in the guidelines, concerning the following concepts: improvement of energetic and environmental performances, reduction of critical raw materials utilisation, avoiding or minimising the use of virgin critical raw materials, green supply management, and integration of end-of-life management in order to facilitate recovery, reuse, recycle, disassembly and dismantling, following a circular economy approach;
- Integration of safety, economic and social assessments and improvements for FCH systems to achieve comprehensive SSbD guidelines. These aspects need to be integrated with the existing eco-design approaches, which primarily focus on environmental impacts, in order to create a holistic approach to sustainability and safety;
- Incorporation of various methods (e.g., Life Cycle Sustainability Assessment, circularity assessment, material criticality assessment, optimisation techniques) in the development of the guidelines and their application to the selected systems. The guidelines should encompass the following steps at a minimum: defining and evaluating a reference system, generating eco-design ideas, multi-criteria prioritisation of SSbD, defining safe and sustainable-by-design system concepts and evaluating their impact on the different stakeholders of the hydrogen value chain (e.g., industry, research organisations, academia, policy makers). Social Sciences and Humanities (SSH) methods should be used to engage Stakeholders using structured surveys or interviews.

The project should provide the datasets (life cycle inventories) of the FCH systems analysed into the upcoming “hydrogen node” of the Life Cycle Data Network (LCDN)[196].

Proposals are expected to involve experts in hydrogen technologies, safety and eco-design (e.g. research centres, universities) as well as industries and technology developers.

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

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[195] https://cordis.europa.eu/project/id/101007166
[196] https://eplca.jrc.ec.europa.eu/LCDN/index.xhtml

HORIZON-JTI-CLEANH2-2024-05-02: Development of non-fluorinated components for fuel cells and electrolysers

Specific conditions	
Expected EU contribution per project	The JU estimates that an EU contribution of maximum EUR 3.00 million would allow these outcomes to be addressed appropriately.
Indicative budget	The total indicative budget for the topic is EUR 3.00 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)[197].

Expected Outcome

Green hydrogen is routinely cited as a major pillar of the clean energy transition by the European Commission, where fuel cell and electrolyser technologies are expected to play an important role in achieving Europe's emissions reduction targets. Proton exchange membrane (PEM)-based fuel cells (PEMFCs) and electrolysers (PEMELs) are currently among the most mature technologies, dominating both current capacity and expected near-term growth. Currently, all PEM-based hydrogen technologies rely on perfluorinated sulfonic acid (PFSA)-based ionomers combined with a membrane reinforcement made from expanded polytetrafluorethylene (ePTFE) and contain polytetrafluoroethylene (PTFE) in other functional layers such as the gas diffusion layer (GDL). These fluoropolymer PFSA and ePTFE components have exceptional chemical stability and durability, as well as high ionic conductivity and favourable wetting properties for optimal water balance. Together, these properties enable high performance PEMFC/PEMEL operation over extended lifetimes.

However, there is growing concern that per and polyfluorinated substances (PFASs) present health and environmental hazards as their production, degradation, and disposal can result in the release of perfluorinated compounds that accumulate in the environment. As a result, possible future European regulation of the use of PFAS compounds is under discussion.

The development of non-fluorinated proton exchange membranes with the same KPIs as fluorinated membranes (considering performance, durability, efficiency, and economic viability) but with lower environmental impact will be instrumental for the development of the hydrogen industry.

The development of non-toxic, safe-by-design, fluorine-free materials for the use in fuel cell and electrolyser technologies is, therefore, essential to ensure that renewable green hydrogen

[197] 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/ls-decision_he_en.pdf

technologies remain environmentally friendly solutions. The development of stable, high-performance, non-fluorinated components has also the potential to produce innovative solutions that can provide advantages in cost-reduction, performance, and stability over the incumbent fluorinated materials which are exclusively used in today's hydrogen technologies. Furthermore, new approaches provide the opportunity to tailor material properties to the exact requirements to the component. This will contribute to the aim of the Clean Hydrogen JU to accelerate the development and deployment of the European value chain for safe and sustainable clean hydrogen technologies.

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

- The development of new non-fluorinated materials, e.g., proton exchange membrane, reinforcement, and catalyst layer ionomer, paving the path to fluorine-free PEM fuel cells and/or electrolysers;
- Ensuring that these new materials are free of the hazardous properties that currently characterise PFASs and that the risks for contamination are significantly reduced i.e., regrettable substitution need to be avoided;
- A breakthrough in performance and durability of fluorine-free PEM fuel cell and electrolyser technologies;
- Demonstration of full-scale PEMFC and/or PEMEL stacks which are free from fluorinated components by 2030;
- Contribute to the development of safe and sustainable clean hydrogen technologies in line with the European Green Deal;
- Contribute to the goals of the Chemicals Strategy for Sustainability[198], an important part of the EU's zero pollution ambition and a key commitment of the European Green Deal.
- Find new materials with a view to improve overall system and value chain sustainability (including durability) and environmental footprints

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

- Ensure circularity by design for materials and for production processes, minimising the life-cycle environmental footprint of electrolysers and fuel cells;
- Reducing the use of critical (raw) materials with sustainability or environmental concerns, such as for instance those deriving from poly/perfluoroalkyls.

The project should make good progress towards the 2030 performance and durability targets for PEMFC and/or PEMEL technologies. For PEMFCs this corresponds to a power density >1.5 W/cm^2 @ 0.650 V and a degradation rate < 5 µV/hr. For PEMEL this corresponds to an operating current density of 3.0 A/cm^2 at a cell voltage of 1.8 V and a degradation rate < 5 µV/hr.

Scope

The scope of this topic is limited to proton exchange membrane (PEM-based) fuel cells (PEMFCs) and/or electrolysers (PEMELs) because other hydrogen fuel cell and electrolyser technologies, e.g., high temperature solid oxide or proton conducting ceramics, and low temperature anion exchange membrane technologies typically do not incorporate PFAS in

[198] https://environment.ec.europa.eu/strategy/chemicals-strategy_en

their materials components.

More specifically, the proposed project should focus on the development of non-fluorinated ionomers, both membrane and catalyst layer ionomer, as well as non-fluorinated membrane reinforcement materials to replace ePTFE-based membrane reinforcements.

Proposals should address the following:

- The development of non-fluorinated ionomers for membranes and catalyst layers with low resistance, low H_2 permeability, high thermal and chemical stability, as well as, for membranes, high mechanical stability in both wet and dry states;
- The development of non-fluorinated membrane reinforcement technologies to enhance the mechanical strength and reduce the dimensional swelling of fluorine-free membranes;
- Studies investigating the use of non-fluorinated ionomers in the catalyst layer, including the optimisation of catalyst ink composition and subsequent catalyst layer deposition;
- Validation of single cells/short stacks in PEMFC and/or PEMEL (minimum cell size of 25 cm^2) employing appropriate performance and durability protocols.
- Lifecycle and environmental impact assessment comparing the novel non-fluorinated components developed within the project with the existing fluorinated components to demonstrate the sustainability of the proposed solutions.
- Techno-economic analysis of the new non-fluorinated components to identify potential advantages in capital and/or operational expenditures is also considered within the scope of this topic.

Projects should build synergies with current projects that include the development on non-fluorinated fuel cell and electrolyser components, e.g., SUSTAINCELL[199] and HIGHLANDER[200]. Collaboration between academic institutes, research organisations, and industry partners are expected to address the scope of the topic in a suitable manner. The consortium should consist of at least one partner with the capability to produce membranes and/or catalyst-coated membranes (CCMs) at industrially relevant scales to ensure that the developed technologies are compatible with high-volume manufacturing technologies. This will ensure rapid market uptake and technology transfer following the conclusion of the project. The developed components should be demonstrated in a single cell PEM fuel cell and/or electrolysis cell. The minimum cell size for demonstration should be 25 cm^2 and testing in a short stack of up to five cells could also be considered.

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[201] (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[202] to benchmark performance and quantify progress at programme level.

Proposals are expected to contribute towards the activities of Mission Innovation 2.0 - Clean

[199] https://cordis.europa.eu/project/id/101101479
[200] https://cordis.europa.eu/project/id/101101346
[201] https://www.clean-hydrogen.europa.eu/knowledge-management/collaboration-jrc-0_en
[202] https://www.clean-hydrogen.europa.eu/knowledge-management/collaboration-jrc-0/clean-hydrogen-ju-jrc-deliverables_en

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.

HYDROGEN VALLEYS

HORIZON-JTI-CLEANH2-2024-06-01: 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 budget for the topic is EUR 20.00 million. (additional funding from the RepowerEU Plan budget maybe available to support projects submitted under this topic and placed in the reserve list, 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.
Evaluation Procedure	The procedure is described in General Annex F. Seals of Excellence will be awarded to applications exceeding all of the evaluation thresholds set out in this work programme, but cannot be funded due to lack of budget available to the call.
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)[203]. 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

[203] 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/ls-decision_he_en.pdf

	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.

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)[204]. 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[205].

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;
- Full integration into the broader 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.

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, especially when applications are used in symbiose with each other.

Proposals should demonstrate innovative approaches at system level: global 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.

[204] https://h2v.eu/media/7/download
[205] 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 4000 tonnes of clean hydrogen[206,207] per year using new hydrogen production capacity. 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.
- 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 KPIs;
- Demonstration of how hydrogen enables sector coupling, allows large integration of renewable energy[208] 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.

More broadly, proposals should:

- 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 [209]. 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[210] which are part of the hydrogen valley to be deployed and demonstrated in line with the topic requirements;

[206] As defined in the SRIA of the Clean Hydrogen JU, clean hydrogen refers to renewable hydrogen. For the purpose of 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.

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

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

[209] Including applications for funding planned, applications for funding submitted and funding awarded

[210] 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))

- 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) should be provided. The practical implementation of these LOI will be followed during the Grant Agreement implementation;
- Provide a preliminary 'hydrogen safety planning and management plan'[211] at the project level, which will be further updated during project implementation;
- Ensure coverage of aspects such as replicability and 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;
- 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) 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.

This topic is expected to contribute to EU competitiveness and industrial leadership by supporting a European value chain for hydrogen and fuel cell systems and components.

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[212]).

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).

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

HORIZON-JTI-CLEANH2-2024-06-02: 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 budget for the topic is EUR 9.00 million. (additional funding from the RepowerEU Plan budget maybe available to support projects submitted under this topic and placed in the reserve list, see

[211] 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
[212] https://www.certifhy.eu

	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.
Evaluation Procedures	The procedure is described in General Annex F. Seals of Excellence will be awarded to applications exceeding all of the evaluation thresholds set out in this work programme, but cannot be funded due to lack of budget available to the call.
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)[213]. 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.

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)[214] 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

[213] 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/ls-decision_he_en.pdf

[214] https://h2v.eu/media/7/download

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[215.]

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;
- Full integration into the broader 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.

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: global 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 500 tonnes of clean hydrogen[216,217] per year using new hydrogen production capacity. Due to the large volumes of hydrogen involved, production plants may be distributed across the territories involved but should share common hydrogen

[215] https://ec.europa.eu/info/news/mission-innovation-launches-new-global-coalition-support-clean-hydrogen-economy-2021-jun-02_en

[216] As defined in the SRIA of the Clean Hydrogen JU, clean hydrogen refers to renewable hydrogen. For the purpose of 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.

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

supply infrastructure;

- Use of the hydrogen produced to supply more than one 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 KPIs;
- Demonstration of how hydrogen enables sector coupling, allows large integration of renewable energy[218] 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.

More broadly, proposals should:

- 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 [219]. 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[220] 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) should be provided. The practical implementation of these LOI will be followed during the Grant Agreement implementation;
- Provide a preliminary 'hydrogen safety planning and management plan'[221] at the project level, which will be further updated during project implementation;

[218] In line with the definitions provided in the Renewable Energy Directive 2018/2001/EU
[219] Including applications for funding planned, applications for funding submitted and funding awarded
[220] 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))
[221] 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

- Ensure coverage of aspects such as replicability and 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;
- 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) 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.

This topic is expected to contribute to EU competitiveness and industrial leadership by supporting a European value chain for hydrogen technologies' systems and components.

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[222]).

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).

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

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

2.2.3.2 Conditions of the call and call management rules

Conditions for the Call

Call identifier: **HORIZON-JTI-CLEANH2-2024-1**

Total budget: **EUR 113.5 MEUR**

Indicative budget(s)[223]

Topic	Type of Action	Budgets (EUR million)	Expected EU contribution per project (EUR million)	Number of projects expected to be funded
Publication[224]: 17 January 2024 Deadline[225]: 17 April 2024				
HORIZON-JTI-CLEANH2-2024-01-01	RIA	3	3	1
HORIZON-JTI-CLEANH2-2024-01-02	RIA	4	4	1
HORIZON-JTI-CLEANH2-2024-01-03	RIA	4	4	1
HORIZON-JTI-CLEANH2-2024-01-04	RIA	4	4	1
HORIZON-JTI-CLEANH2-2024-01-05	IA	10	10	1
HORIZON-JTI-CLEANH2-2024-02-01	RIA	3	3	1
HORIZON-JTI-CLEANH2-2024-02-02	RIA	4	4	1
HORIZON-JTI-CLEANH2-2024-02-03	IA	6	6	1
HORIZON-JTI-CLEANH2-2024-02-04	IA	6	6	1
HORIZON-JTI-CLEANH2-2024-02-05	IA	8	8	1
HORIZON-JTI-CLEANH2-2024-03-01	RIA	4	4	1
HORIZON-JTI-CLEANH2-2024-03-02	RIA	4	4	1
HORIZON-JTI-CLEANH2-2024-03-03	RIA	5	5	1
HORIZON-JTI-CLEANH2-2024-03-04	IA	6	6	1
HORIZON-JTI-CLEANH2-2024-04-01	IA	5	5	1
HORIZON-JTI-CLEANH2-2024-04-02	RIA	4	4	1
HORIZON-JTI-CLEANH2-2024-05-01	CSA	1.5	1.5	1
HORIZON-JTI-CLEANH2-2024-05-02	RIA	3	3	1
HORIZON-JTI-CLEANH2-2024-06-01	IA	20	20	1
HORIZON-JTI-CLEANH2-2024-06-02	IA	9	9	1

[223] 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.

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

[225] 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 calls 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 2023-2024[226] 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.

<u>General Annex A (Admissibility conditions): Exceptions</u>

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

<u>General Annex B (Eligibility conditions): Additional conditions</u>

- 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-JTI-CLEANH2-2024-01-05
HORIZON-JTI-CLEANH2-2024-02-03
HORIZON-JTI-CLEANH2-2024-02-04
HORIZON-JTI-CLEANH2-2024-02-05

[226] 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

HORIZON-JTI-CLEANH2-2024-03-04
HORIZON-JTI-CLEANH2-2024-04-01
HORIZON-JTI-CLEANH2-2024-06-01
HORIZON-JTI-CLEANH2-2024-06-02

- For some topics, 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 2024 this applies to the demonstration of innovative hydrogen production for energy intensive industries and the chemical sectors, demonstration of innovative technologies for the distribution of hydrogen including multi-purpose hydrogen refueling infrastructure, demonstration of hydrogen-powered inland shipping or short sea shipping solutions. This will also apply to the two Hydrogen Valley topics as they are considered of strategic importance for the European Union ambitions to double the number of Hydrogen Valleys by 2025. For these flagship topics 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-JTI-CLEANH2-2024-01-05
HORIZON-JTI-CLEANH2-2024-02-03
HORIZON-JTI-CLEANH2-2024-02-04
HORIZON-JTI-CLEANH2-2024-02-05
HORIZON-JTI-CLEANH2-2024-03-04
HORIZON-JTI-CLEANH2-2024-04-01
HORIZON-JTI-CLEANH2-2024-06-01
HORIZON-JTI-CLEANH2-2024-06-02

General Annex F (Evaluation procedure):

Seal of Excellence:

- For the two topics in the Call 2024 addressing Hydrogen Valleys, the **'Seal of Excellence'** will be awarded to applications exceeding all of the evaluation thresholds set out in this Annual Work Programme but cannot be funded due to lack of budget available to the call. This will further improve the chances of good proposals, otherwise not selected, to find alternative funding in other Union programmes, including those managed by national or regional Managing Authorities. With prior authorisation from the applicants, the Clean Hydrogen JU may share information concerning the proposal and the evaluation with interested financing authorities. In this Annual Work Programme 'Seal of Excellence' will be awarded for the following topic(s):

Seals of Excellence is applicable to the following topics
HORIZON-JTI-CLEANH2-2024-06-01
HORIZON-JTI-CLEANH2-2024-06-02

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 sum[227]s 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)[228]. Lump sums will be used across all topics in the Call 2024.

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:

Exceptional declaration of full capitalised costs
HORIZON-JTI-CLEANH2-2024-01-05
HORIZON-JTI-CLEANH2-2024-02-03
HORIZON-JTI-CLEANH2-2024-02-04
HORIZON-JTI-CLEANH2-2024-02-05
HORIZON-JTI-CLEANH2-2024-03-04
HORIZON-JTI-CLEANH2-2024-04-01
HORIZON-JTI-CLEANH2-2024-06-01
HORIZON-JTI-CLEANH2-2024-06-02

3. *Subcontracting*

[227] https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/programmes/horizon/lump-sum
[228] 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)

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.

Common elements applicable to all topics in the Call

EU competitiveness and industrial leadership

In line with the activities started already in 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 2024 are expected to contribute to EU competitiveness and EU industrial leadership by supporting a European value chain for hydrogen and fuel cell systems and components.

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 2024, 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[229].

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

[229] 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

request for certain fields to be considered as "confidential"[230] 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[231].

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[232]).

Safety

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[233]. 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 2.0[234]. Projects reporting on safety should report annually either the safety-related events[235]: 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 alongsideany 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

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230 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).

231 https://www.clean-hydrogen.europa.eu/knowledge-management/technology-monitoring-trust_en

232 https://www.certifhy.eu/

233 https://www.clean-hydrogen.europa.eu/get-involved/european-hydrogen-safety-panel-0/reference-documents-ehsp_en

234 The JRC has developed a template to input new events in HIAD: https://ec.europa.eu/eusurvey/runner/HIAD_for_JU_projects

235 Definitions of near-miss, incident, and accident according to EIGA document INCIDENT/ACCIDENT INVESTIGATION AND ANALYSIS SAC Doc 90/13/E

Assessments (LCAs) should follow and comply with the LCA checklist developed by the JRC[236].

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[237] 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 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.

In particular for the call 2024, low TRL research activities on (hydrogen) gas turbines and 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[238] 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 Horizon Europe - Work Programme 2023-2024 General Annexes:

Explicit encouragement for International Collaboration
HORIZON-JTI-CLEANH2-2024-04-02
HORIZON-JTI-CLEANH2-2024-05-02
HORIZON-JTI-CLEANH2-2024-06-01
HORIZON-JTI-CLEANH2-2024-06-02

[236] https://www.clean-hydrogen.europa.eu/knowledge-management/collaboration-jrc-0_en
[237] https://www.clean-hydrogen.europa.eu/knowledge-management/collaboration-jrc-0_en
[238] For the list of countries which are members/participant to Clean Hydrogen Mission, please see: http://mission-innovation.net/missions/hydrogen/

2.2.3.3 List of countries entrusting the JU with national funds for the call 2024

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 2023-2024 will be applied by the Clean Hydrogen Joint Undertaking without derogation

2.2.4 Calls for tenders and other actions

2.2.4.1 Calls For Tenders

In 2024, 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.

In addition and from the RePowerEU funds, a procurement will be executed for an indicative amount of **EUR 12.5 million** to accelerate the number of hydrogen valleys in Europe by providing dedicated project development assistance.

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
Sustainable paths for the use and management of water in the hydrogen value chain The Clean Hydrogen JU is planning to launch a call for tenders to assess the techno-economic, environmental and social sustainability of water use in green hydrogen value chain. The study will also analyse the resilience of water availability with respect the concurrent demand from different sectors and in the proximity to upcoming large hydrogen production capacities in Europe and neighbouring countries at regional levels and across the seasonal changes. Proposed recommendations to develop a circular approach to reduce and manage water consumption in a sustainable way is also part of the study.	600,000 EUR	Open procedure	Q3
Potential of natural/geologic hydrogen in Europe The Clean Hydrogen JU is planning to launch a tender to address the lack of understanding and assess the potential for geologic hydrogen in Europe. The exact scope of the study will be further elaborated while preparing the tender specifications to avoid duplication with on-going and planned activities in this area.	450,000 EUR	Open procedure	Q1-Q2

Subject (Indicative title)	Indicative budget (EUR)	Expected type of procedure	Indicative Schedule
Techno-economic-environmental analysis on the use of hydrogen in a RES-dominated European power generation sector. The Clean Hydrogen JU is planning to launch a tender to perform a techno-economic-environmental analysis on the role of hydrogen in Europe's power generation sector. Different scenarios with large shares of renewable power generation in the energy system will be investigated. The study will look at hydrogen use in different forms (pure hydrogen, hydrogen blends in natural gas, ammonia, etc).	450,000 EUR	Open procedure	Q1-Q2
Hydrogen Valleys Facility The Clean Hydrogen JU is planning to launch a tender to set-up and run a 'Hydrogen Valley Facility' aiming at accelerating the number of hydrogen valleys in Europe. The facility will include project development assistance to support Hydrogen Valleys at different level of maturity. Whilst the focus will be on European countries, such project development assistance may be extended to third countries, in line with the Comission policy priorities. In addition, it will include activities aiming to ensure that the knowledge gathered and the lessons learnt from Hydrogen Valley projects (including skills) are retained, collected, analysed and widely disseminated and used in a structured and efficient way. The Facility will also be used to maintain and update the Mission Innovation Hydrogen Valley Platform[239].	12,500,000 EUR[240]	Open procedure	Q1-Q2

The exact budget to be allocated to each of these procurements 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.

[239] https://h2v.eu/
[240] This budget will come from the 'RePowerEU funds'

2.2.4.2 Support to EU policies

Support to Climate and Energy Policies

In 2024, the Clean Hydrogen JU will continue supporting climate related policies, similar to 2023. 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 2023, the Clean Hydrogen JU provided input for the preparation of the Hydrogen Bank, 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 view of the European Commission Work Programme for 2024[241], the Clean Hydrogen JU remains available to support the European Commission in its process for establishing a 2040 climate target, by providing information on the expected technology development of hydrogen technologies, to be considered in the European Commission's modelling activities, as well as to any other information that may be deemed useful for that exercise. In addition, the planned procurement on 'Sustainable paths for the use and management of water in the hydrogen value chain 'should prove relevant to contribute to the European Commission planned initiative on water resilience. Finally, the Clean Hydrogen JU remains available to support the European Commission in its 2024 initiative[242] on the "European wind power package", especially concerning the direct coupling of hydrogen production with electricity produced from wind turbines, both for energy storage and hydrogen utilisation purposes.

Support to Industrial Policy

The Clean Hydrogen JU remains ready to continue supporting DG GROW and cooperate with the European Clean Hydrogen Alliance (ECH2A)[243] 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 2024, 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 [244] on the area of hydrogen in general and concerning skills in particular.

In addition, the outcomes of the ongoing JU study (to be delivered throughout 2024) 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 will analyse the current and future strengths and weaknesses of the European renewable hydrogen supply chain related to 14 hydrogen technologies across the value chain and provide recommendations to enable Europe to keep its leader in the hydrogen economy and to support

[241] https://commission.europa.eu/strategy-documents/commission-work-programme/commission-work-programme-2024_en
[242] https://commission.europa.eu/strategy-documents/commission-work-programme/commission-work-programme-2024_en
[243] https://ec.europa.eu/growth/industry/policy/european-clean-hydrogen-alliance_en
[244] https://single-market-economy.ec.europa.eu/publications/net-zero-industry-act_en

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 addition, the study “Hydrogen for ports and industrial coastal areas” delivered a report in September 2023 on “Recommendations on the areas of priority for R&I projects, safety regulations, codes and standards and non-technical enablers” that includes suggestions for measures fostering the implementation of EU policy context and legal framework. These recommendations should prove useful to European Commission in view of their activities in 2024.

Strategic Energy Technology (SET) Plan

The Clean Hydrogen JU will continue following and contributing as necessary to the SET-Plan[245] 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 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 2024

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 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 2024, a maximum budget of EUR 1 million Euro from the Clean Hydrogen JU operational budget is

[245] https://energy.ec.europa.eu/topics/research-and-technology/strategic-energy-technology-plan_en

foreseen.

The annual Rolling Plan 2024 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 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 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.

Under Horizon Europe, the approach to RCS strategy is 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 new body, participating to the activities of the RCS SC Task Force, jointly by all stakeholders. The RCS SC Task Force meets bi-monthly, hence the proposed deliverables may be modified according to the priority set by the RCS SC Task Force activities.

A.1 Support to RCS SC Task force contributing to its activities.

A.2 Report on the international progress in the area of RCS by international bodies (UN-ECE, ISO/TC 197, IEC/TC105, IMO, IPHE) (December 2024).

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 tests facilitate 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. Their use is voluntary, nevertheless there is growing evidence that research and industry players make regular use of those already available. In the post-2023 time frame, the possibility of experimental validation of the testing protocols and test procedure developed for low-and high-temperature water electrolysis will be explored together with the dedicated working group.

In 2024, the JRC electrolysis testing harmonisation work will continue to complete the task on standardisation of testing of high temperature electrolysis together with the dedicated working group, updating of the SOCTESQA[246] test module 03 on current-voltage characteristics to explicitly include proton-conducting cells (GAMER recommendation).

In addition, a dedicated survey will be conducted to check to what extent the proposal for AST protocols for low temperature electrolysis (JRC133726) have been applied by various stakeholders and whether there are suggestions for future improvements based on the gained experience of using these protocols. The outcome of the survey will be used to plan eventual follow-up work in this direction.

JRC will also continue participation in the activities of ISO/TC 197 Hydrogen technologies,

[246] https://cordis.europa.eu/project/id/621245

IEC/TC 9 Electrical equipment and systems for railways and 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.

Finally, JRC will continue providing technical support and assistance to individual users on request with regards to the ZERO∇CELL[247], 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 EU harmonised testing procedure: polarisation curve measurement of high-temperature fuel cell and electrolyser. Draft report for public consultation (December 2024)

B.2 Survey among stakeholders on their use of AST protocols. JRC will produce a note on the results (December 2024)

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 Key Performance Indicators 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 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 2024 with an update of the historical analysis of electrolysers (work originally planned for 2023). In general, this type of analysis will be increasingly included as part of the Annual Programme Technical Assessment.

The use of high-purity water for hydrogen production may cause shortages of freshwater in some areas of Europe. Seawater is abundant but must be desalinated before use in water electrolysers. Direct seawater electrolysis (DSS) without any pre-treatment faces serious challenges. An alternative to DSS is to first desalinate seawater. This conventional approach may not be optimal in all cases though. DSS approaches that combine water purification with water splitting in an integrated device can result in a more compact design with reduced engineering costs. JRC will provide an overview of the current State of the Art of DSS and

[247] https://op.europa.eu/en/publication-detail/-/publication/57794ea3-7585-11eb-9ac9-01aa75ed71a1/language-en

discuss the advantages and disadvantages against desalination as a benchmark. The JRC will also provide support to the JU for the definition and monitoring of the related call for tender included in section 2.2.4.1.

C.1 Update of 2018 historical analysis report on project portfolio of Clean Hydrogen JU on electrolysis. Deliverables will be datasets, graphs and a presentation summarizing the findings (June 2024).

C.2 Report on assessment of State-of-the-Art of direct Seawater Electrolysis based on a literature review. (April 2024)

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 TIM Analytics to the JU[248]. 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.

To track KPIs, TIM develops metrics grounded in CORDIS projects, scientific publications, and patents. TIM employs diverse datasets to maximize the recall of significant documents. Specifically:

- For CORDIS[249] projects, TIM is working in close collaboration with JRC.C.1 to map the projects into relevant JU research pillars;
- For patents, TIM utilizes datasets from the CORDIS website to associate patent publication numbers with relevant CORDIS projects and subsequently with the research pillars;
- For scientific publications, TIM leverages datasets from the CORDIS website and funding details found within the publication text to associate the publications with CORDIS projects and subsequently with the research pillars.
- Moreover, to disseminate TIM's analytical findings based on analysis performed for JU, TIM will design (public) dashboards. Clean Hydrogen JU will actively participate in the review, approval, and testing of these dashboards.
- JU now benefits from direct access to the TIM platform as internal users. This includes Scopus data on scientific literature, allowing for keyword searches. We will provide consistent content delivery and analysis based on Clean Hydrogen JU's requirements.

Detailed tasks for the 2024 include:

A) Support to Programme Monitoring and Assessment by means of JRC's TIM analytics.

1. Adapt the Clean Hydrogen instance of TIM Analytics to the JU.
   - 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 broadened.
   - Ensure precision of the findings by providing regular data cleaning.

[248] TIM is a data analytics tool gathering scientific literature, patent data, news articles and data from R&D projects funded by the EU, aiming at analysing thematic or technological areas and detecting/monitoring emerging or established technologies. The JRC has developed a specific version of its TIM tool to provide a system customised with features related specifically to Clean Hydrogen's programme, such as tagging functions for FCH beneficiaries.
[249] https://www.cordis.europa.eu/

- Track KPIs: continue to develop metrics grounded in CORDIS projects, scientific publications, and patents.

2. Maintain and improve the public Clean Hydrogen JU dashboards (review, approval, and testing of these dashboards by CleanH2).
3. Provide access to the TIM platform for Clean Hydrogen JU staff as internal users (includes Scopus data on scientific literature).
4. Provide consistent content delivery and analysis based on Clean Hydrogen JU's requirements.

B) In addition, unit JRC.T.5 will:

5. Create additional graphs/plots (e.g. Sankey-Diagram).
6. Create additional fields in the data for better visualisations.
7. Perform an additional analysis of EU project contribution at country/organization level per year - time series.
8. Attempt to harmonize organization names and add detailed information about organisation type, especially for companies SME/non-SME. In addition, JRC will perform a granular assignment of sector to companies (sector assignment based on SRIA research area).

C.3 Maintenance, operation and extension of FCH Technology Innovation Monitoring System for the Clean Hydrogen JU (January to December 2024).

Annual Technical Programme Assessment. As in previous years, JRC will perform a full programme review cycle for the year 2023, in the form of an internal report.

C.4 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 2024, 2nd draft July 2024).

C.5 Final report containing confidential information, delivered before the EU research days 2024 (November 2024).

C.6 Final version without confidential information for distribution to JU members (December 2024)

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 complete and integrated life cycle thinking tools, enhanced recovery of PGMs/CRMs including per- and polyfluoroalkyl substances (PFAS), development of recycling integrated processes, and development of eco-design guidelines and eco-efficient processes.

Building on the outcomes of the activities initiated or carried out last year, in 2023, JRC will continue assessing the life cycle based deliverables of all ongoing projects and will continue supporting the projects resulted from the call 2020 (SH2E and eGHOST projects), supporting the development of harmonised guidelines for assessing the environmental life cycle impact of hydrogen technologies (with the focus on efficient use of critical raw materials used in the FCH technologies value chains), and supporting the identification of key performance indicators (KPI) for social aspects of FCH technologies. JRC also plans to support the project that will continue the work started in SH2E responding to the call topic “Product environmental footprint pilot for a set of FCH product categories".

In addition, JRC will continue supporting the Clean Hydrogen JU in developing a life cycle inventory (LCI) data collection process to collect LCI datasets from projects, and for using the Life Cycle Data Network infrastructure to host these datasets in a "Hydrogen node", addressing in particular data quality requirement (e.g., ILCD compliance/EF compliance) and other methodological aspects (e.g. End of Life modelling and Circular Footprint Formula). JRC plans to have at least 6 datasets related to hydrogen technologies available in the LCDN by the end of 2024, including 2 datasets developed by Clean Hydrogen JU projects.

Furthermore, in view of the launch of the European Hydrogen Sustainability and Circularity Panel (EHS&CP), expected in 2024, the JRC will provide support to the Panel on certain aspects, decided in coordination with the Clean Hydrogen JU, if requested. One of the deliverables planned for 2024 is a summary of all previous assessments of LCA deliverables produced by JU projects to assist the Panel. The deliverable will provide an overview of the coverage of the assessments already performed, and on their quality. The report will be useful for the Panel to understand the state of play and the main shortcomings of the available assessments.

JRC will also further develop the social impact assessment methodologies for hydrogen technologies. In 2023 JRC provided a preliminary assessment of the potential social impact of the hydrogen supply chain. JRC will work based on this preliminary assessment and on the work carried out by SH2E. The work will involve social LCA experts and selected stakeholders as much as possible. The methods could be validated on a case study on hydrogen delivery.

D.1 The report will include 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 2024)

D.2 JRC will provide a summary of all previous assessments (2018 – 2023) of LCA deliverables produced by JU projects to support the work of the EHS&CP. (July 2024)

D.3 JRC will produce a summary of its supporting activities provided to projects resulted from the Call 2020: SH2E[250] and eGHOST[251] projects, and in case there is a project from Call 2023 on PEFCR of hydrogen (December 2024)

D.4 JRC will continue the activities performed with regards to the life cycle inventory (LCI) data collection process and on the development and use of a "Hydrogen node" in the Life Cycle Data Network infrastructure. Deliverables will be IT development and a summary of the activities. (December 2024)

D.5 JRC will support the activities of the EHS&CP and provide feedback on the input provided by the panel experts. JRC will provide a short summary (December 2024)

D.6 Further development of social impact assessment methodologies applied to hydrogen technologies (interim public draft and/or scientific paper). (December 2024)

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

[250] https://cordis.europa.eu/project/id/101007163
[251] https://cordis.europa.eu/project/id/101007166

the EHSP. Since the phasing out of the online platform hosting HIAD, the database has operated off-line tool (available upon request) for the past years.

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 2022-23 period, JRC has maintained the relationship with the customers, input approximately 100 new events and issued the version HIAD 2.1., now available for download at the JRC platform hosting also the Major Accidents Hazard Bureau. In 2024, JRC will support the JU contractor responsible for the Knowledge Hub to re-build HIAD database structure and making it available online as publicly accessible web-service. The JRC will deliver the conceptual input required for an upgrade to HIAD 3.0. For this, the re-installation and the re-start of the activities of the Task 3 of a new EHSP is required, without which the task cannot be completed. Until that moment, JRC will keep guaranteeing availability of the database, its updates and upgrades.

E.1 Report on the JRC input to enable HIAD as a public database (December 2024), pending involvement of the EHSP. The report will also contain the summary of JRC annual work done in maintaining, distributing and updating the database.

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)	1
B	Direct contribution to implementing RCS strategy (Harmonisation)	5
C	Contribution to programme monitoring and assessment	18
D	Assessment of sustainability	10
E	Hydrogen Safety	1
	Manpower Totals [PM]	**35**

	Overview indicative costs (with overhead) [k€]
Personnel costs	*500*
Missions	*22*
Consumables (for Deliverables B)	*10*
Software licence (SIMAPRO, Deliverables D)	*22*
Subcontract[252] (for Scientific & Technical services, Deliverables D, sLCA)	*30*

[252] Expert contracts as a follow-up of social LCA analysis

Subcontract[253] (for Scientific & Technical services, Deliverables D, data network)	*65*
Hardware (TIM Deliverables C.3)	*10*
Specific costs[254] (for TIM Deliverable C.3)	*300*
Scopus license (for TIM Deliverables C.3)	*10*
Total indicative cost for 2024	**969**

Costs includes overhead costs = 25%

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 2024

Technology and programme monitoriThe ng 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 Programme Review Days.

The annual data collection exercise from projects is mainly performed via the internally developed data collection platform TRUST (Technology Reporting Using Structured Templates)[255] and complemented via a questionnaire to collect additional qualitative information. Projects will be invited to provide their data in February 2024 concerning results

[253] Expert contract for data network

[254] These costs include the work of IT consultants, other TIM staff and of the TIM Team leader, 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.

[255] https://www.fch.europa.eu/sites/default/files/documents/TRUST_ExplanationFile_Draft_2019%20%28ID%205709356%29%20%28ID%205833842%29.pdf

generated in 2023.

Until 2022 the questionnaire was performed through EU Survey. In 2023, in an effort to further restructure and simplify data collection, the Project Fiche was introduced in 2023, as a means to integrate all important project related information and data available in the different platforms and tools, as well as stand-alone information coming from the projects or the project officers following them. In the gradual transition to the Clean Hydrogen Knowledge Hub (see **Error! Reference source not found.** D below), the Programme Office prepared the first v ersion of the Project Fiches in EXCEL, pre-filled them with all available information and asked the projects to update them accordingly. As EXCEL is not the ideal tool for this purpose, the Programme Office has been working on an alternative platform (Suite CRM[256]) to migrate all information collected in a single database and further simplify the data collection process. The aim is to use this platform for the Data Collection of 2024, as well as a transitory tool to facilitate the transition to the Knowledge Hub.

After the successful first data collection workshop in 2023, a second workshop with the data providers shall be organised in the second half of January, to provide clarifications on the process and the templates that the projects need to fill in. The data collection will be start again in February, but its duration will be reduced to one month as before 2023, as the additional month provided last year to the projects did not alter their reaction time or the quality of their submissions.

Finally, the JU is working closely with EIC, aiming to include its relevant projects to the Annual Data Collection of 2024. The process has already been presented to the relevant project officers and projects of EIC. Considering that in the recent (and most importantly forthcoming) years hydrogen topics are increasingly addressed in various EU programmes and partnerships under Horizon Europe, the Clean Hydrogen JU will continue examining ways[257] 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 a detailed assessment 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 2024. Following the changes in the 2023 structure of the report, adapted to the new objectives and research priorities of the Clean Hydrogen JU, the Report will again include a more complete overview of the Programme, its

[256] https://suitecrm.com/

[257] 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.

budget and its evolution, it’s progress towards its strategic objectives and recommendations on possible new topics for research.

Continuing the good experience and practice, the 14th annual Programme Review Days will be organised in autumn 2024. 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[258] (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 European Hydrogen Observatory (EHO) was successfully relaunched. A number of new data sets and functionalities were already added compared to its predecessor, the Fuel Cell and Hydrogen Observatory. In 2024 the data sets, reports and tools offered by EHO will be further expanded, aiming to have by end of 2024 the complete set of functionalities and resources envisaged in the related contract.

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[259].

Moreover, the Hydrogen Valley platform (H2V),[260] 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

[258] https://observatory.clean-hydrogen.europa.eu/
[259] https://s3platform.jrc.ec.europa.eu/hydrogen-valleys
[260] https://www.h2v.eu/hydrogen-valleys

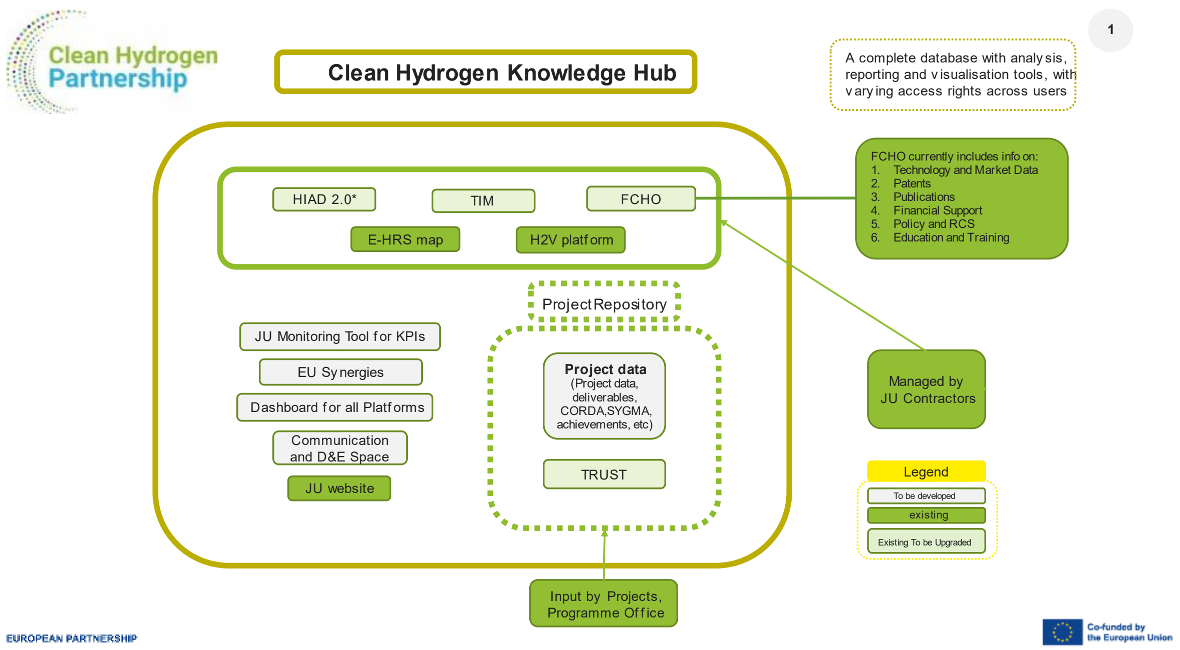
organizations in the hydrogen world, and presents insights about the Hydrogen Valley platform stakeholders. With the current contract of H2V ending in May 2024, discussions have already started in its Steering Committee on the future of the platform. From the side of IT support, it is foreseen that, at least until a decision is taken, the platform will be maintained by the Contractor for the Clean Hydrogen Knowledge Hub.

D. Clean Hydrogen Knowledge Hub

In 2023, a Call for Tenders was published for the development of the Clean Hydrogen Knowledge Hub[261]. A contract is expected to be operational at the beginning of 2024.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. An overview of the entire ecosystem of different platforms that will support the Hub platform can be seen in Figure 2.

Figure 2 Envisaged Schema of the Clean Hydrogen Knowledge Hub



Source: Clean Hydrogen JU

261 https://etendering.ted.europa.eu/cft/cft-display.html?cftId=15172

E. *Other Knowledge Management Tools*

The Programme Office will continue to use and further develop the tools used in its predecessor FCH 2 JU to collect and monitor information, most notably the platform TRUST, the EU Survey questionnaire used for the annual data collection activity and the TIM tool maintained by JRC. These will be complemented by the tools provided by DG RTD for monitoring R&I projects (CORDA, COMPASS, CORTEX, etc.), as well as the databases and tools developed internally to better manage information for supporting the operations of the Programme Office.

The Clean Hydrogen JU website will continue to be enriched with more information concerning the Clean Hydrogen JU's projects, technology developments, etc. Combined with EHO, the two websites shall remain a 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[262]) 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 2023, 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[263]. 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 the Cluster 5 for 2024. The implementation of the framework will be also supported by the F2P repository, as part of the R&I knowledge base[264].

All in all 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

[262] 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.
[263] https://webgate.ec.europa.eu/fpfis/wikis/pages/viewpage.action?pageId=1330839701
[264] 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[265] 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 taken into account the support provided in Horizon Europe Work Programme 2023-24. 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 EURAMET (and European Partnership on Metrology) concerning topics HORIZON-JTI-CLEANH2-2024-01-03 'Development of innovative technologies for direct seawater electrolysis' , HORIZON-JTI-CLEANH2-2024-01-04 'Development and implementation of online monitoring and diagnostic tools for electrolysers', HORIZON-JTI-CLEANH2-2024-02-01 'Investigation of microbial interaction for underground hydrogen porous media storage' , HORIZON-JTI-CLEANH2-2024-01-03 'Development of innovative technologies for direct seawater electrolysis', HORIZON-JTI-CLEANH2-2024-02-03 ' Demonstration of hydrogen purification and separation systems for hydrogen-containing streams in industrial applications' and HORIZON-JTI-CLEANH2-2024-02-05 'Demonstration and deployment of multi-purpose Hydrogen Refuelling Stations combining road and airport, railway, and/or harbour applications'. Synergies has been flagged in particular with projects under the EURAMET research programmes EMPIR and EMRP and with the European Partnership on Metrology. The relevant topics have been added to the topic description. The expertise available within the metrology community within EURAMET would be beneficial for other topics such as HORIZON-JTI-CLEANH2-2024-01-05 ' Hydrogen production and integration in energy-intensive or specialty chemical industries in a circular approach to maximise total process efficiency and substance utilisation' and HORIZON-JTI-CLEANH2-2024-03-03 'Next generation on-board storage solutions for hydrogen-powered maritime

[265] Annex 7 of the Clean Hydrogen JU SRIA provides more information on Common R&I Roadmap between the Clean Hydrogen JU and other partnerships

applications'.

Synergies with the ZEWT partnership and Clean Aviation JU have been identified for topic HORIZON-JTI-CLEANH2-2024-02-05 'Demonstration and deployment of multi-purpose application for airports, railways, and/or harbours addressing road transportation' as this topic has the potential for providing operational and technical solutions for hydrogen refuelling infrastructure in ports and airports. Simialrly, topic HORIZON-JTI-CLEANH2-2024-02-02 ' Novel large scale aboveground storage solutions for demand-optimised supply of hydrogen' is of relevance to ZEWT partnership and CA-JU as both ports and airports will require large scale hydrogen storage facilities. There are also potential synergies with ZEWT and 2ZERO partnership for topics HORIZON-JTI-CLEANH2-2024-03-01 'Optimising BoP components, architectures and operation strategies for improved PEMFC system performance and lifetime' and HORIZON-JTI-CLEANH2-2024-03-02 'Scaling up Balance of Plant components for efficient high power heavy duty applications', as the outputs of the projects supported under these topics should be of direct interest to companies in the road and port-maritime sector (e.g. trucks, pilot boats, cargo port handling equipment, etc). Finally synergies with ZEWT are also relevant for topics HORIZON-JTI-CLEANH2-2024-03-03 'Next generation on-board storage solutions for hydrogen-powered maritime and other heavy-duty applications ' (as it could provide storage solutions for hydrogen fuelled vessels) and HORIZON-JTI-CLEANH2-2024-03-04 'Demonstration of hydrogen-powered inland shipping or short sea shipping'.

Synergies with Processes4Planet has Partnership has been identified for HORIZON-JTI-CLEANH2-2024-01-05 'Hydrogen production and integration in energy-intensive industries in a circular approach to maximise total process efficiency and substance utilisation'.

Synergies with the European Innovation Council have been identified for the topic HORIZON-JTI-CLEANH2-2024-01-03 'Development of innovative technologies for direct seawater electrolysis'

In addition, the Call 2024 of the JU is asking proposal submitted under topics for Innovation Actions 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 2024, 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 2024 concerns proposal 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[266].

In addition, for the Hydrogen Valleys topics, Seals of Excellence will be awarded to applications exceeding the evaluation thresholds set out in this work programme but cannot be funded due to lack of budget available to the call. The Seal of Excellence will further

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[266] 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

improve the chances of sound proposals, otherwise not selected, to find alternative funding in other Union programmes, including those managed by national or regional Managing Authorities.

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. Collaboration with EISMEA has continued in 2023 (e.g join organisation of a workshop on 'water sourcing for renewable hydrogen and chemicals; which lead to the inclusion of a topic in this area in the Clean Hydrogen U). Such collaboration will continue similarly in 2024.

On the aviation side, the Clean Hydrogen JU signed a Memorandum of Understanding (MoU) with Clean Aviation JU in March 2023. In 2024, 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.

As in the past, exchanges of the Clean Hydrogen JU in 2023 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 of collaboration for the energy and transport sectors under both Horizon Europe and CEF Transport programmes. With CEF-T the Clean Hydrogen JU will continue facilitating the implementation of synergies between the ongoing JU project H2Accelerate TRUCKS[267] (Large scale deployment project to accelerate the uptake of Hydrogen Trucks in Europe) and (but not only) the CEF-T supported project Greater4H[268].

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. As in 2023 this is

[267] https://cordis.europa.eu/project/id/101101446
[268] https://greater4h.com/

likely to materialise in the form of joint workshops and round tables where project beneficiaries of JU funding can share their learnings and expectations, thus creating 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 2024 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 work to identify opportunities for collaboration (co-funding 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 2024 (building on the good practices of former years).

2.2.6.3 Supporting regions and Member States through technical assistance

In view of setting up a structured cooperation mechanism between the JU and Managing Authorities of Member States and Regions, the Clean Hydrogen JU is running a Technical Assistance to Generate Synergies with Members States and Regions. This initiative started in 2023 and will run until the first half of 2024. To date, the work analysed the state of play of hydrogen development in Member States/ Regions and has selected a total of 10 Managing Authorities with whom the JU (via the team contracted to deliver this work) will identify concrete areas for collaboration and synergies[269]. The ten selected Managing Authorities include five Members States/Regions of the EU13 and an Associated Country of Horizon Europe. It is expected that bilateral cooperation agreements between the JU and each of the selected Managing Authorities will be signed in the first half of 2024. In addition, lessons learnt will be extracted to benefit a wider range of Managing Authorities.

In 2024 the Clean Hydrogen JU will continue providing Project Development Assistance (PDA) for Regions with a focus on Cohesion Countries, Outermost Regions and Islands. In addition, in collaboration with Mission Innovation 2.0, the Clean Hydrogen JU will continue with the activities of the Hydrogen Valley platform. The platform will see new Hydrogen Valleys added allowing the most advanced Hydrogen Valleys around the globe to provide insights into their project development. It will also allow interested actors to get in touch with Hydrogen Valley developers directly through a dedicated matchmaking section.

Finally in 2024 the Clean Hydrogen JU will launch 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 (through dedicated project development assistance for hydrogen valleys).

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

[269] https://www.clean-hydrogen.europa.eu/media/news/evaluation-results-call-expression-interest-receiving-technical-assistance-generate-synergies-clean-2023-10-04_en

activities within the 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 in RCS development in EU and beyond, with the focus but not limited to Standards. In 2024, the RCS SC Task Force will continue prioritising the coordination of the following activities:

1. Follow up of 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 EU. Building on the previous activity and in consultation with relevant stakeholders, the RCS SC Task Force will assess what RCS developments could contribute the most to foster 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 the collection and effective transfer of 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[270] 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

[270] https://www.clean-hydrogen.europa.eu/get-involved/european-hydrogen-safety-panel-0_en

EHSP have the necessary scientific competencies and expertise covering the technical domain needed to make science-based recommendations to the Clean Hydrogen JU.

In 2024, 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[271] for a single service framework contract for the provision of support for coordinating and managing the EHSP, strengthening its coordination, activities, and impact. The single service framework contract will be operational at the beginning of 2024.

TF.1 Support at project level: 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 2024, the guidance document "Safety Planning and Management in EU Hydrogen and Fuel Cells Projects"[272] will be reviewed and further 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 2024 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 US Hydrogen Safety Panel[273], the International Association HySafe[274] (and related international activities like the International Conference on Hydrogen Safety), the International Partnership for Hydrogen and Fuel Cells in the Economy IPHE[275], and the Hydrogen Council[276] 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.

EHSP activities in 2024 will continue with the addition of new events in HIAD 3.0 (an updated and revamped version of the HIAD 2.0 database), e.g., with the incidents registered in the Hydrogen Tools Portal (H2Tools)[277] and/or those in the public domain. 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 (HIAD 2.0)"[278]. Furthermore, the EHSP will continue updating the lists of the engineering

[271] https://etendering.ted.europa.eu/cft/cft-display.html?cftId=14149
[272] https://www.clean-hydrogen.europa.eu/get-involved/european-hydrogen-safety-panel-0/reference-documents_en

[273] https://h2tools.org/hsp
[274] https://hysafe.info/
[275] https://www.iphe.net/
[276] https://hydrogencouncil.com/en/
[277] https://h2tools.org/
[278] https://www.clean-hydrogen.europa.eu/get-involved/european-hydrogen-safety-panel-0/reference-documents_en

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 2024 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.

2.2.6.6 European Hydrogen Sustainability and Circularity Panel (EHS&CP)

Sustainable development is at the heart of the European Green Deal[279], which along with other policies[280] 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 Clean Hydrogen JU is committed to contribute to putting the EU hydrogen sector at the forefront of the sustainable and circular transition of hydrogen technologies and their associated value chains. To this end, the research and innovation actions supported within the Horizontal Activity 1: Cross-cutting Issues (JU SRIA, section 3.6), the Horizontal Activity 3: Hydrogen Supply Chains (JU SRIA, section 3.8) and the Horizontal Activity 4: Strategic Research Challenges (JU SRIA, section 3.9) will play a key role in providing the foundation to strengthen the sustainability and circularity of hydrogen 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 to support the Programme implementation and the transition of the overall European hydrogen sector towards a sustainable and circular hydrogen economy.

The mission of the EHS&CP will be two-fold:

- To 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, and
- To promote and disseminate knowledge and a more sustainable and circular culture within and beyond the Programme.

The EHS&CP is envisaged as a multidisciplinary pool of experts with knowledge and experience in the relevant areas, covering the technical domains needed to make informed-based recommendations to the Clean Hydrogen JU. The EHS&CP will act as a focal point or

[279] COM(2019) 640 final
[280] https://ec.europa.eu/info/strategy/international-strategies/sustainable-development-goals/eu-holistic-approach-sustainable-development_en

"advisor" to the Programme in these matters in an independent, coordinated, and consolidated way.

In 2023, a consortium led by Ecorys was contracted by the Clean Hydrogen JU under a public procurement contract, to set-up and coordinate the European Hydrogen Sustainability and Circularity Panel. Under this contract, Ecorys is tasked by the Clean Hydrogen JU to select and manage up to 15 independent experts to serve as members of the EHS&CP. The panel members will cover specific technical areas related to sustainability and circularity of hydrogen technologies such as:

- Eco-design and eco-efficiency
- Raw materials and supply chain
- Manufacturing processes, automation and scaling up
- Waste management and recycling
- Hydrogen end-use applications (industrial and transport)
- Techno-economic and social science
- Environment and life cycle assessment.

The European Hydrogen Sustainability and Circularity Panel is expected to kick-off in early 2024, following an open call for expressions of interest and selection procedure based on the technical and professional capacity, and according to the principles of non-discrimination and equal treatment.

The EHS&CP will assist and advice the Clean Hydrogen JU at both the project and the Programme level around three main areas, as detailed below:

1. Support at the Programme and project level. At the Programme level, the EHS&CP will support and coordinate the development of an overarching and comprehensive strategy on sustainability and circularity. At the project level, the EHS&CP will define and coordinate a package of measures to raise the sustainability and circularity of the JU's funded projects by integrating learnings, expertise and planning.
2. Data collection and assessment. The EHS&CP will support and coordinate the development of a systematic data collection approach to extract valuable information from the JU`s funded projects and to provide further guidance to both projects and the Clean Hydrogen JU based on a regular monitoring activity. This could include the development of sustainability and circularity indicators to monitor progress and improve the understanding of environmental and social impacts of products and services. In addition, the EHS&CP will help identifying "hot spots" within the hydrogen value chains where interventions have the greatest potential to improve sustainability and circularity, while providing data and knowledge to support the JU in making informed decisions, etc.
3. Public outreach. EHS&CP activities in this category may include the development of a regularly updated webpage containing for example lessons learned and links to other important hydrogen-sustainable and circular-related information, the drafting of news items, setting up events, etc.

Altogether, the EHS&CP will provide the Clean Hydrogen JU a unique, practical, and direct support to reach the following overarching objective: ensure that the sustainability and circularity are embedded in the development and implementation of research and innovation actions supported in the Programme, and across the Programme, integrating and balancing the three dimensions of sustainable development: 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[281] 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 (or OCT[282]) 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 countries50.

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 2024 in research activities on hydrogen combustion 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)[283] and the International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE)[284]. The Clean Hydrogen JU will hence continue in 2024 to collaborate closely with the EC representatives in the steering committees of these international agreements/associations, in particular within the working-groups on Task 42 'Hydrogen Underground Storage', 'on Task 41 'Analysis and Modelling of Hydrogen Technologies' and in the definition of Tasks on 'Renewable Hydrogen' and 'Hydrogen Export value chains'. In addition, the European study on "Hydrogen for ports and industrial coastal areas" is conducted with the IEA under Clean Energy Ministerial initiative, which investigates the subject on a worldwide scale.

In 2023, 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.

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 continue to contribute in this direction. It will maintain and further improve the Hydrogen Valleys platform through a contract that will last until mid-2024, while contributing also towards the other activities of Clean Hydrogen Mission under MI2.0, aiming to make clean hydrogen

[281] Europe's strategy for international cooperation in a changing world, COM(2021) 252 final.
[282] Overseas countries and territories
[283] http://ieahydrogen.org/
[284] http://www.iphe.net/

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 foreseen study on “Sustainable paths for the use and management of water in the hydrogen value chain” and in the form of the project development assistance within the framework of the planned ‘Hydrogen Valley Facility’ which may be open to (but not only) to these countries.

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 2024

2.3.1 Communication, dissemination and exploitation

2.3.1.1 Communication

A. Communication objectives

The communication plan in 2024 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, and for the European Hydrogen Valleys Platform.

Furthermore, an important element for determining some of the 2024 objectives were the results of the public opinion survey on the topic of awareness and acceptance of hydrogen technologies. The survey showed a high level of awareness regarding hydrogen energy in general, across the EU, with over eight in ten respondents (82%) being aware of hydrogen energy. This high level of awareness is consistent across all sociodemographic subgroups of the population. The survey also showed that traditional media (like national television and newspapers) and online are the sources most likely to be used by the public when seeking information on energy: 54% of respondents say they go on the Internet to get this information, 47% would find it on television.

The following objectives will lead the communication activities in 2024:

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 2022-2023.	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 3rd call for proposals (foreseen in January 2024) 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. *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 through and about the new 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	Based on the results of the Public Opinion Survey on the level of awareness and acceptance of hydrogen technologies across EU, 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
Final results of Call 2023	January – February 2024	Website, social media, newsletter,	• Policymakers and authorities (EU, National, regional, local & International) • Opinion formers (media, experts, NGOs, etc.) • Beneficiaries
Launch of Call2024	January – February 2024	Website, social media, newsletter, events(info-day), brochure	• Policymakers and authorities (EU, National, regional, local & International) • Industry • Research • Beneficiaries
Media campaign	January - June 2024 (TBC)	Articles in traditional media, social media	• Policymakers and authorities (EU, National, regional, local & International) • Industry • Research , academia, education and training organisations • Opinion formers (media, experts, NGOs, etc.) • Consumers/ citizens *N.B. To allow for a wider involvement in the programme of the EU countries in Central, Eastern and Southern Europe, media efforts will focus on targeting policy makers, organisations and young people in these countries.*
Hydrogen Week	November 2024	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 *N.B. To allow for a wider involvement in the programme of the EU countries in Central, Eastern and Southern Europe, media efforts will focus on targeting policy makers, organisations and young people in these countries.*
Launch of the Hydrogen Knowledge Hub	Q4 2024	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 2024. The website, together with the social media channels, are the main gateway to the organisation.

The website underwent an audit in 2023, in order to evaluate key areas like usability, functionality, and user experience. The website was assessed for navigation, content organisation, and technical factors. A total of 82 recommendations have been made to address various aspects of the site, all aimed at boosting user engagement and overall satisfaction. These recommendations will be addressed in 2024 and contribute to the optimal performance of the website.

In addition to its main website, Clean Hydrogen will oversee a series of associated digital platforms: H2V, European Hydrogen Observatory, European Hydrogen Refuelling Station Availability System (E-HRS-AS) and the website dedicated to the Hydrogen Week (which may be further integrated in the future Knowledge Hub –see above related section).

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.

Social media

A social media plan will complement 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 13K 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. In 2023 the newsletter underwent an audit, were design, call-to-action effectiveness, and performance metrics were analysed. The results of the audit will be addressed, and its recommendations implemented in the course of the year.

Media

Public awareness and acceptance remains 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. Further communication towards audiences in the Central and East-European countries should be continued and enhanced. A dedicated media plan will be developed for this purpose, and will be implemented through a campaign continuing the efforts started in 2022 and 2023.

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 forum might 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 .

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.

The JU will also use the occasion to showcase the synergies between and with the various Commission services/programmes, industry and research partners and reflect on the entire hydrogen value chain from production, storage, to transport, distribution and utilisation.

In addition, the JU aims to work with the EU presidencies (Belgium and Hungary) in 2024 to organise joint event(s) (if possible, on the agendas of the respective presidencies), contribute to the European Hydrogen Forum of the Clean Hydrogen Alliance, and participate in other events that EC / partnerships are organising by participating at external events such as 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 2024 Info Day;
- Own webinar series – following up on experience last years, the JU may continue its successful online events to allow for discussion around its new priorities and projects (and their achievements or final reports);
- Projects events – such as demonstrations, projects visits, etc;

- Participation in major EU/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 .

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 communication (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[285]. The governance of the D&E Strategy for Horizon Europe mandates that the Horizon Dissemination & Exploitation Group will be one of the pillars (together with the Horizon Feedback to Policy Group) to coordinate implementation. Clean Hydrogen JU is planning to continue participating and contributing through this group.

Furthermore, as also depicted in the D&E Strategy, an ecosystem of services and tools has been established to enhance circulation of knowledge stemming from R&I projects:

- CORDIS[286]: Multilingual articles and publications that highlight research results, based on an open repository of EU project information.
- Horizon Results Platform[287]: 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[288]: 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[289]: 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[290]: 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;

[285] Dissemination & Exploitation Strategy for Horizon Europe - Towards an Integrated Dissemination & Exploitation Ecosystem, European Commission, DG-RTD, CIC, 2020
[286] https://cordis.europa.eu/en
[287] https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/horizon-results-platform
[288] https://ec.europa.eu/digital-single-market/en/innovation-radar
[289] https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/horizon-dashboard
[290] https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/d-e-booster

- Horizon Standardisation Booster[291]: 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 on Standardisation[292].
- Open Research Europe[293]: 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[294]: A collection of the most recent success stories from EU-funded research & innovation.

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 key exploitable results. 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 MGA. 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.

Innovation Radar (IR)[295] is a prominent initiative, aiming at identifying breakthrough innovations and innovators emerging from the programme. Clean Hydrogen JU, following the legacy of FCH 2 JU, is supporting and participating through the on-going and new projects. This activity 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 PMON workflow in Sygma/Compass, 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[296], a matchmaking platform supported by the EC to help projects commercialize their innovations,

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[291] Horizon Standardisation Booster (https://hsbooster.eu/)
[292] 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
[293] https://open-research-europe.ec.europa.eu/
[294] https://ec.europa.eu/research-and-innovation/en/projects/success-stories
[295] https://innovation-radar.ec.europa.eu/about
[296] https://dealflow.eu/

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 organized 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.

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 2.3.2), 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 tender (as a result of the current framework contracts ending in 2024, or seeing as the need is not already covered in another framework contract):

- HR Consultancy Services (Inter-institutional call for tenders)
- provision of agency staff in Brussels (Inter-institutional call for tenders)
- learning and development services (Inter-institutional call for tenders)
- catering services for large events (individual call for tenders)
- on-line data protection register services (Inter-institutional call for tenders)
- on-line recruitment platform and related services (Inter-institutional call for tenders)
- leasing of a hydrogen powered vehicle (individual call for tenders)

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 will prepare and launch all of its 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.

2.3.3 Other support operations

2.3.3.1 ICT management

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 IT 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 2024 by specific objectives in the following five areas: 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 (Aresbridge).

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. This will be supported by the implementation of the back-office arrangements for ICT services based on the agreed description of the model in the concept noted adopted by the Executive Directors and Governing Board of the Clean Hydrogen JU, as well as by Governing Boards of other JUs. The Clean Hydrogen JU will take the lead for the governance of ICT back-office, with IHI JU as co-lead.

This will also be supported by added-value interinstitutional framework contracts or inter-agency joint procurements the JU will continue joining (see also above in section 2.3.2 “Procurement and contracts”). In particular, we will adapt to the new DIGIT strategy moving from traditional public procurement to a Dynamic Purchasing System (DPS) per market.

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 will be operated under the new DIGIT broker model and will be shared as a pilot experience with the IT community. The common conference center of the White Atrium building will be upscaled with the necessary audio-visual functions to held hybrid meetings. Two designs of room equipment will be deployed, one of the type “plenary session” ideal for governance meetings, one for large hybrid meetings with scalable set-up of space and equipment.

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 2024 focusing on the digital culture, promoting digital skills, mobile hardware and software solutions, and collaboration:

- The cloud adoption will be encouraged for storage and application;
- 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 introduction of PPMT in the area of procurement (see above paragraph 2.3.2).

The year 2024 also has the challenge of possible changes in the ICT services provision following the adoption of the new regulation on information security and cyber security. The developments and practical implementations will be followed by participation in the relevant inter-institutional groups. Cybersecurity will be reinforced by the dedicated role of Cyber Security Officer to reinforce the JU’s resilience to ever evolving digital security threats. Mutualization of the role and measures will be analysed under the service group “Security and compliance management” developed in the back-office arrangements for ICT.Document Management

The main objective of **information and document management** is to use a portfolio of secure, state-of-the-art corporate digital solutions. The Clean Hydrogen JU will continue to use or adopt corporate digital solutions such as ARES, eProcurement suite, eGrants suite

In 2024, the Clean Hydrogen JU will exploit the potential of data, information, knowledge and content management for running the program, communication to citizens and stakeholders and best staff engagement. Digital solutions available to the Joint Undertaking under the Microsoft 365 package will also be further investigated.

To facilitate the interaction between all internal actors, a new intranet will be released.

For the support to the JU Governance, private channels and libraries for exchange of information will be developed for the Governing Board, Stakeholders Group and State Representative Group.

We also foresee the implementation of AresBridge integrated in Microsoft 365 SaaS information system to complement the IT tool Hermes-ARES-NomCom already adopted as document (record) management system provided by DIGIT. Microsoft 365 has been implemented in common for the Joint Undertakings as Workplace Services Provision by the ICT back-office arrangement.

2.3.3.2 Data protection

Concerning the processing of personal data, the Clean Hydrogen JU is bound by Regulation (EU) 2018/1725 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.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 https://www.clean-hydrogen.europa.eu/about-us/privacy-policy_en.

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 administrative activities related to data protection in coordination with other Joint Undertakings (see section 2.3.2).

2.3.3.3 Logistics and facility management

The year 2024 also has the challenge of a possible change in the space allocation and arrangements for staff members to adapt to the new ways of working, in line with the Commission decision on working time and hybrid working adopted by analogy by the Governing Board at the end of 2023 and its subsequent implementing measures (see below).

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 2024, specific attention will be paid to the effective implementation of the Commission decision on working time and hybrid working, adopted by the Governing Board in 2023, and to the related implementing measures and monitoring along the year 2024. This will allow preparing for the evaluation of the implementation of the decision in the first part of 2025.

Furthermore, in 2024, the following actions will be carried out in the area of HR:

- Ensuring that all new staff will follow a mandatory training on ‘Ethics and Integrity’;
- Finalisation of recruitments to fill the Staff Establishment Plan (see below in section 2.3.4.3): temporary agents for Synergies Officer and Internal Control and Audit Manager (2 AD positions) and for Financial Officer (AST position), contract agent for Personal Assistant to the Executive Director and to the Head of Unit for Operations and Communication, Seconded National Expert (one position). In addition, the selection of the new Executive Director (AD position) should be finalised in 2024 by the Governing Board.

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: in the field 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 CBE JU as Lead.

2.3.4.2 Strategy for achieving efficiency gains and synergies

With the aim to achieve further efficiency gains, in 2024, special focus will be put on the implementation of the following HR tools:

- Preparation and update of the job descriptions in a new JIS module in SysPer;Completion of the personnel files using ‘Numérisation Dossiers Personnels’ (NDP) of current staff members in SysPer, to be completed by the end of February, and continue with staff members who have left the organisation;
- Implementation of the EC tool MiPS+ for missions.

2.3.4.3 Staff Establishment Plan

Function group and grade	2023				2024	
	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
AD 13						
AD 12		2		2		2
AD 11						
AD 10		2		2		2
AD 9		3		2		3
AD 8		2		2		2
AD 7		5		5		5
AD 6		2		2		2
AD 5						
TOTAL AD		17		15		17
AST 11						
AST10						1
AST 9		2		2		1
AST 8		1		1		1
AST 7		1		1		1
AST 6						1
AST 5		5		5		4
AST 4						
AST 3		1		1		1
AST 2						
AST 1						
TOTAL AST		10		10		10
GRAND TOTAL	27		25		27	

Contract Agents	FTE corresponding to the authorised budget 2023	Executed FTE as of 31/12/2023	Headcount as of 31/12/2023	FTE corresponding to the authorised budget 2024
Function Group IV	1			1
Function Group III	1	1	1	1
Function Group II				
Function Group I				
TOTAL	2	1	1	2

Seconded National Experts	FTE corresponding to the authorised budget 2023	Executed FTE as of 31/12/2023	Headcount as of 31/12/2023	FTE corresponding to the authorised budget 2024
	3	2	2	3
TOTAL	3	2	2	3

Recruitment forecasts 2024 following retirement/mobility or new requested posts					
Job title in the JU	***Type of contract (Official, CA, TA)***		***TA/Official***		***CA***
			Function group/grade of recruitment internal (Brackets) and external (single grade) foreseen for publication		***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*			*AST5*	
Internal Control and Audit Manager	*1*			*AD7*	
SNE		*SNE*			

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 2024, with a possible additional ad-hoc meeting for the selection of the new Executive Director in Q1 2024. The indicative key decisions of the GB in 2024, adopted by preference through written procedures in accordance with the Rules of procedure adopted in 2022, are listed below:

Key decisions in 2024	Timetable
Selection of the new Executive Director (to be confirmed)	Q1
Assessment of the Annual Activity Report for 2023	Q2
Adoption of the AWP and budget for 2025	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 32 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 2024. Issues to be covered include:

- opinion on the JU's Annual Activity Report for 2023,
- opinion on the JU's AWP for 2025,

Furthermore, the SRG will prepare in 2024 its annual report on national and regional policies and programmes on Hydrogen.

The Chair of the SRG represents the SRG at the Clean Hydrogen Joint Undertaking's Governing Board meetings, where he has an observer status.

Lastly, in 2024, the Chair and Vice-Chairs will reach the term of their office, which may be extended upon their request to SRG representatives and decided in accordance with the Rules of procedure of the SRG.

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.

The SG will hold at least two meetings in 2024. The objectives of the meeting will be to update the SG on the activities of the Clean Hydrogen JU with a view to gather suggestions to enable concrete synergies between the JU and the sectors represented by the SG members, including on the AWP / Call for Proposals 2025.

Finally, 2024 may see the expansion of the SG in order with the objective of having additional sectors represented.

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 2024 the implementation of back-office arrangements will continue in four areas: the accounting function, ICT management, joint procurement opportunities and HR support. In addition, a fifth area of opportunity for back-office arrangements will be addressed regarding the White Atrium occupation and facility management.

The largely preferred model for the back-office arrangements (BOA) among JUs is a set-up with one JU and one back-up JU taking the lead dealing in coordinating tasks, organising the work among staff of several JUs and having a clear scope and decision-making power.

BOA Accounting (in place since 01/12/2022):

The JUs took over the Accounting services that until 2022 were provided by DG BUDG.

In this BOA, EU Rail is the lead JU, and Accounting Officer's services will be provided by 3 JU: CA JU, SESAR3 JU and EU-Rail JU.

The Executive Director of the Lead JU is responsible for the organization, oversight and coordination of the accounting services to the other JUs on the basis of an annex of the BOA SLA.

The Head of Administration and Finance or another officer with the necessary grade, skills and competencies of the Lead JU shall act as Accounting Coordinator of the BOA Accounting Officers.

The Accounting Officer(s) of the JU Accounting Providers delivers the service to one or more JU Accounting Beneficiary and is responsible for the accounts she/he signs off, while counting on the support and coordination with the lead JU.

BOA Human Resources management (SLA under negotiation):

For what concerns the HR domain, the study recommended to explore synergies by coordinating the management of SYSPER, possibly obtaining a single contract for all JUs, perform joint recruitments, harmonise job profiles and procedures.

These synergies will allow to obtain a better harmonisation among the JUs, exploiting best practices, achieving efficiency gains and economy of scale. In particular the areas where this BOA will act are: recruitment, legal framework and IT landscape in the HR domain.

Following the screening of HR resources in each JU, the study also points out no more than marginal FTE gains would be achieved in this area owing to the very limited number of human resources of the JUs.

In this BOA, CBE JU is the lead JU, with IHI JU as back-up.

BOA ICT (Concept note under drafting):

Mutualisation and centralisation is not new in the ICT function of the JUs. Since 2010, JUs have consistently looked for mutualisation / centralisation / outsourcing of common ICT operations and infrastructure.

The ICT area covers a list of ~50 services (service catalogue) structured in 6 service groups:

- Inter-JU IT Governance,
- Management of shared ICT infrastructure,
- Management of ICT tools, services and contracts,
- Workplace services provision,
- Security and compliance management,
- ICT activities specific per JU.

The underlying concept is that, out of the ICT service catalogue, everything that is non-specific to a JU should be managed through the BOA ICT.

In this BOA, Clean Hydrogen JU and IHI JU are co-leads.

BOA Procurement (in place since January 2023):

This BOA has been established with the objective of centralising administrative procurement capability and process to maximise open tenders for award of inter-JUs FWCs and middle value negotiated procedures (see above in section 2.3.2).

The focus is on the critical joint administrative procurement such as ICT, building management/corporate services and common support services that will be identified and agreed via joint Procurement Plan (JPP).

2.5.2 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 2023, the following main actions were identified for 2024:

- 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. In addition, an update of the Staff Leaving Procedure is to be finalised and fully implemented..

- Regarding the component Risk Assessment, a revision of the anti-fraud policy at Clean Hydrogen JU in the view of the update of the R&I anti-fraud policy is expected in 2024. 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 components Control Activities and Information and Communication, a Data Retention Policy will be adopted and implemented in 2024.

2.5.3 Financial procedures

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. 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[297]. 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 EMI and COMPASS. All payments are executed via the ABAC IT tool (EC accounting system). ABAC LCK is used for contract management and reporting purposes.

2.5.4 Ex-ante and ex-post controls

Ex-ante controls are essential to prevent errors and avoid the need for ex-post corrective actions. In accordance with Article 74 of the Financial Regulation 2018/1046[298], "each operation shall be subject at least to an ex-ante control relating to the operational and financial aspects of the operation, on the basis of a multiannual control strategy which takes risk into account.". Therefore, the main objective of ex ante controls is to ascertain that the principle of sound financial management has been applied.

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 2024, specific attention will be put to the following elements of ex-ante control:

- Financial webinars offered to projects to learn and ask questions on the new Horizon

[297] Ares(2020)4735320
[298] OJ L193, 30.7.2018 p.66

Europe rules;

- Participation of the finance officers to audits launched by Common Audit Service (CAS) with the aim to identify potential risks as well as for training purposes;
- 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 related to anti-fraud.

Ex-post controls for H2020 programme are defined as the controls executed to verify financial and operational aspects of finalised budgetary transactions in accordance with Article 19 of Financial Rules. The main objectives of the ex-post controls are to ensure that legality, regularity and sound financial management (economy, efficiency and effectiveness) have been respected and to provide the basis for corrective and recovery activities, if necessary. Clean Hydrogen JU ex-post controls of FCH 2 JU grants include financial audits which are monitored by CAS (Unit H2) of the Common Implementation Centre (CIC), in close cooperation with the Clean Hydrogen JU, except for implementation which remains fully with the Clean Hydrogen JU. CAS may also outsource the audit work to external audit firms for the FCH-H2020 grants. In 2024, focus will be put on the following:

- In cooperation with CAS, launching of new H2020 audits in two rounds: early in 2024 based on analytical risk-profile review of the main beneficiaries and later in 2024 based on the JUs' random sampling methodology to cover annual targets as per Annex 1 of the H2020 ex-post audit strategy;
- In cooperation with CAS, and in line with H2020 Working Arrangements, ensure monitoring of timely completion of the H2020 audits;

Building on the knowledge gained in H2020, to participate in establishing the Horizon Europe ex-post audit strategy (in cooperation with CAS). As regards with the Horizon Europe 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 control system will maintain a balance between economy, effectiveness and efficiency in the achievement of the HE programme goals. In that respect, the error rate from the ex-post audits on HE projects will be a single aggregated risk-based error rate based on all JU's error rate and not an error rate at each JU level anymore. The first HE projects signed early 2023 with a 12-month reporting periods could be audited and part of this new risk-based audit strategy. In addition, a risk-based *ex-ante* controls methodology in all grant management cycles in order to prevent the error from being (re-) appearing (in the first place) will be applied. The more significant the risk (detected), the higher the intensity of risk-based *ex-ante* controls.

2.5.5 Anti-fraud initiatives

Clean Hydrogen JU implements the common Research Anti-Fraud Strategy. In March 2019, CIC adopted the revised Research Family Anti-Fraud Strategy (RAFS 2019) and the associated action plan (replacing RAFS 2015 and its action plan). The implementation of the action plan is monitored through regular meetings of the Fraud and irregularity Committee (FAIR) to which the Clean Hydrogen JU takes part. Furthermore, for areas of expenditure other than grants, the Clean Hydrogen JU applies 'mutatis mutandis' by analogy the anti-fraud strategy of DG R&I. This is relevant in particular for expert management, procurement and internal fraud and the risk analysis leads to the conclusion that the residual risks (after mitigating actions) are low. In 2024, Clean Hydrogen JU will:

- continue to apply harmonised preventive measures for fraud detection, e.g. via enhanced-monitoring tool available as a new feature in Sygma-Compass workflow;
- participate to FAIR meetings organised by DG R&I and common trainings organised for the JUs (in cooperation with CAS).

2.5.6 Audits

Internal audits are carried out by the Internal Audit Service of the European Commission (IAS) in liaison with Internal Control and Audit Manager.

In 2024, focus will be put on providing input and assistance to IAS in conducting their reviews / audits as per the Annual Audit Plan of the IAS for the Clean Hydrogen JU. As regards European Court of Auditors (ECA) audits, in 2024 the Clean Hydrogen JU will:

- Liaise with the independent auditor (contracted in 2022 based on the results of the reopening of competition under EC (DG BUDG) FWC) to audit Clean Hydrogen JU accounts for 2023 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 2023 and 2024 accounts;
- Assist and support ECA in their new horizontal audit for the JUs for 2024 (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 CAS.

3 BUDGET 2024

The 2024 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 2024 and a comparison with 2023 budget (as after its revision in March 2023).

Revenues

2024 administrative budget will be financed by frontloaded commitment from EC (under H2020) and fresh appropriations under Horizon Europe, and by private members contributions.

2024 operational budget 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 60,000,000 in terms of commitments and EUR 36,000,000 in terms of payments will be funded through third countries contribution and will finance additional hydrogen valleys.

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 2024.

STATEMENT OF REVENUE										
Heading	**Title Chapter**	**Financial year 2023**				**Financial year 2024**				
		Commitment Appropriations	***% Ratio***	**Payment Appropriations**	***% Ratio***	**Commitment Appropriations**	***% Ratio***	**Payment Appropriations**	***% Ratio***	***Remarks***
EU contribution (excluding EFTA and third countries contribution)		198,709,380	74%	279,437,730	85%	117,777,031	63%	103,875,655	70%	
of which (fresh C1) Administrative (Title 1&2)			0%		0%	2,786,736	1%	2,786,736	2%	
of which frontloaded commitments (Title 1 and Title 2)	2002	3,530,303	1%	3,323,813	1%	790,664	0%	767,511	1%	
of which FP7 Operational (Title 3)	2001		0%	2,859,868	0%		0%		0%	
of which H2020 Operational (Title 3)	2005		0%	56,550,203	0%		0%	18,625,100	13%	
of which Horizon Europe Operational (Title 3)	2006	195,179,077	73%	216,703,846	0%	114,199,631	61%	81,696,308	55%	*In 2023* PA: 117,107,446.1 from 2023 EC commitment, 90,000,000 from 2022 EC commitment and 9,596,399.92 from 2021 EC commitment
EFTA and third countries contribution		65,640,675	24%	43,889,996	13%	64,141,317	34%	39,572,478	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		0%	81,711	0%	98,650	0%	121,676	0%	EFTA for H2020 calculated at 3.54% and for HE at 3%
of which Operational EFTA in FP7 (Title 3)	2001		0%	155,337	0%		0%		0%	EFTA for FP7 calculated at 2.11%

STATEMENT OF REVENUE										
Heading	**Title Chapter**	**Financial year 2023**				**Financial year 2024**				
		Commitment Appropriations	***% Ratio***	**Payment Appropriations**	***% Ratio***	**Commitment Appropriations**	***% Ratio***	**Payment Appropriations**	***% Ratio***	***Remarks***
of which Operational EFTA in H2020 (Title 3)	2005		0%	1,390,207	0%		0%	558,753	0%	EFTA for H2020 calculated at 3.54% and for HE at 3%
of which Operational EFTA in Horizon Europe (Title 3)	2006	5,640,675	2%	6,262,741	2%	4,042,667	2%	2,892,049	2%	EFTA for Horizon Europe calculated at 3%
of which operational third countries excluding EFTA (Title 3)	2006	60,000,000	22%	36,000,000	11%	60,000,000	32%	36,000,000	24%	60,000,000 in CA and 36,000,000 in PA in Horizon Europe line in 2024
Financial Members other than the Union contribution		3,530,302	1%	3,405,524	1%	3,676,050	2%	3,675,923	2%	
Hydrogen Europe contribution to administrative costs	2003	3,036,060	1%	2,928,751	1%	3.161.403	2%	3.161.293	2%	
Hydrogen Europe Research contribution to administrative costs	2004	494,242	0%	476,773	0%	514,647	0%	514.629	0%	
Unused appropriations from previous years		427,395	0%	993,279	0%	404,216	1%	513,304	1%	
Of which administrative 2021	3021	127,395	0%	517,694	0%		0%		0%	
Of which administrative 2022	3022	300,000	0%	159,257	0%	404,216	0%	513,304	0%	
Of which operational 2021	3020		0%	316,328	0%		0%		0%	
Of which operational 2022	3023		0%		0%		0%		0%	
TOTAL REVENUE		**268,307,752**		**327,726,529**		**185,998,614**		**147,637,360**		

Expenditure

Overall, the administrative budget (Titles 1 and 2) will show an increase by 13 % compared to 2023. In more details:

Title 1 - Staff

Title 1 (staff costs) represents 56% of the administrative budget for 2023 and will increase by 22% overall compared to 2023. 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 PMO services.

Salaries and allowances for staff in the establishment plan (Temporary Agents) will show an increase by 18% compared to 2023 due to the 5% indexation and the retroactive contribution to pension scheme. An additional 13% 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 45% compared to 2023 provisions, as a consequence of one additional Contract Agent and one SNE, starting to be effective in 2024 and also due to salaries adjustments, as explained above.

Expenditure related to recruitment, socio-medial infrastructure, training and representational costs will remain at 2023 levels, as no additional needs are identified.

Expenditure related to mission expenses will show a decrease by 9%, compared to the revised 2023 provisions, as we enfaced the need to transfer more credits in this line in 2023, which might be the case in 2024 too.

External services will show an increase by 99% compared to 2023 provision due to the estimation for more interim needs and the opening of two traineeships in the JU.

Title 2 - Infrastructure and operating costs

Title 2 (infrastructure and operating costs) represents 44% of the administrative budget for 2024 and will increase by 2% compared to 2023.

It covers rentals and building costs that are expected to remain stable with no high deviations from its costs in 2023. It is noted that rental provision is increased by 6% (anticipated inflation rate in Belgium in 2023) due to the uncertainty on the rental conditions at the time of the initial drafting of the budget. Rental and building costs also include a provision to cover an increase of the costs of energy in 2024.

IT costs will slightly increase by 1% as no significant additional needs are identified in 2024. The same applies for the increase by 4% in information and communication costs and meeting expenses and by 3% in current administrative expenditure.

On the other side, there will be a 18% decrease to telecommunication and postage costs as there are not expected in 2024 adjustments in telephony contracts due to inflation as it was the case in 2023.

Furthermore, there will be a significant decrease by 75% to movable property, as there are not expected many purchases or rental of office equipment in 2024.

Running costs in connection with operational activities include the needs for project technical assistants. The latter needs will remain stable in 2024, as technical assistance will be needed in support of the Horizon Europe grant agreement preparations for the whole year.

Title 3 - Operational costs

2024 budget includes:

H2020: payment appropriations for 30 payments (25 final and 5 interim) as well as procurement activities financed by this budget.

Horizon Europe: commitment appropriations will cover for the call of 2024, 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 540,000.

Commitment appropriations also include a EUR 60,000,000 provision on funding additional valleys through grants and procurements, as explained in sections 2.2.3 and 2.2.4 above.

Payment appropriations will cover for the entire pre-financings to grants expected to be signed in the beginning of 2024 (relating to the 2nd GB decision on call 2023) and call 2024. In addition, there is a provision for pre-financing to grants expected to be signed under hydrogen valleys.

Note on Call 2024 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 2023		Financial year 2024				Remarks
		Commitment Appropriations	Payment Appropriations	Commitment Appropriations	% Ratio 2024/2023	Payment Appropriations	% Ratio 2024/ 2023	
1- Staff costs		***4,221,000***	***4,221,000***	***5,168,000***	***122%***	***5,168,000***	***122%***	
Salaries and allowances	11	3,926,000	3,926,000	4,716,000	120%	4,716,000	120%	
- Of which establishment plan posts	1101	3,660,000	3,660,000	4,330,000	118%	4,330,000	118%	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	266,000	266,000	386,000	145%	386,000	145%	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	75,000	75,000	68,000	91%	68,000	91%	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	30,000	30,000	30,000	100%	30,000	100%	Training costs
External Services	1500	166,000	166,000	330,000	199%	330,000	199%	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		***3,267,000***	***3,267,000***	***3,330,614***	***102%***	***3,330,614***	***102%***	
Rental of buildings and associated costs	2000	436,000	436,000	480,000	110%	480,000	110%	Rent, works, insurance, common charges (water/gas/electricity), maintenance, security, and surveillance. Minor refurbishment.
Information, communication technology and data processing	2100	445,000	445,000	449,847	101%	449,847	101%	IT purchases, hardware and software, licences, software development

STATEMENT OF EXPENDITURE								
Heading	Title Chapter	Financial year 2023		Financial year 2024				Remarks
		Commitment Appropriations	Payment Appropriations	Commitment Appropriations	% Ratio 2024/2023	Payment Appropriations	% Ratio 2024/ 2023	
Movable property and associated costs	2200	20,000	20,000	5,000	25%	5,000	25%	Purchases and rental of office equipment, maintenance, and repair
Current administrative expenditure	2300	9,000	9,000	9,270	103%	9,270	103%	Office supplies, library, translation service, bank charges and miscellaneous office expenditure
Postage / Telecommunications	2400	11,000	11,000	8,998	82%	8,998	82%	Telephones, video conferences and postal services
Meeting expenses	2500	50,000	50,000	52,000	104%	52,000	104%	Official meetings such as SRG, Scientific Committee, Governing Board and caterings
Information and publishing	2600	755,000	755,000	786,500	104%	786,500	104%	External communication and events
Running costs in connection with operational activities	2700	1,541,000	1,541,000	1,539,000	100%	1,539,000	100%	Project technical assistance, audits, consulting activities and accounting services with DG BUDG
TOTAL ADMINISTRATIVE COSTS (1+2)		7,488,000	7,488,000	8,498,614	113%	8,498,614	113%	
3-Operational		***260,819,752***	***320,238,530***	***177,500,000***	***68%***	***139,138,746***	***43%***	
FP7	3001		3,039,328				0%	This appropriation shall cover the operational costs of the JU regarding FP7 grants (pre-financings, interim and final payments) and studies.
H2020	3002		58,232,615			19,081,415	33%	This appropriation shall cover the operational costs of the JU regarding H2020 grants (pre-financings, interim and final payments), studies and JRC contribution.
HORIZON EUROPE	3003	260,819,752	258,966,587	177,500,000	68%	120,057,331	46%	This appropriation shall cover the operational costs of the JU regarding Horizon Europe grants (pre-financings), studies and JRC contribution.
TOTAL EXPENDITURE		**268,307,752**	**327,726,530**	**185,998,614**	**69%**	**147,637,360**	**45%**	

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 2024 – 31 December 2024.

The Plan includes Additional Activities for a total amount of **EUR 675.85 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 2024		
Detailed description of the AA	**Type of contributor**	**Estimated value AA for 2024 (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	12.30
B To contribute to the implementation of the 2020 European Commission's Hydrogen Strategy for a climate neutral Europe	Private members	0.14
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	0.55
D To stimulate research and innovation on clean hydrogen production, distribution, storage and end use applications	Private members	2.06
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	65.08
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	0.16
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	5.37
SUB TOTAL (A)		**85.66**

DETAILED ESTIMATED IKAA FOR 2024		
Detailed description of the AA	**Type of contributor**	**Estimated value AA for 2024 (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	4.18
B To contribute to the implementation of the 2020 European Commission's Hydrogen Strategy for a climate neutral Europe	Private members	1.42
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	5.53
D To stimulate research and innovation on clean hydrogen production, distribution, storage and end use applications	Private members	0.77
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	39.20
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	0.05
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	3.47
SUB TOTAL (B)		**54.62**

DETAILED ESTIMATED IKAA FOR 2024		
Detailed description of the AA	**Type of contributor**	**Estimated value AA for 2024 (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	0.05
B To contribute to the implementation of the 2020 European Commission's Hydrogen Strategy for a climate neutral Europe	Private members	2.14
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	77.07
D To stimulate research and innovation on clean hydrogen production, distribution, storage and end use applications	Private members	0.09
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	10.94
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	0.99
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	0.95
SUB TOTAL (C)		**92.23**

DETAILED ESTIMATED IKAA FOR 2024		
Detailed description of the AA	**Type of contributor**	**Estimated value AA for 2024 (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	71.20
B To contribute to the implementation of the 2020 European Commission's Hydrogen Strategy for a climate neutral Europe	Private members	60.11
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	1.99
D To stimulate research and innovation on clean hydrogen production, distribution, storage and end use applications	Private members	0.01
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	0.72
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	18.40
H Increase public and private awareness, acceptance, and uptake of clean hydrogen solutions, in particular through cooperation with other European partnerships under Horizon Europe	Private members	0.03
SUB TOTAL (D)		**152.49**

DETAILED ESTIMATED IKAA FOR 2024			
Detailed description of the AA		**Type of contributor**	**Estimated value AA for 2024 (in M€)**
E	**Awareness-raising activities on hydrogen technologies and safety measures**		
D	To stimulate research and innovation on clean hydrogen production, distribution, storage and end use applications	Private members	0.12
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	1.86
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	0.30
H	Increase public and private awareness, acceptance, and uptake of clean hydrogen solutions, in particular through cooperation with other European partnerships under Horizon Europe	Private members	0.09
SUB TOTAL (E)			**2.37**

DETAILED ESTIMATED IKAA FOR 2024		
Detailed description of the AA	**Type of contributor**	**Estimated value AA for 2024 (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	3.00
B To contribute to the implementation of the 2020 European Commission's Hydrogen Strategy for a climate neutral Europe	Private members	0.11
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	53.36
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	1.77
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	0.27
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	0.28
SUB TOTAL (F)		**58.87**

DETAILED ESTIMATED IKAA FOR 2024		
Detailed description of the AA	**Type of contributor**	**Estimated value AA for 2024 (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	31.52
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	53.08
D To stimulate research and innovation on clean hydrogen production, distribution, storage and end use applications	Private members	28.54
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	98.29
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	0.67
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	2.92
SUB TOTAL (G)		**215.02**

DETAILED ESTIMATED IKAA FOR 2024		
Detailed description of the AA	**Type of contributor**	**Estimated value AA for 2024 (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	0.66
B To contribute to the implementation of the 2020 European Commission's Hydrogen Strategy for a climate neutral Europe	Private members	5.25
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	0.75
D To stimulate research and innovation on clean hydrogen production, distribution, storage and end use applications	Private members	0.38
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	2.37
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	5.12
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	0.04
H Increase public and private awareness, acceptance, and uptake of clean hydrogen solutions, in particular through cooperation with other European partnerships under Horizon Europe	Private members	0.02
SUB TOTAL (H)		**14.59**

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 environmental impacts	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[299]

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-CLEANH2-2024-01-01	✓	✓		✓	✓				✓	✓	✓
HORIZON-JTI-CLEANH2-2024-01-02	✓	✓		✓	✓				✓	✓	✓
HORIZON-JTI-CLEANH2-2024-01-03	✓	✓		✓	✓				✓	✓	✓
HORIZON-JTI-CLEANH2-2024-01-04			✓	✓					✓	✓	✓
HORIZON-JTI-CLEANH2-2024-01-05	✓	✓		✓					✓	✓	✓
HORIZON-JTI-CLEANH2-2024-02-01		✓	✓					✓			✓
HORIZON-JTI-CLEANH2-2024-02-02	✓	✓		✓	✓						✓
HORIZON-JTI-CLEANH2-2024-02-03	✓	✓		✓	✓						✓
HORIZON-JTI-CLEANH2-2024-02-04		✓			✓						✓
HORIZON-JTI-CLEANH2-2024-02-05		✓			✓	✓					✓
HORIZON-JTI-CLEANH2-2024-03-01		✓			✓	✓			✓		✓
HORIZON-JTI-CLEANH2-2024-03-02		✓			✓	✓			✓		✓
HORIZON-JTI-CLEANH2-2024-03-03					✓	✓			✓		✓
HORIZON-JTI-CLEANH2-2024-3-04	✓	✓	✓	✓		✓	✓	✓	✓		✓
HORIZON-JTI-CLEANH2-2024-04-01		✓							✓		
HORIZON-JTI-CLEANH2-2024-04-02	✓	✓		✓							

[299] 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-CLEANH2-2024-05-01	✓		✓	✓				✓			✓
HORIZON-JTI-CLEANH2-2024-05-02	✓			✓		✓					✓
HORIZON-JTI-CLEANH2-2024-06-01	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
HORIZON-JTI-CLEANH2-2024-06-02	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Other Activities											
Support to EU Policies			✓				✓	✓			✓
Knowledge Management			✓				✓	✓			✓
Collaboration with other entities			✓			✓	✓	✓			✓
RCS SC			✓				✓	✓			✓
EHSP			✓				✓	✓			✓
EHS & CP	✓		✓	✓			✓	✓			✓
International Cooperation			✓				✓	✓			✓
Communication			✓				✓	✓			✓
Dissemination & Exploitation			✓				✓	✓			✓
Procurement -01 – Water management	✓		✓	✓			✓				✓
Procurement -02 Natural/geologic hydrogen			✓				✓				✓
Procurement -03 – Use of hydrogen in a			✓								✓

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
RES-dominated power sector											
Procurement-04 – Hydrogen Valleys Facility			✓			✓	✓	✓			✓

4.3 Renewable Hydrogen Production. Objectives of the Clean Hydrogen JU addressed in the Call for Proposals 2024

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 the scale of deployment	Improved manufacturing for both water and steam electrolysis
HORIZON-JTI-CLEANH2-2024-01-01 Innovative proton conducting ceramic electrolysis cells and stacks for intermediate temperature hydrogen production	RIA	O	X	X		O		
HORIZON-JTI-CLEANH2-2024-01-02 Advanced anion exchange membrane electrolysers for low-cost hydrogen production for high power range applications	RIA	O	X	X		O		
HORIZON-JTI-CLEANH2-2024-01-03 Development of innovative technologies for direct seawater electrolysis	RIA	O	X	X		O		
HORIZON-JTI-CLEANH2-2024-01-04 Development and implementation of online monitoring and diagnostic tools for electrolysers	RIA	X	X					
HORIZON-JTI-CLEANH2-2025 -01-05 Hydrogen production and integration in energy-intensive industries in a circular approach to maximise total process efficiency and substance	IA	X	X	X	O	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
n/a					

4.4 Hydrogen Storage and Distribution. Objectives of the Clean Hydrogen JU addressed in the Call for Proposals 2024

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-JTI-CLEANH2-2024 -02-01 Investigation of microbial interaction for underground hydrogen porous media storage	**RIA**			X	
HORIZON-JTI-CLEANH2-2024 -02-02 Novel large scale aboveground storage solutions for demand-optimised supply of hydrogen	**RIA**	X	X		

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.
n/a					

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-JTI-CLEANH2-2024 -02-03 Demonstration of hydrogen purification and separation systems for renewable hydrogen-containing streams in industrial applications	IA	X	X	X	X	
HORIZON-JTI-CLEANH2-2024-02-04 Demonstration of innovative solutions for high-capacity, reliable, flexible, and sustainable hydrogen compression technologies in commercial applications	IA	X	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-JTI-CLEANH2-2024 -02-05 Demonstration and deployment of multi-purpose HRS between road and application for airports, railways, and/or harbours	IA	X	X	O	X

4.5 Hydrogen end uses: Transport. Objectives of the Clean Hydrogen JU addressed in the Call for Proposals 2024

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-JTI-CLEANH2-2024 -03-01 BoP components, architectures and operation strategies for improved PEMFC system efficiency and lifetime	RIA	O		O	X
HORIZON-JTI-CLEANH2-2024 -03-02 Scaling up Balance of Plant components for efficient high-power heavy-duty applications	RIA	O		O	X
HORIZON-JTI-CLEANH2-2024 -03-03 Next generation on-board storage solutions for hydrogen-powered maritime applications	RIA			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-JTI-CLEANH2-2024 -03-01 BoP components, architectures and operation strategies for improved PEMFC system efficiency and lifetime	RIA	X	X		
HORIZON-JTI-CLEANH2-2024 -03-02 Scaling up Balance of Plant components for efficient high-power heavy-duty applications	RIA	X	X		
HORIZON-JTI-CLEANH2-2024 -02-05 Demonstration and deployment of multi-purpose HRS between road and application for airports, railways, and/or harbours	IA				O

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-JTI-CLEANH2-2024 -03-03 Next generation on-board storage solutions for hydrogen-powered maritime applications	RIA			X	O
HORIZON-JTI-CLEANH2-2024 -03-04 Demonstration of hydrogen fuel cell-powered inland or short sea shipping	IA	O	X	O	X
HORIZON-JTI-CLEANH2-2024 -02-05 Demonstration and deployment of multi-purpose HRS between road and application for airports, railways, and/or harbours	IA				O

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..
HORIZON-JTI-CLEANH2-2024 -02-05 Demonstration and deployment of multi-purpose HRS between road and application for airports, railways, and/or harbours	IA				O

4.6 Hydrogen end uses: Clean Heat and Power. Objectives of the Clean Hydrogen JU addressed in the Call for Proposals 2024

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-JTI-CLEANH2-2024 -04-01 Portable fuel cells for backup power during natural disasters to power critical infrastructures	IA	X	X	O		

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.
HORIZON-JTI-CLEANH2-2024 -04-02 Improved characterisation, prediction and optimisation of flame stabilisation in high-pressure premixed hydrogen combustion at gas-turbine conditions	RIA	X	O

4.7 Cross-cutting issues. Objectives of the Clean Hydrogen JU addressed in the Call for Proposals 2024

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.	Develop eco-design guidelines and eco-efficient processes.	Develop enhanced recovery processes in particular for PGMs/CRMs and per- and polyfluoroalkyl substances.
HORIZON-JTI-CLEANH2-2024-05-01 Guidelines for sustainable-by-design systems across the hydrogen value chain	CSA	X	X	
HORIZON-JTI-CLEANH2-2024 -05-02 Development of non-fluorinated components for fuel cells and electrolysers	RIA			O

Cross-cutting issues **Education and public Awareness**	*Type of Action*	Develop educational and training material and building training programs for professionals and students on hydrogen and fuel cells.	Raise public awareness and trust towards hydrogen technologies and their system benefits..
n/a			

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-JTI-CLEANH2-2024 -02-01 Investigation of microbial interaction for underground hydrogen porous media storage	RIA		X

4.8 Hydrogen Valleys, Supply Chain and Strategic Research Challenge. Objectives of the Clean Hydrogen JU addressed in the Call for Proposals 2024

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-JTI-CLEANH2-2024-06-01: Large-scale Hydrogen Valley	IA		X	
HORIZON-JTI-CLEANH2-2024-06-02: 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-JTI-CLEANH2-2024-05-02: Development of non-fluorinated components for fuel cells and electrolysers	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.
HORIZON-JTI-CLEANH2-2024-05-02: Development of non-fluorinated components for fuel cells and electrolysers	RIA	X		