ANNEX to GB decision no CleanHydrogen-GB-2024-07

Clean Hydrogen Partnership

CLEAN HYDROGEN JOINT UNDERTAKING

CONSOLIDATED ANNUAL ACTIVITY REPORT YEAR 2023

Clean Hydrogen Partnership
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EUROPEAN PARTNERSHIP

Co-funded by the European Union

In accordance with Article 26 of Council Regulation (EU) No 2021/2085 establishing the Clean Hydrogen Joint Undertaking and with Article 23 of the Financial Rules of the Fuel Cells and Hydrogen 2 Joint Undertaking as re-adopted by the Clean Hydrogen Governing Board on 17 December 2021 (CleanHydrogen-GB-2021-02).

The consolidated annual activity report is made publicly available after its approval by the Governing Board.

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Contents

FACTSHEET

NAME OF THE JU	CLEAN HYDROGEN JOINT UNDERTAKING
OBJECTIVES	The Clean Hydrogen Joint Undertaking (JU), through the involvement and commitment of its partners, will enhance cooperation between the diverse stakeholders along the whole hydrogen value-chain and mobilise them to increase the leverage effect of investments in R&I, with the main objectives being to: • contribute to the EU ambitious 2030 and 2050 climate ambition; • support the implementation of the Commission's Hydrogen Strategy; • strengthen the competitiveness of the Union clean hydrogen value chain; • stimulate research and innovation on clean hydrogen production, distribution, storage and end use applications. The Clean Hydrogen JU has the following specific objectives: a) 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; b) 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; c) 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; d) increase public and private awareness, acceptance and uptake of clean hydrogen solutions, in particular through cooperation with other European partnerships under Horizon Europe. Moreover, the Clean Hydrogen Joint Undertaking shall carry out the following specific JU tasks: a) assess and monitor technological progress and technological, economic and societal barriers to market entry, including in emerging hydrogen markets; b) notwithstanding the Commission's policy prerogatives, under the Commission's policy guidance and supervision, contribute to the development of regulations and standards with the view to eliminating barriers to market entry and to supporting interchangeability, inter-operability and trade across the internal market and globally; c) support the Commission, including through technical expertise, in its international initiatives on hydrogen, such as the International Partnership on the Hydrogen Economy (IPHE), Mission Innovation and the Clean Energy Ministerial Hydrogen Initiative.
LEGAL BASIS	Established under article 187 of the Treaty on the Functioning of the European Union and 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] (hereon: SBA)
EXECUTIVE DIRECTOR	Ms Valérie Bouillon-Delporte, Executive Director (since June 2024) Ms Mirela Atanasiu, Executive Director *ad interim* (from May 2023 until May 2024)
GOVERNING BOARD	Governing Board (3 representatives of the European Commission, 6 representatives of the Industry Grouping and 1 representative of the Research Grouping) Chair: Melissa Verykios (Industry Grouping) Vice-chair: Rosalinde van der Vlies (European Commission) Current composition: https://www.clean-hydrogen.europa.eu/about-us/organisation/governing-board_en
OTHER BODIES	States Representatives Group Stakeholders Group
STAFF NUMBER	27 temporary agents, 2 contract agents and 3 seconded national experts

NAME OF THE JU	CLEAN HYDROGEN JOINT UNDERTAKING
TOTAL BUDGET [2023](A) [1]	Commitment appropriations [2]: EUR 268.7 million, of which EUR 261.2 million for operational activities and EUR 7.5 million for administrative expenditure Payment appropriations [3]: EUR 327.7 million, of which EUR 320.2 million for operational activities and EUR 7.5 million for administrative expenditure
BUDGET IMPLEMENTATION/ EXECUTION	Commitments: EUR 259 769 594 (97 % of appropriations): Title 1: EUR 3 700 698 (87%) Title 2: EUR 2 342 185 (71%) Title 3: EUR 253 726 711 (97%) Payment appropriations: EUR 280 033 966 (85 % of appropriations): Title 1: EUR 3 644 352 (86%) Title 2: EUR 1 992 931 (61%) Title 3: EUR 274 396 683 (86%)
GRANTS/TENDERS/PRIZES	60 grants signed in 2023 (incl. those remaining and complex from call 2022) for a total value of EUR 411 104 967.17 Two operational tenders and specific contracts for a total value of EUR 2 916 million and administrative tenders for a total value of EUR 3 703 million
STRATEGIC RESEARCH & INNOVATION AGENDA	Strategic Research and Innovation Agenda 2021–2027 (https://www.clean-hydrogen.europa.eu/about-us/key-documents/strategic-research-and-innovation-agenda_en)
CALL IMPLEMENTATION	Number of calls launched in 2023 = 1 Number of proposals submitted = 132 Number of eligible proposals = 122 Number of proposals granted (signed GAs and on-going GAPs for Call 2023) = 32 Number of global project portfolio as of end of 2023 (since the setting up; signed grant only; for evolution overview) = 85
PARTICIPATION, INCLUDING SMES	Total of 710 beneficiaries in funded projects of the Clean Hydrogen JU (Calls 2022 and 2023), securing EUR 544.25 million of funding. Of these beneficiaries: • 23 % were SMEs, of which receiving 21 % of total EU funding; • 65 % were private for profit/large companies, receiving 48 % of total EU; • 5 % were non-EU, non-associated members' entities (openness); • 70 % were newcomer entities; • 26% were members of the Clean Hydrogen JU's private members, receiving 38% of the total funding

[1] Total budget includes operational budget (used for funding selected projects) & administrative (used for funding Programme Office activities).
[2] Voted commitment appropriations were EUR 267.1 million, subsequently amended to include the increase of revenues and expenditure related to the requested revision from the EU Commission and unused appropriations from prior years.
[3] Voted payment appropriations were EUR 326.5 million and the amendment increased the amount -as a result of the requested revision from the EU Commission and to include unused appropriations from prior years.

FOREWORD

Dear readers,

My role as the new Executive Director of the Clean Hydrogen Partnership started on 1 June 2024.

I would like to take the opportunity of the foreword of this annual activity report for 2023 to pay a tribute to the staff members of the Clean Hydrogen Partnership and especially to Ms Mirela Atanasiu in her role as executive director *ad interim*.

Under her guidance, since May 2023, the JU's operations were successfully and seamlessly continued, which allowed the Clean Hydrogen JU to brilliantly address the ambitious challenges of our sector. The year 2023 has been a very active year with many key milestones reached, thanks to the professionalism and the deep commitment of all the team members.

Ms Mirela Atanasiu will continue in her role of Head of Operations and Communications with the Clean Hydrogen JU. I'm thrilled to join the Clean Hydrogen JU as its new Executive Director and to ensure that we do contribute to the European climate neutrality ambitious goals by accelerating the development and deployment of the European value chain for safe and sustainable clean hydrogen technologies, strengthening its competitiveness with all the stakeholders working hands in hands.

Valérie Bouillon-Delporte
Executive Director (since 1st June 2024)

I am pleased to present you the annual activity report for 2023. The report highlights the strong progress we have made, showing that the year 2023 has been a landmark period for the Clean Hydrogen Joint Undertaking (Clean Hydrogen JU), marked by significant achievements.

This was also my first year as executive director ad interim, a role I took over from Bart Biebuyck in May 2023, to whom I'd like to thank for his strong vision and leadership. As executive director ad interim, I have ensured smooth continuity in JU's operations, continuing to meet the sector's ambitious expectations as well as challenges.

First, building upon the foundation laid in previous years, the Clean Hydrogen JU doubled its portfolio of projects, with 29 new grants signed in 2023. The number of hydrogen valley projects has surged to fourteen, with EU funding exceeding EUR 120 million, positioning Europe as a leader in developing hydrogen ecosystems and contributing to Mission Innovation objectives. Notably, the year 2023 marked the first year of implementing additional funding dedicated to hydrogen valleys under the REPowerEU Plan, with EUR 60 million fully committed, showcasing the Clean Hydrogen JU's capability to swiftly enact policy measures.

Moreover, the Clean Hydrogen JU successfully committed half of its overall operational budget for the 2021-2031 period; thanks to a comprehensive approach which includes significant investments in flagship projects such as underground storage and hydrogen valleys, while also supporting projects across the entire hydrogen value chain at various technology readiness levels (TRL) and successfully fostering synergies with CEF (H2Accelerate), European Innovation Council (EIC), Clean Aviation JU, and other partnerships.

The 2023 call for proposals for low TRL topics, aimed at enhancing electrolyser performance, attracted numerous high-quality submissions, resulting in EUR 54 million in funding. A notable innovation from 2023 was the first flight of an aircraft powered by liquid hydrogen within the HEAVEN project, co-funded by the Clean Hydrogen JU.

As part of the EU Year of Skills, the Clean Hydrogen JU launched the Hydrogen Academy to develop a skilled workforce to achieve the European Commission's hydrogen strategy objectives, contributing to job creation and conversion. Additionally, the establishment of the Circularity and Sustainability Panel in 2023 ensures sustainable hydrogen solutions by design, engaging recognized experts in the field.

Knowledge management saw substantial progress with the relaunch of the European Hydrogen Observatory and the global hydrogen valleys platform under the Mission Innovation initiative, encompassing over 80 valleys across more than 15 countries, and the initiation of the Knowledge Hub.

The Clean Hydrogen JU's work with the regions entered in a new phase with the launch of a call for regional and national Managing Authorities from the EU-27 and Horizon Europe associated countries aiming to develop cooperation in relevant key areas for hydrogen development. Ten Authorities were selected to receive the Technical Assistance from the Partnership. This initiative has been the latest in a series of valuable collaborations between the Clean Hydrogen Partnership and authorities at different territorial levels (regional/national) with the purpose of advancing hydrogen on a regional/national level.

In terms of communication and stakeholder engagement, the Clean Hydrogen JU co-created the fourth European Hydrogen Week and organized the EU Hydrogen Research Days, providing policymakers and industry with a forum to discuss the state of the hydrogen economy and for the Clean Hydrogen Partnership to present the innovative results of its various funded projects. More than 8 000 visitors and 250 exhibitors took part in the 2023 edition of the EU Hydrogen week, demonstrating increased interest from various publics. The state of play of public awareness was explored as well in a webinar organised in July 2023, with the participation of industry, policy and research representatives, which discussed the results of the public opinion survey on the public awareness of hydrogen technologies in Europe.

The private sector's strong commitment to hydrogen investment was evident in the significant in-kind contributions from partners Hydrogen Europe and Hydrogen Europe Research, surpassing the targets set in the SBA. With a leverage effect of EUR 1.7, the Clean Hydrogen JU demonstrates efficiency, where every Euro invested by the European Union is matched by EUR 1.7 from the private sector.

Overall, the year 2023 was another transformative year for the JU, and the European hydrogen sector. Our achievements, as outlined in this report, give multiple examples of the true value of partnership and reflect the Clean Hydrogen JU's steadfast commitment to driving innovation and sustainability in the hydrogen sector, setting a strong precedent for the years to come.

Mirela Atanasiu
Executive Director *ad interim* (from May 2023 until May 2024)

EXECUTIVE SUMMARY

During the year 2023, the Clean Hydrogen JU has made important achievements, in continuation of the previous years. At the end of this term, half of the overall operational budget of the Clean Hydrogen JU for the period from 2021 to 2031 has been committed, and the overall portfolio of projects has doubled in size (number of projects). As a result, the budget execution figures, both for the administrative and the operational budget, are outstanding: 96.62% in commitments and 85.43% in payments. This is the measurable outcome of the effort of the Clean Hydrogen JU and its stakeholders in 2023, continuing the effort made in previous years.

In particular, 29 new grants have been signed in 2023. Some of these grants include synergies with CEF (H2Accelerate), Clean Aviation JU, European Partnership on Metrology, Process-for-Planet Partnership, Zero Emission Waterborne Transport Partnership, the European Innovation Council, together with regional and national funds. And the number of the hydrogen valleys projects has exponentially increased from two under H2020 to fourteen today representing a total EU funding of more than EUR 120 million thereby positioning Europe at the forefront for the development of such ecosystems, fully contributing to Mission Innovation objectives. The year 2023 was the first year of implementation of the additional funding dedicated to hydrogen valleys under the REPowerEU Plan, the first tranche of which (EUR 60 million) being fully committed, demonstrating the ability of the Clean Hydrogen JU to implement policy measures at a fast pace. The topic of hydrogen valleys is also supported by communication activities, with a dedicated workshop and high-level event organised in February 2023 in Brussels under the sponsorship of Commissioner Gabriel, thus benefitting from the highest political support. The Clean Hydrogen JU also actively contributed to the set-up of the Hydrogen Valleys Partnership. Aside of grants and policy support activities, the Clean Hydrogen JU also supports 15 regions through Project Development Assistance and provides technical assistance to another 10 regional managing authorities.

While significant investment is made on flagships such as underground storage (40M€ invested to demonstrate large salt caverns and depleted gas fields, in full complementarity) and hydrogen valleys, the Clean Hydrogen JU continues to invest in projects along the whole value chain of Hydrogen at different technology readiness levels (TRL). Low TRL topics were included in the 2023 call for proposals and received an outstandingly large number of high-quality proposals, especially with the aim of increasing electrolysers performance. As such, low TRL topics received a total funding amounting to EUR 54 million in 2023. Amongst the other significant innovations, the first flight of an aircraft powered by liquid hydrogen took place in 2023 within the HEAVEN project co-funded by the Clean Hydrogen JU.

The year 2023 was also the EU Year of skills, and, as part of this, the Clean Hydrogen JU launched the Hydrogen Academy to ensure talents and qualified workforce will be in place to implement concretely objectives laid down by the European Commission through its hydrogen strategy and subsequently job creation/conversion.

To ensure sustainability by design of the hydrogen solutions, the new Circularity and Sustainability Panel was set up and officially launched in 2023 as a new cross-cutting activity, gathering recognised experts in this field.

Great achievements were also accomplished in the area of knowledge management, with the relaunch the European Hydrogen Observatory and hydrogen valleys platform which counts more than 80 Valleys across the globe in more than 15 countries, and with the start of the Knowledge Hub.

In the area of Communication and Stakeholders relation, the Clean Hydrogen JU co-created the fourth Hydrogen Week and organised the EU Hydrogen Research Days (previously Programme Review Days) with the support of the Joint Research Centre. Cooperation with Africa on hydrogen was also launched.

Thanks to the strong momentum and commitment from the private sector to invest in hydrogen, the Clean Hydrogen JU has also seen major developments in in-kind contribution from the private partners, Hydrogen Europe and Hydrogen Europe Research, both to operational activities (IKOP) and to additional activities (IKAA), with an identified combined amount exceeding the target set forth in the SBA for the contribution of Members other than the Union. The Clean Hydrogen JU will monitor that these identified contributions materialise in validated and certified contribution over the next years. To date, a leverage effect of 1.7 is envisioned, meaning for each Euro invested by the European Union, EUR 1.7 is invested by the private sector thereby demonstrating the efficiency of the Clean Hydrogen JU.

Thanks to a dedicated and knowledgeable management and staff, under the leadership of under the leadership of Mr Bart Biebuyck till May 2023 and after that of Ms Atanasiu as acting executive director with her vastly demonstrated experience in the JU. A smooth service continuity was fully ensured – after the termination of the mandate of the Executive Director: the Clean Hydrogen JU continued to implement its work programme and to respond to its ever-increasing ambitious challenges and expectations of the sector. The Clean Hydrogen JU thanked Mr Biebuyck for his outstanding contribution to the sector.

1 Implementation of the Annual Work Programme 2023

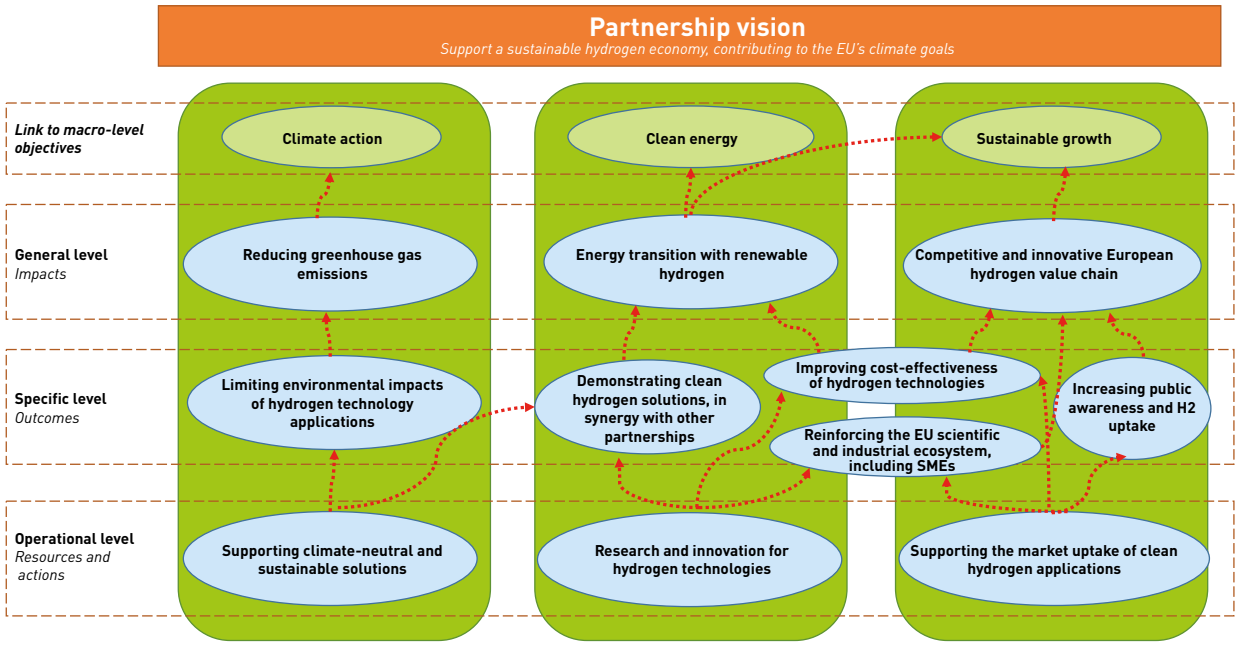
1.1. Key objectives for 2023, associated risks and corrective measures

1.1.1. Progress towards achieving the Clean Hydrogen JU objectives

The Clean Hydrogen JU aims to accelerate the development and deployment of safe and sustainable clean hydrogen technologies for a European value chain, 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, thereby 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 to map its large number of (often high level) objectives to more specific ones ([4]). This facilitated the identification of the necessary actions over the lifetime of the Clean Hydrogen JU, necessary to meet its objectives. The Strategy Map links the resources of the Clean Hydrogen JU and the actions taken (operational objectives / indicators) to concrete outcomes (specific objectives / indicators) and directly to one (or more) of the general objectives and intended impacts of the Clean Hydrogen JU, which in turn contribute to one or more high-level objectives of the European Union. The Figure 1 presents the Clean Hydrogen JU's strategy map, linking actions with expected outcomes and intended impacts.

Figure 1. Strategy map of the Clean Hydrogen JU



Source: Clean Hydrogen JU.

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

Therefore, the programme's progress towards its objectives can be assessed based on the progress of its KPIs towards achieving the targets associated with the Clean Hydrogen JU Strategy Map, as described in Section 1.7 and Annex 5.5.5. Despite the fact that the first Call of the Clean Hydrogen JU was only published in 2022 and the first projects signed their grant agreements only in the end of 2022 to early 2023, the KPIs indicate that there has already been significant progress towards the Clean Hydrogen JU objectives.

The projects funded and activities led by the Clean Hydrogen JU aim to support the competitiveness of the European Union across the entire clean hydrogen value chain. All projects support climate neutral and sustainable solutions, as well as many of them the market uptake of clean hydrogen applications. Significant support is given both to SMEs (23% of the total beneficiaries) and to low TRL projects (almost 50% of the total projects) and to demonstration projects (50% of its budget).

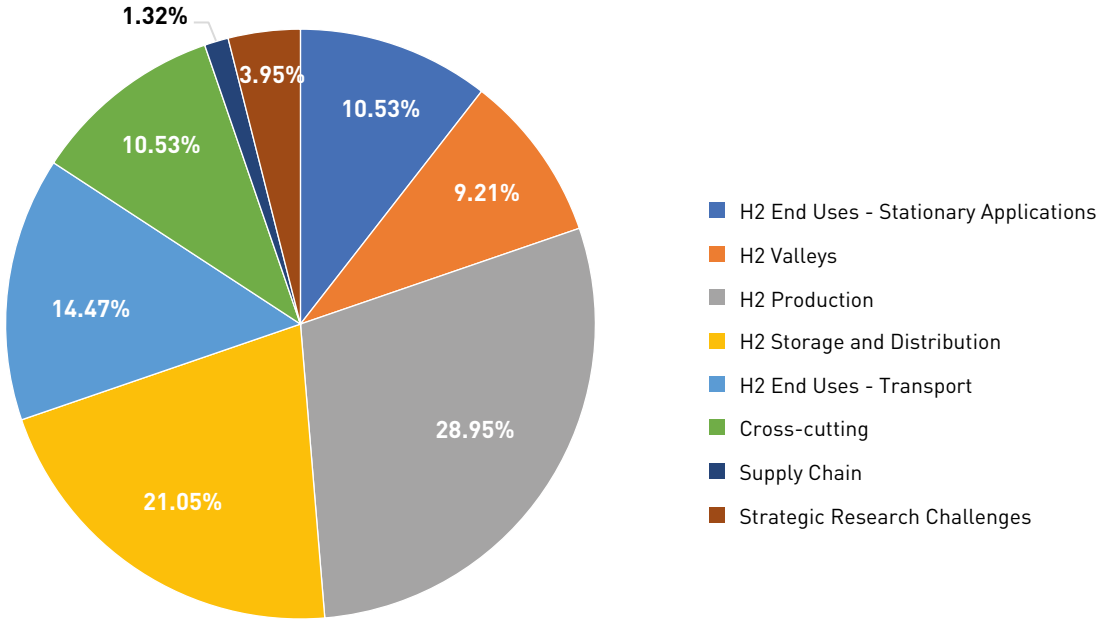
Therefore, the Clean Hydrogen JU activities are fully in line with its objectives, strengthening the knowledge and capacity of scientific and industrial actors, improving the technology characteristics of hydrogen technologies and thus contributing to the implementation of the European Commission's Hydrogen Strategy and the achievement of the objectives set out in the European Green Deal and the 2030 Climate Target Plan.

In particular, looking at the Calls 2022 and 2023, close to EUR 500 million ([5]) have been used to support projects across the whole hydrogen value chain, covering different technology readiness levels including research actions up to the demonstration of specific technologies as well as of projects aiming to demonstrate fully functional hydrogen ecosystems or Hydrogen Valleys. Out of the EUR 500 million, a share of 12% (EUR 60 million) correspond to Hydrogen Valleys funded by the "REPowerEU Plan", an additional investment of €200 million available for the Clean Hydrogen Partnership through the Horizon Europe Programme. The funds aim at helping to double the number of Hydrogen Valleys in Europe and thus accelerating the implementation of the hydrogen economy across the EU. In addition, a number of projects have been supported looking at cross-cutting issues such as skills, pre-normative research and sustainability of hydrogen technologies.

The figure below shows the breakdown of the support provided under these calls per pillar in the SRIA:

In addition, the breakdown per type of action is shown in the figure below. A good balance between Research and Innovation actions and Innovation Actions (demonstrations) is observed.

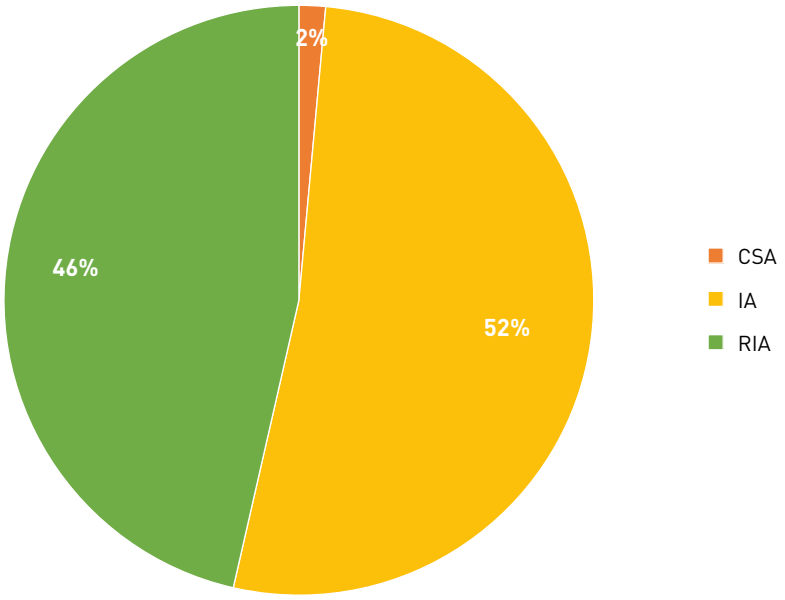
Figure 2. Share of total funding for 2022 and 2023 calls



Source: Clean Hydrogen JU.

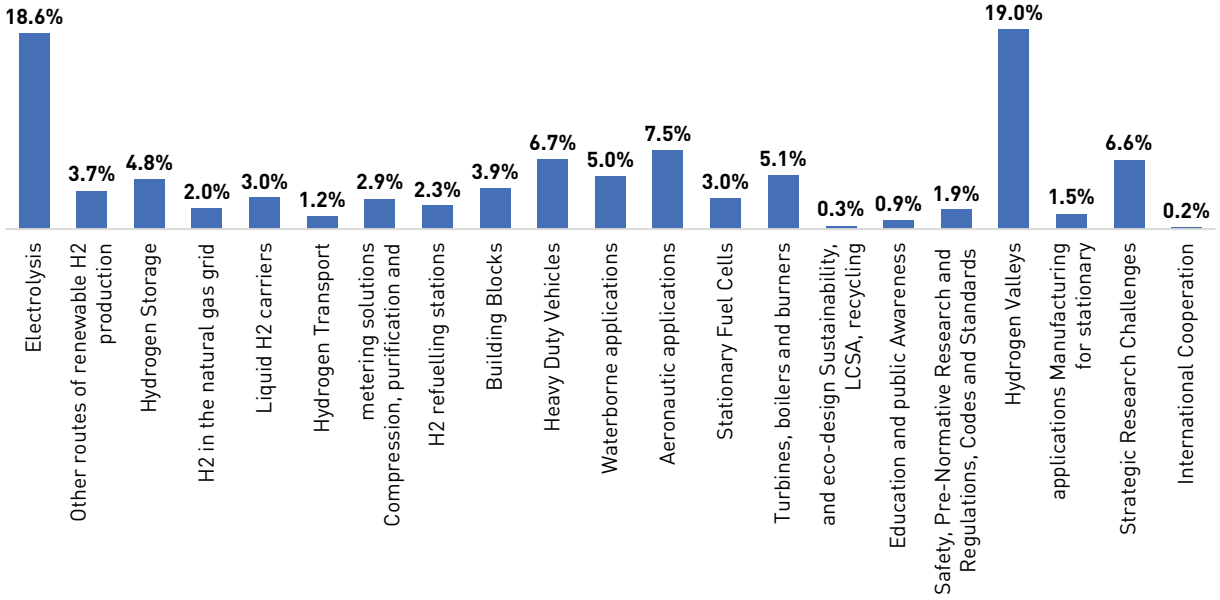
([5]) Figures for the 2023 Call do not include the 5 grants that were signed early 2024 and another one concerning a REPowerEU Hydrogen Valley

Figure 3. Share of total funding for 2022 and 2023 calls per type of action



Source: Clean Hydrogen JU.
NB: CSA, coordination and support action; IA, innovation action; RIA, research and innovation action.

Figure 4. Share of total funding for 2022 and 2023 calls by SRIA research area

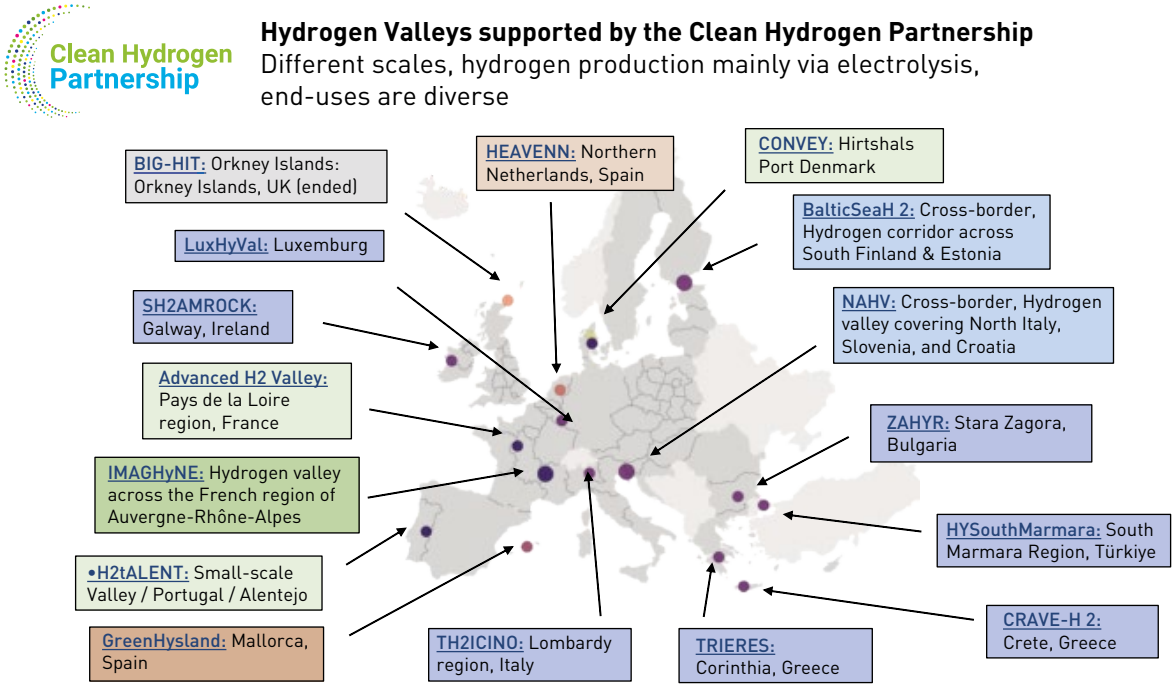


Source: Clean Hydrogen JU.
NB: LCSA, life cycle sustainability assessment. The figures exclude the support provided for Hydrogen Valleys using the EUR 200 million from RePowerEU.

At a deeper level of granularity, the Figure 4 shows the funding per type of sub-pillar. This helps to identify where most efforts have been channelled.

Under Horizon Europe, the Clean Hydrogen JU has provided support to 13 Hydrogen Valleys ([6]). This includes funding awarded under the budget included in the main JU calls and the dedicated budget under RePowerEU. Together with the 3 Hydrogen Valleys supported under H2020, the total JU funding to Hydrogen Valleys is close to EUR 190 million (16 projects) with total project costs of around EUR 1,000 million. These projects include around 360 unique beneficiaries covering around 40 countries.

Figure 5. Hydrogen valleys supported by the Clean Hydrogen Partnership



Source: Clean Hydrogen JU.

More **information on all the Clean Hydrogen JU projects** supported by the Clean Hydrogen Partnership can be found in the Clean Hydrogen JU website ([7]).

1.1.2. Operational risks, mitigation and corrective measures

1.1.2.1. Risk assessment in 2023

Risk management is a crucial part of the strategic decision-making process. Robust risk management frameworks help to ensure that the EU budget is used effectively and efficiently, that potential risks to achieving objectives are identified in a timely fashion and that appropriate mitigating action is taken. All members of staff share responsibility for risk management. The Executive Director is accountable to the Governing Board, is ultimately responsible for the management of the Clean Hydrogen JU's activities and achievement of objectives and must ensure that the Clean Hydrogen JU's critical risks are known and appropriately managed ([8]).

([6]) For completeness we include here and in the Figure 5 two Hydrogen Valleys that were signed early in 2024, as part of the 2023 Call
([7]) https://www.clean-hydrogen.europa.eu/projects-dashboard_en
([8]) Ref to. COUNCIL REGULATION (EU) 2021/2085 of 19 November 2021, Article 19, 4(t)

In October 2023, in a continuation of the practice of the Clean Hydrogen JU in previous years, an annual risk assessment exercise was conducted for the purpose of identifying, analysing and responding to key risks (including fraud risks) across all the areas of responsibility of the Clean Hydrogen JU's Programme Office (PO), and the purpose of establishing the baseline for the 2024 annual work programme (AWP). A risk management workshop was organised involving all staff members, with the objectives being to (i) reassess the relevance of the risks identified in the previous risk-assessment exercises (i.e. in the scope of the risk assessment for the 2023 AWP) and (ii) identify and assess any relevant new risks (e.g. new risks related to the new mandate and new objectives of the Clean Hydrogen JU under the Horizon Europe Framework Programme)that could hinder achieving the objectives of the Clean Hydrogen JU, including operational, financial and compliance risks.

To reassess the already identified risks, the following aspects of each risk were assessed:

- Relevance of the risk: Is the risk still present? Has it materialised? Is it well described?
- Rating of the risk: Has the rating (in terms of impact/likelihood) increased or decreased over the period?
- Relevance and fulfilment of the action plan: Should we continue/expand/reduce action plans?

Based on the discussions, the risks were either removed (when considered no longer relevant) or modified, while the action plans were reviewed for adequacy and completeness.

The Table 1 provides a summary of the outcomes of the exercise on the main risks and the fulfilment of the action plans, up to 31 December 2023.

Table 1. Fulfilment of the action plans up to December 2023 (as identified in the AWP 2023)

RISK LEVEL	OBJECTIVE	INDICATORS	RISK IDENTIFIED IN AWP 2023	ACTION PLAN – AS IDENTIFIED FOR 2023 – AND STATUS OF IMPLEMENTATION
HIGH	All objectives	All indicators	Risk to not meeting H2020 and Horizon Europe objectives due to insufficient human resources, as in the upcoming years, the programme office will be running two framework programmes simultaneously, H2020 at the peak of its implementation, Horizon Europe with an increase of 50% of the budget plus additional budget from the REPowerEU (approximatively one half to be committed in the first 2 years), with only two additional FTEs 51 for 2022 – 2027. While back-office arrangements are helping to harmonize the working processes between JUs and gain efficiencies, they do not represent a solution to this issue.	Use of service contracts for support activities in Operations, while increased coordination will be explored through synergies on administrative activities with other joint undertakings. JU will continue to discuss with the Governing Board (GB) on the adequacy of the current staff establishment plan supporting this with a real workload analysis for the entire organization. JU will continue to investigate further simplification opportunities, among them the use of lump sums as a cost model in new calls/grants implementation. The Clean Hydrogen JU should shorten time for recruitment of staff, including a new Executive Director. Governing Board should be continuously informed of the staffing situation and should be informed and provide guidance accordingly.
MEDIUM	Synergies	Indicator 9	Risk of missing opportunities for synergies with other partnerships and other EC programmes or Member States/regional funds for hydrogen technologies due to lack of strategic guidance and consequently a lack of proper JU 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 being supported by JU funding which focuses 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 the synergies in the predecessor FCH JU. A Synergies Officer joins the programme office in 2024 to reinforce the monitoring of the synergies. Working with the newly established Stakeholders Group should also be 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 strategic guidance.

RISK LEVEL	OBJECTIVE	INDICATORS	RISK IDENTIFIED IN AWP 2023	ACTION PLAN – AS IDENTIFIED FOR 2023 – AND STATUS OF IMPLEMENTATION
MEDIUM	Reporting financial objectives / Operationa l objectives	Indicators 1- 5,9,12,13 (Table 1)	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 updating 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 Clean Hydrogen JU administrative expenses, which could result in non-compliance with the Clean Hydrogen JU financing rules. This could result in a potentially high negative impact on the Clean Hydrogen JU's reputation. Moreover, due to membership conditions, some signed projects may have to be cancelled.	A process to ensure the eligibility criteria are met and continuously monitored throughout the lifetimes of the projects is being put in place. The Clean Hydrogen 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.
MEDIUM	Operational objectives	Indicators 1, 4, 5, 9	Risk that programme objectives will not be achieved fully and in a timely manner due to delays in project execution attributed to late impacts of the COVID-19 crisis and due to hydrogen market changes. This has a negative impact on the duration of the projects, including FIDs ("financial investment decision") for demonstration projects as regards co-funding, and consequently on budget execution and the programme reaching its objectives. Due to the Russian war of aggression against Ukraine, there is increased disruption in the value chain and general economic impact (increases in the prices and scarcity of raw materials and energy resources).	Mitigation actions are in place for monitoring any delays in the project, restructuring of the projects, if necessary, granting project extensions for an average of 6 months resulting from the impacts of the COVID-19 crisis via the amendment process.

Furthermore, a new risk was added: "Industrialization gap – due to lack of regulations and standards, permitting and standards for a timely scale-up of the technologies funded by the JU". This risk is documented in the AWP for 2024.

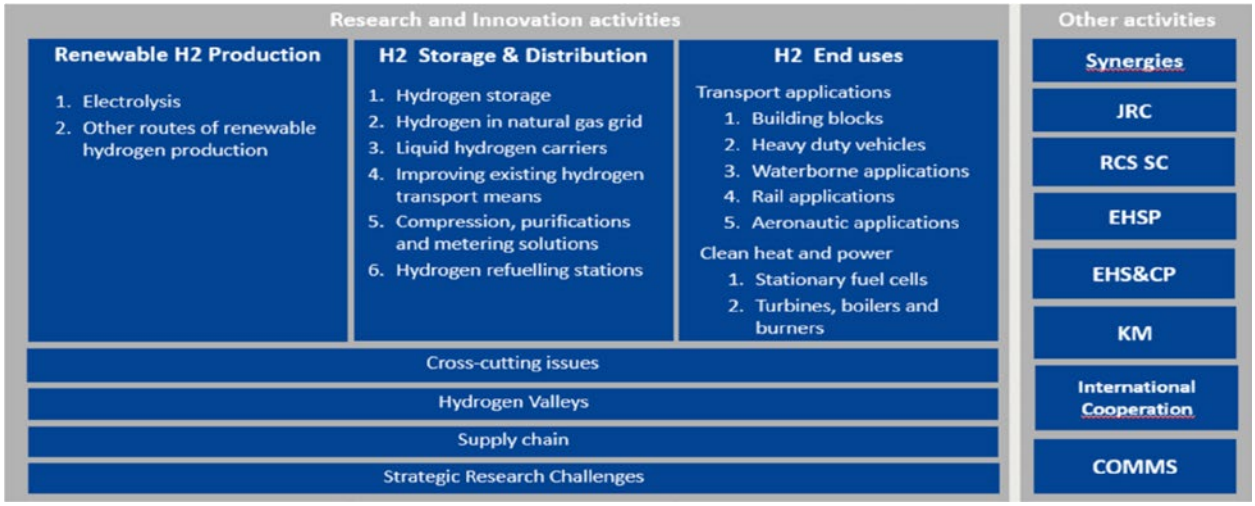
The outcomes of the 2023 risk assessment workshop on new or continuing risks for 2024 are included in the 2024 AWP.

1.2. Research & Innovation activities/achievements

1.2.1. Overview of R&I Activities

The Programme of the Clean Hydrogen JU has been structured to cover all aspects of the hydrogen value chain (Figure 6). Its main focus will be on research and innovation actions on renewable hydrogen production, but also hydrogen transmission, distribution and storage, alongside stationary and transport end-use technologies, with a strong emphasis on "circularity and safety by design".

Figure 6. Overview of the Clean Hydrogen JU activities



Source: Clean Hydrogen JU.
NB: EHS&CP, European Hydrogen Sustainability and Circularity Panel; EHSP, European Hydrogen Safety Panel; RCS SC, regulations, codes and standards strategy coordination

In line with the new programme structure of the Clean Hydrogen JU, explained in the SRIA [9], projects on-going in 2023, including those from H2020 managed by the Clean Hydrogen JU predecessor have been assigned to eight Pillars:

- Pillar 1: Hydrogen Production
- Pillar 2: Hydrogen Storage and Distribution
- Pillar 3: Hydrogen End Uses – Transport
- Pillar 4: Hydrogen End Uses – Clean Heat and Power
- Pillar 5: Cross-Cutting Issues
- Pillar 6: Hydrogen Valleys
- Pillar 7: Hydrogen Supply Chains
- Pillar 8: Strategic Research Challenges

Each SRIA Pillar is characterised by a wide range of activities and applications. Moreover, the Clean Hydrogen JU continues certain activities and applications of its predecessor, which are part of its legacy projects. To better map the different current and possible future activities of the Clean Hydrogen JU, its Programme (including on-going legacy projects) can be further mapped into a set of Research Areas [10], which group projects covering related topics. This split in research areas is presented in the Table 2 below, providing also a short summary of the topics of ongoing projects in 2023.

[9] https://www.clean-hydrogen.europa.eu/about-us/key-documents/strategic-research-and-innovation-agenda_en
[10] These Research Areas are the basis of the annual programme technical assessment performed by JRC. For more information see Section 1.5.1.1.

Table 2. Pillars of R&I Activities

PILLARS	RESEARCH AREAS	RESEARCH TOPICS
1) Hydrogen Production	1 – Low temperature electrolysis	Projects targeting AEL, PEMEL and AEMEL
	2 – High-temperature electrolysis (incl. co-electrolysis)	Projects targeting SOEL and PCCEL
	3 – Other hydrogen production methods	Projects covering solar driven thermochemical hydrogen production
2) Hydrogen storage and distribution	4 – Aboveground storage	Projects addressing optimisation and deployment of large-scale aboveground solid state storage solutions
	5 – Underground storage	Projects targeting the feasibility, risks and impact of H2 underground storage
	6 – H2 in the natural gas grid	Projects assessing the effect of H2 on transmission and distribution of Natural Gas (NG) pipelines
	7 – Liquid H2 carriers	Projects focusing on the improvement of the roundtrip efficiency of conversion and system cost
	8 – Compression, purification and metering solutions	Projects demonstrating compression, material research on proton conducting ceramic electrochemical cells (PCC and purification concepts)
	9 – H2 refuelling stations	Projects addressing refuelling capacity, reliability and availability issues indicated by operation of existing Hydrogen Refuelling Stations (HRS)
	10 – Hydrogen transportation (pipelines, road transport and shipping)	Projects focusing on the improvement of the transportation and storage of LH2 in shipping
	11 – Hydrogen distribution (pipelines)	Not covered by any on-going projects in 2023
3) Hydrogen end uses – transport	12 – Building Blocks	Projects focusing on material, design and system optimisation for LT and HT PEMFC
	13 – Heavy Duty Vehicles	Projects addressing optimisation of BoP architectures design to meet Heavy-Duty Vehicles (HDV) needs
	14 – Waterborne Applications	Projects focusing on improving access to the market for hydrogen, its derivatives and FCs, initially on smaller vessels, including large scale demonstrations
	15 – Rail Applications	Projects with the objective of enabling hydrogen to be recognised as the leading option for trains on non-electrified or partially electrified routes
	16 – Aviation Applications	Projects addressing optimisation of Balance of Plant (BoP) components and architectures design to meet aviation needs
	17 – Bus/Coaches	Projects with the objective of improving the deployment of hydrogen in this segment
	18 – Cars	Projects with the objective of improving the deployment of hydrogen in this segment
4) Hydrogen end uses – Energy	19 – m-CHP	Project exploring the deployment of PEMFC and SOFC for micro-Cogeneration
	20 – Commercial Size CHP	Demonstration projects for commercial size CHP using SOFC and HT PEMFC
	21 – Industrial Size CHP	Not covered by any on-going projects in 2023
	22 – Off-grid/back up/genset	Demonstration projects exploring the application of Proton Exchange Membrane (PEM), Solid Oxide and Alkaline hydrogen technologies (FC and electrolysers)
	23 – Next generation degradation and performance & Diagnostic	Exploration projects on the utilisation of biogas fed with a SOFC CHP system and use of Electrochemical Impedance Spectroscopy (EIS) technology for monitoring and diagnostic purposes
	24 – Turbines, boilers and burners	Research projects to allow low NOx combustion of hydrogen-enriched fuels (up to 100%) at high-pressure conditions for new or existing gas turbine combustion systems

PILLARS	RESEARCH AREAS	RESEARCH TOPICS
5) Cross-cutting topics	25 – Sustainability, Life Cycle Sustainability Assessment, recycling and eco-design	Projects addressing the needs to define guidelines for sustainability assessment
	26 – Education and Public Awareness	Projects aiming to increase the understanding and knowledge of hydrogen technology at public and the educational level (schools /universities)
	27 – Safety, Pre-Normative Research and Regulations, Codes and Standards	Projects focusing on improving knowledge of risks of hydrogen utilisation and the definition of a protocol for permitting and measuring
6) Hydrogen Valleys	28 – Small-scale Valley	Projects aiming to develop island and micro-hydrogen integrated systems, to showcase the potential of hydrogen technologies
	29 – Large-scale Valley	Projects aiming to demonstrate a cross-border or interregional hydrogen integrated system when favourable conditions at industrial or geographical point of view
7) Hydrogen Supply Chains	30 – Manufacturing for stationary applications	Projects aiming to advance high-volume production techniques and quality control measures for manufacturing SOFC components and stacks
	31 – Manufacturing for transport applications	Not covered by any on-going projects in 2023
	32 – Critical Raw Materials (CRM)	Not covered by any on-going projects in 2023
8) Strategic Research Challenges	33 – Strategic Research Challenges	Projects aiming in the development a sustainable European supply chain of materials, components and cells, less reliant on CRM, with lower environmental footprint and costs, and higher performance and durability.

NB: CHP, combined heat and power; m-CHP, micro-scale combined heat and power; PEMFC, proton exchange membrane fuel cell; SOFC, solid oxide fuel cell.

1.2.2. Financial Support

1.2.2.1. Overview of the financial support from 2008 to 2023

Before the establishment of the Clean Hydrogen JU, the FCH JU (2008-2013, funded under the FP7 programme) and the FCH 2 JU (2014-2020, funded under the H2020 programme), have supported and funded 287 projects in total, with a combined budget of EUR 1.08 billion, complemented by equivalent funding from non-EU sources (e.g.: regional, national or private).

In line with the ambition to drive research and innovation of hydrogen technologies and achieve the objectives set for the Clean Hydrogen JU, the EU almost doubled its budget in comparison with that of its predecessor the FCH2 JU, supporting the JU with another EUR 1 billion for 2021-2027. As a result, under the Horizon Europe programme, the overall Clean Hydrogen JU programme funding, including investment from the private members of the Clean Hydrogen JU, it is expected to go beyond EUR 2 billion. Moreover, the EC has topped up the Clean Hydrogen JU budget with an additional EUR 200 million, to be matched by the same amount from industry, with the goal of doubling the number of Hydrogen Valleys and accelerating hydrogen projects under the REPower EU Plan [11].

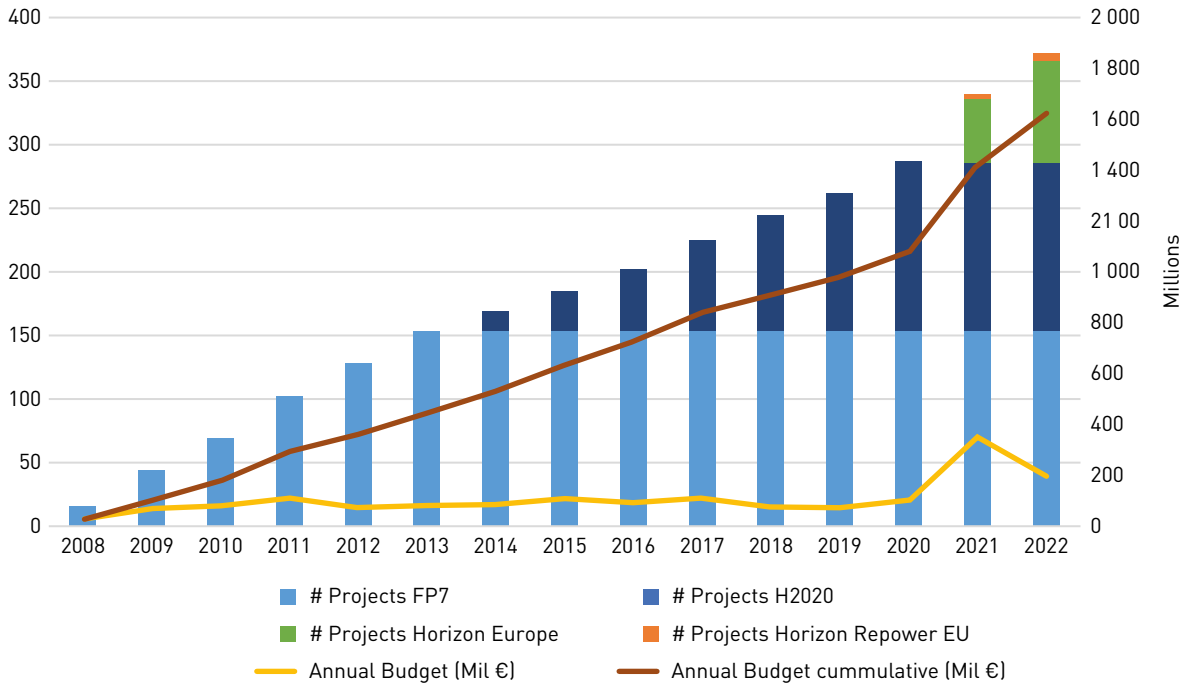
[11] Communication from the Commission on REPowerEU Plan

Figure 7. Sequence of deployed EU budget (*including expected funding for hydrogen valleys from the RePowerEU Plan)

Source: Clean Hydrogen JU.

Under the Horizon Europe Programme, the Clean Hydrogen JU inherited the technological achievements and funding of the previous programmes, and started to implement this new programme. Based on the updated data from E-Grants, Figure 8 shows the cumulative number of projects supported by the FCH, FCH 2 and Clean Hydrogen JUs programmes (respectively, 154 projects under FP7, 133 projects under H2020 and 82 projects under Horizon Europe) and the annual and cumulative JU financial support given to the projects per year and per fund origin.

Figure 8. Cumulative number of projects supported by the Clean Hydrogen JU and annual commitments of calls 2008-2023

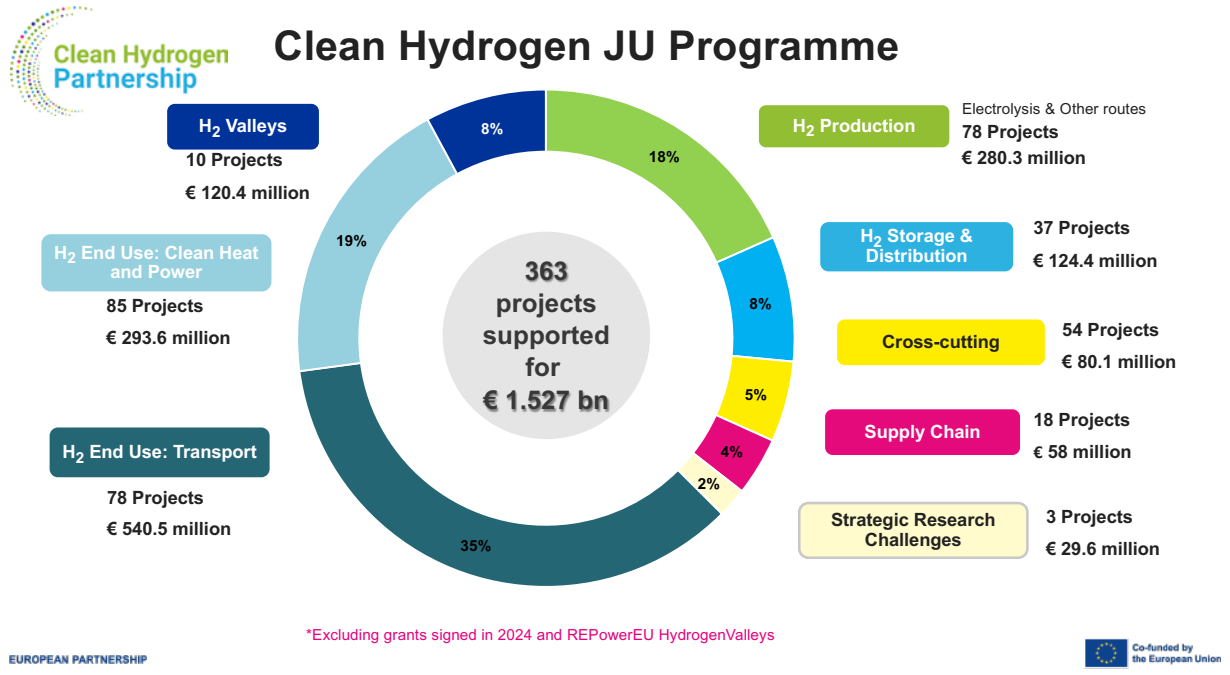


Source: Clean Hydrogen JU.

The bars show the cumulative number of the projects supported by the Clean Hydrogen JU since 2008. The yellow line shows the annual commitments undertaken by the Clean Hydrogen JU against the new projects signed under the call of each year. The purple line shows the cumulative amount of Clean Hydrogen JU funding, including the commitments undertaken for ongoing projects, taking into account any amendments, and the final amount of funding per finished project. Projects suspended or terminated with ongoing recovery processes are not included.

The overall split of the Clean Hydrogen JU funding is summarised in Figure 9.

Figure 9. Total Funding of the Clean Hydrogen JU programme (2008 – 2023 project call years



Source: Clean Hydrogen JU.

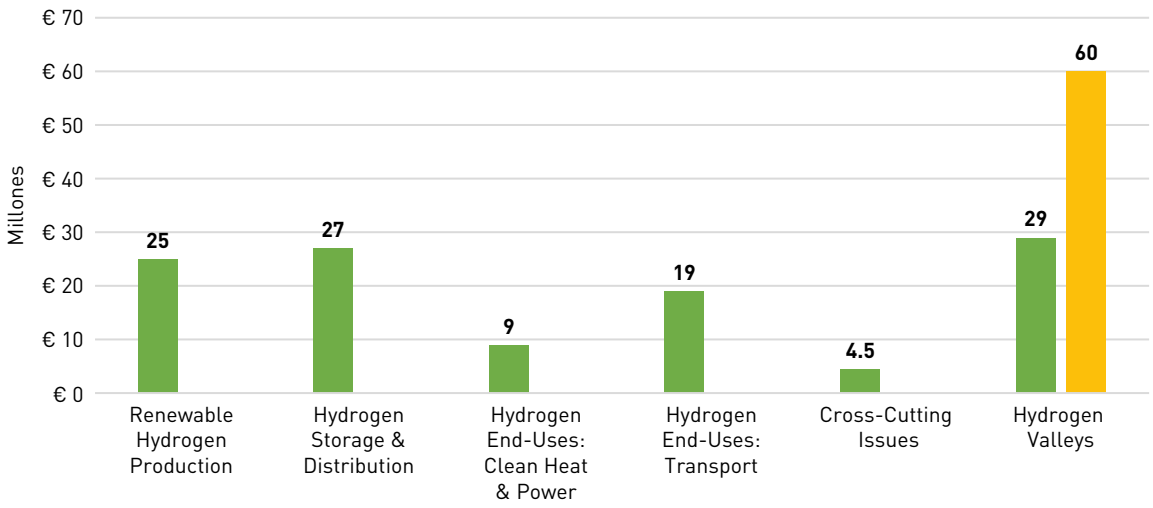
1.2.2.2.Financial support in 2022 and 2023 (Horizon Europe programme)

The second call for proposals under the Horizon Europe programme was launched in 2023. Following the evaluation results of Call 2023, 29 grant agreements were signed for funding under Horizon Europe by December 2023 ([12]), for a total amount of EUR 160.3 million ([13]), including an additional amount of EUR 60 million from Horizon Europe to support Hydrogen Valleys topics ([14]), in accordance with the REPowerEU Plan. Figure 10 shows the distribution of Call 2023 total amount across the SRIA Pillars.

The Call 2023 projects were added to the 53 projects signed (partially in 2022) following the Call 2022. Under Horizon Europe, a total of 80 projects had signed grant agreements with the Clean Hydrogen JU by the end of 2023, with a total EU funding of EUR 499.4 million. Figure 11 shows the distribution of the budgets for projects funded in the Calls 2022 and 2023 per pillar, together with the funding ratio of the Clean Hydrogen JU maximum contribution and the expected contribution of non-EU sources (regional, national, private). The total costs of the projects, combining both EU and non-EU funding, equal EUR 1,372.85 million.

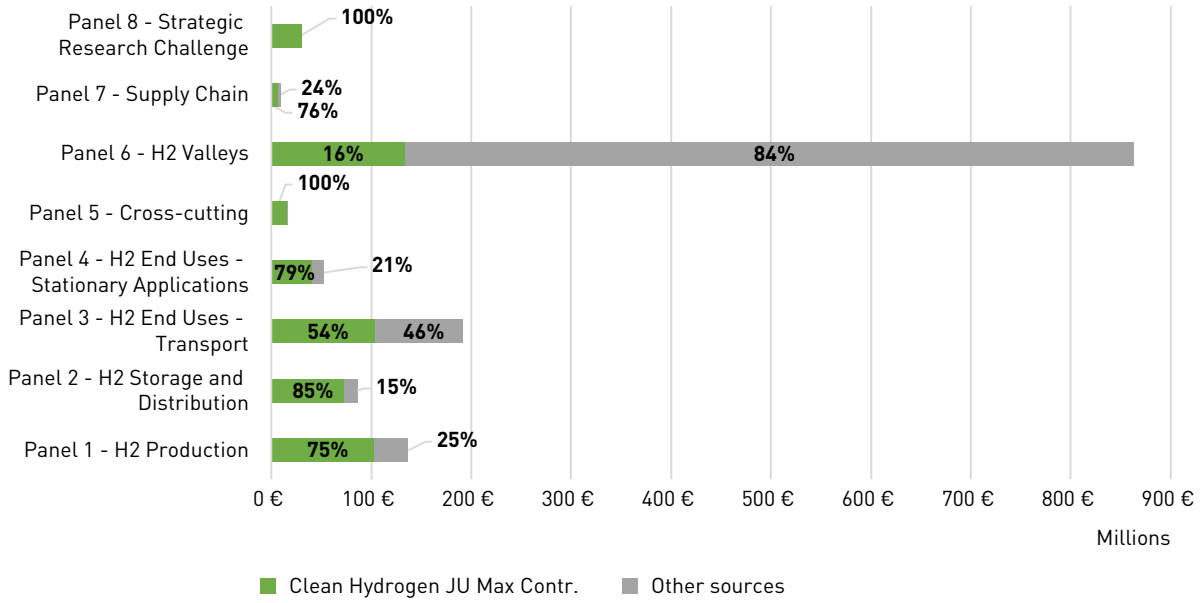
[12] Including EUR 48.6 million for 4 Hydrogen Valleys to be funded via REPowerEU
[13] There are still 3 successful projects of Call 2023 in the final stages of grant preparation, not included in the figures above
[14] https://www.clean-hydrogen.europa.eu/system/files/2022-05/Hydrogen-Valley_Facsheet_18.05.2022.pdf Communication from the Communication on REPowerEU Plan

Figure 10. Clean Hydrogen JU Call 2023 maximum budget allocation per SRIA Pillar



Source: Clean Hydrogen JU.

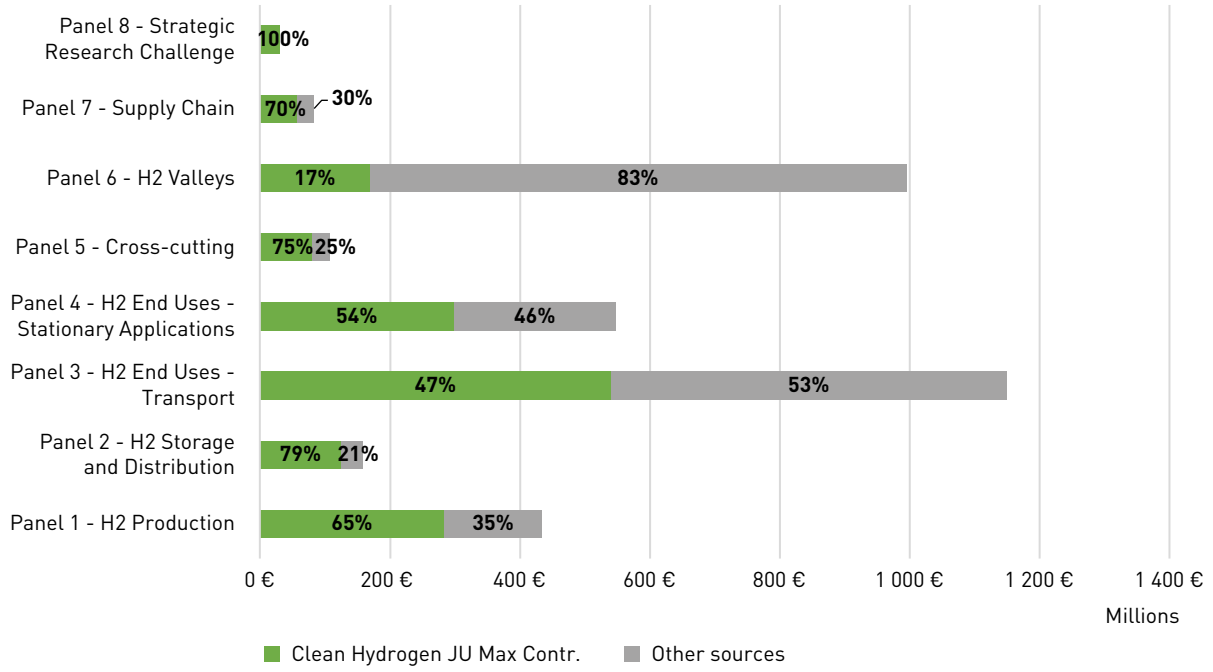
Figure 11. Source of funding of Clean Hydrogen JU Calls 2022 and 2023



Source: Clean Hydrogen JU.

Due to the evolving structure of the Clean Hydrogen JU Programme compared with those of its predecessors, all previous projects under FP7 and H2020 were redistributed to the seven Pillars of the new Programme. The eighth Pillar on Strategic Research Challenges will include only projects funded under the current Programme. The total cost of legacy projects supported by the Clean Hydrogen JU and its predecessors so far, including the Grant Agreements (GAs) signed in 2022 and 2023, is presented in Figure 12, aggregated by pillar.

Figure 12. Energy consumption between R&I and Commercial projects of Alkaline and PEM electrolysers



Source: Clean Hydrogen JU.

1.2.3. Achievements and impact of funded projects

The projects funded under the previous programmes are continuously contributing to hydrogen technology development, as also highlighted in the *Programme Review Report 2023* [15]. Under the Clean Hydrogen JU programme, for which the first projects from Call 2022 started only during 2023, the projects are expected to begin contributing to the overall programme impact potentially as of 2024, paving the way for further advancements. The overview of the main achievements of the on-going projects (from H2020) per pillar is as follows:

Pillar 1 – Hydrogen Production: The projects in this pillar contribute mainly towards achieving the techno-economic objective of making hydrogen production from renewables competitive and enabling the scale-up of these technologies. In that respect, improvements in efficiency and cost reduction are required across all hydrogen production routes.

The Low-Temperature Electrolysis Research Area consisted of nine H2020 projects: three on alkaline electrolysis (AEL) – **DEMO4GRID, DJEWELS, OYSTER**, three on PEM electrolysis (PEMEL) – **REFHYNE, HAEOLUS, NEPTUNE** and other three on anion exchange membrane electrolysis (AEMEL) – **ANIONE, CHANNEL, NEWELY**.

The PEMEL projects contributed to reaching the majority of the MAWP 2020 targets for PEM electrolysers. The PEMEL footprint has been reduced by far, with the average footprint reported in 2022 being 13.75 m^2/kW, less than half the average value of 2015.

One KPI related to the Critical Raw Materials (Iridium) has shown considerable decrease from an average of around 0.74 mg/kW over 2015-2020 to around 0.16 mg/kW in 2022.

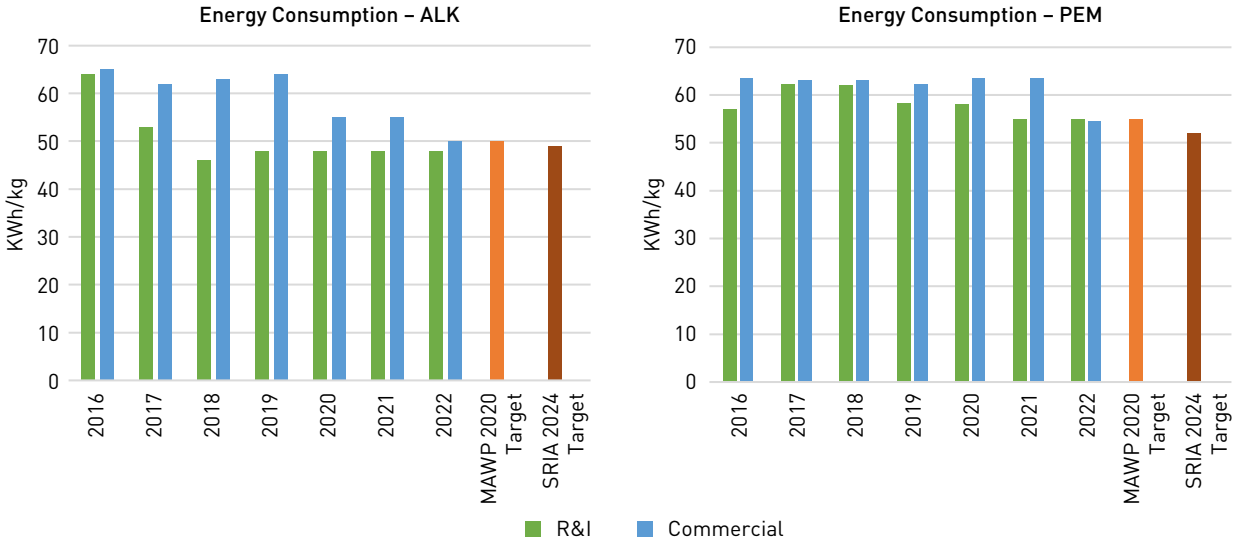
In 2022, both the degradation rate (0.13%/1000hours) and current density (2.7 A/cm2) are considered to have met already the 2024 SRIA target.

[15] https://op.europa.eu/en/publication-detail/-/publication/00f833fa-7ec4-11ee-99ba-01aa75ed71a1/language-en/format-PDF/source-296436320

In terms of CAPEX (euro/kW), there is a trend in PEM towards lower values with more than one project achieving the SRIA 2024 cost target.

The improvement in terms of energy consumption per kg of H2, for both AEL and PEMEL, is depicted in Figure 13 below. The figure includes the comparison of the annual achievements of the R&I electrolysers and the commercial ones, commercial electrolysers are the ones used in the HRS projects ([16]).

Figure 13. Energy consumption between R&I and Commercial projects of Alkaline and electrolysers



Source: Clean Hydrogen JU.

Additional effort is necessary to achieve the 2024 SRIA target for energy consumption.

Under Horizon Europe, three more projects on AEL (HYPRAEL, PEACE and EPHYRA) and two on PEM electrolysis (ADVANCEPEM and HOPE) started in 2023 and will continue to address this issue.

AEM electrolysis is currently still at a low TRL level, while **CHANNEL**, **ANIONE** and **NEWELY**, three projects supported by the Clean Hydrogen JU, are progressing well towards reaching the SRIA 2024 targets. Under Horizon Europe, two more projects on AEM electrolysis (HERAQCLES and HYScale) started in 2023 shall contribute to bring this technology to higher TRL levels.

The High-Temperature Electrolysis Research Area mainly corresponds to the SOEL technology. There have been fewer projects at higher TRL levels, as the technology is less advanced than AEL or PEMEL. Therefore, most of the KPIs have been achieved by only one or two projects (with the exception of production loss where a number of projects achieved the 2020 target). Significant progress against most technical KPIs appears to have been made in the previous programme:

- The System CAPEX KPI has been deemed to have been significantly overachieved for the 2020 target and the SoA for 2020 has been reduced to 3 550 EUR/(kg/day).
- The 2024 SRIA target of 2 000 EUR/kW has been achieved by the projects reporting in 2022. Over time, the average value reported has decreased in 2022, which can be considered a significant improvement.
- In terms of reversible capacity (around 27% on average) and production loss rates (around 0.28%/1000h), projects have shown considerable improvement.

The reversibility of SOEL technology is technically very promising; when renewable energy is available the system produces green hydrogen as an electrolyser but can also generate electricity in a reverse fuel cell (SOFC) mode (project **SWITCH**). It can also contribute to the improvement of energy efficiency using the waste

[16] Commercial projects refer to data coming from transport projects using commercial electrolysers for the production of hydrogen for their HRS. The bars indicate the best values reported per year (not the best value up until that year). Note also that almost in all cases there were better values than the ones depicted in the graphs, but these cannot be reported for confidentiality reasons. Finally, in some cases the values do not come from one project, but are the result of averaging across projects to respect confidentiality.

heat in industrial processes (GrInHy2.0, MULTIPLHY). Such reversibility concept still needs to be fully justified by the use cases.

PCCEL (Proton Conducting Ceramic Electrolyser) technology is addressed by the project **GAMER**. It has advanced tubular PCEL technology and is currently building a 10kW system; however, the high degradation rates have thus far prevented scaling up the project.

Clean Hydrogen JU projects on electrolysis are demonstrating not only the potential and scalability of the technologies but also business cases suitable for different industries (refineries, steel making, etc) and ancillary services:

- A 3.2 MW pressurised AEL in Austria, at the MPREIS industrial bakery is commercially setup and has been operating since March 2022 under the project **DEMO4GRID** [17] to provide hydrogen (for heavy-duty vehicles), heat and grid balancing services. The project has received many awards, such as the Tirol Change Award and the Energy Globe Award Austria.
- A 10 MW PEM electrolyser from ITM has been operating since the beginning of 2022 in the Shell Rhineland Refinery in Wesseling, Germany, by the project **REFHYNE**. It supplies the refinery with 4,000 kg of green hydrogen a day (at 20 bar pressure). Based on the experience gained, a new 100 MW installation is being developed.
- A 2.5 MW PEMEL, directly connected to a 45 MW wind farm in a remote area of Norway, has been operating since June 2022. The **HAEOLUS** project can produce up to 1 tonne of hydrogen a day (at 30 bar and 60°C) and is combined with a storage tank and a 120 kW fuel cell for re-electrification. The project achieved its own targets for electrolyser efficiency and cost per kW.
- Considerable progress has been made in low-TRL AEMEL technology through the projects CHANNEL, ANIONE and NEWELY. In general, the projects have managed to achieve promising data on novel membranes, electrocatalysts and combined as Membrane Electrode Assemblies. **CHANNEL** demonstrated a 2KW prototype with non-PGM reaction catalysts achieving the performance targets set for the cell and the catalysts, while **ANIONE** has successfully developed two membranes and managed to integrate large-area membranes delivering 25 large-area MEAs (>100 cm^2). Finally, **NEWELY** developed PSEBS [18] membrane with characteristics successfully reaching the project's targets, having completed several publications and submitted 2 patent applications.
- **SWITCH** has demonstrated a reversible system (rSOC) of 25 kW (SOFC) / 75 kW (SOEC), able to operate in SOEC and SOFC mode, that achieved a conversion efficiency of 80% and a SOEC mode to SOFC mode switchover time of 15 minutes, which is half the target value.
- **NewSOC** has identified an optimum SOE cell configuration, offering low ASR and high mechanical strength. It succeeded in improving the SoA of Ni/YSZ fuel electrodes aided by modelling. Robust and high performing electrodes, namely titanate doped Ni/GDC and LCr fuel electrodes and CO-free oxygen electrodes for intermediate temperature operation (650-700°C), were developed and tested with promising results comparable or superior to SoA.
- The world's biggest HT SOEL at a capacity of 720 kW was demonstrated in August 2021 by the project **GrInHy2.0.** The installation uses steam coming from industrial waste heat at a Salzgitter steel mill. By project end, the system operated for more than 14,000 hours, injecting more than 100 tons of hydrogen into the grid, having also achieved the target of 84.6% of lower heating value (LHV) efficiency.

Under Horizon Europe, three more projects on SOEL (OUTFOX, PilotSOEL and PressHyous) and one on PCCEL technology (PROTOSTACK) started in 2023.

Other Routes of Renewable H2 Production: Compared to electrolysis, all other renewable hydrogen production technologies are at lower TRL. The Clean Hydrogen JU is supporting alternative routes to electrolysis for renewable hydrogen production, for example project **HYDROSOL-BEYOND** in demonstrating solar thermochemical hydrogen production. The project is still addressing a number of technical challenges regarding the durability and stability of the materials operating at temperatures over 1,000°C.

Pillar 2 – Hydrogen Storage and Distribution: The RePowerEU plan and the European Hydrogen Strategy recognise the importance of hydrogen storage and distribution to facilitate the access to renewable

[17] It is building on the outcomes of the ELYGRID and ELYNTEGRATION projects
[18] Polystyrene-block-poly(ethylene-ran-butylene)-block-polystyrene

hydrogen deposits in Europe. There are various options to transport and store hydrogen, that can serve as building blocks for an EU-wide logistical infrastructure in its multifaceted complexity. The SRIA calls for a pluralistic approach in respect of these technologies to be investigated and supported.

Above-ground Storage: This research area currently consists of one finished project, **HYCARE**, focusing on solid state storage. The HYCARE project is targeting the upscaling of a solid-state hydrogen storage system based on metal hydrides, albeit at a much smaller scale (44 kg H2 reversibly stored) than the SRIA target of 5 tonnes for 2024.

Underground Hydrogen Storage: Underground storage ([19]) offers the potential to deploy large amounts of gas storage at a relatively low cost. As large-scale hydrogen underground storage in salt caverns is at a higher TRL, the SRIA's main aim for this topic is to reduce costs and identify best practices and business cases for coupling renewable hydrogen production with underground storage. In addition, there is more fundamental research needed in order to investigate hydrogen compatibility with porous rock media and improve associated designs. The **three** projects (HYPSTER, HYSTORIES and HyUsPRe) funded by the Clean Hydrogen JU on this topic can build on the findings of several nationally funded projects and will exploit synergies with several other initiatives.

H_2 in the natural gas grid: Several research and demonstration pathways are being explored to decarbonise the natural gas grid and to distribute hydrogen. This research area focuses on a mixture of hydrogen and natural gas on the repurposing of natural gas pipelines for the transmission and distribution of 100% hydrogen. In 2023, two new projects started in this research area: OPTHYCS and CANDHy.

Liquid H_2 carriers: Hydrogen delivery at large scales and over long distances is deemed challenging, due to the low energy density of hydrogen. Transfer over distances of 3 000 km with pipelines is likely to be a less economic option than the shipping of compressed or liquid hydrogen, or shipping of chemical carriers. Liquid hydrogen, due to its high gravimetric and volumetric density, is a promising option for hydrogen transport, but there are still numerous technical issues to be overcome, such as reducing the energy demand for liquefaction and boil-off management. Other chemical hydrogen carriers being considered by stakeholders are ammonia, methanol and Liquid Organic Hydrogen Carriers (LOHC). Under Horizon Europe, four new projects (HyLICAL, SINGLE, UnLOHCked and ANDREAH) started in 2023.

Compression, purification and metering solutions: Compressors are critical for the delivery of hydrogen, with pressures above 700 bar required for refuelling and up to 100 bar for injection into pipelines. Higher reliability of the compressors must be achieved, especially for HRS; work is ongoing in the **COSMHYC XL** and **COSMHYC DEMO** projects. The project **WINNER** was also under review in 2023 in this research area**.** In 2023, two new projects started in this research area: H2REF-DEMO and HQE.

H_2 Refuelling Stations: The deployment of HRS is expanding globally. In 2022, 130 new HRS went into operation worldwide, of which 45 in Europe (more than ever before). The Clean Hydrogen JU has funded the installation of 113 HRS up to date (planned, deployed and decommissioned units). The two projects being assessed, **COSMHYC XL** and **COSMHYC DEMO**, are based on the innovative scalar and modular hybrid compression solution developed under the **COSMHYC** project ([20]). Also, new projects in the same research area initiated in 2023, ROAD THRYP and RHeaDHy.

In addition, under the new SRIA research area of Hydrogen Transport the project LH2CRAFT started in 2023 and addresses liquid hydrogen.

The projects under this Pillar are demonstrating significant advances in many areas of research and innovation.

HyCARE has started the testing of a small-scale prototype hydrogen storage tank based on solid state storage solutions, aiming to couple the storage system with an electrolyser and a fuel cell. This follows the optimisation and the production of the selected metal hydride material (a titanium-iron-manganese alloy) at scale, the finalisation of the full storage design and the completion of the qualification process.

([19]) There are salt caverns operating commercially for storage of hydrogen in the U.K. and U.S. In Teesside, U.K., three smaller caverns of 70 000 m3 capacity are owned by Sabic Petrochemicals. In Texas, U.S., three larger caverns (operated by Praxair, Air Liquide and ConocoPhillips), each with capacity over 560 000 m3 each are supplying hydrogen to the petrochemical industry.

([20]) If successfully deployed this original technology, combining a metal hydride compressor with a mechanical compressor, will enable lower CAPEX and OPEX, reduced noise, increased Availability and higher hydrogen delivery efficiency.

HYSTORIES has gathered publicly available data on different types of potential porous media in Europe into a geological database. This will help to identify how many of the gas fields in Europe are likely to be suitable for hydrogen storage, paving the way, together with HYPSTER, for future large demonstrations.

HIGGS has completed dynamic and static tests for blends of 20 vol% hydrogen in natural gas, assessing the sensitivity to hydrogen and gas tightness of API 5L steels, valves, fittings and equipment present in NG European natural gas transmission grids, with promising results. Additional campaigns are planned with injections of 30 % hydrogen in natural gas, and 100% hydrogen.

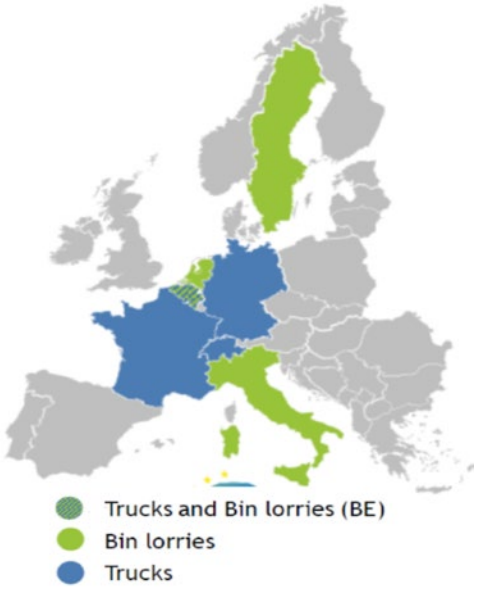
SHERLOCK achieved the hydrogen productivity in dehydrogenation target (3g of H2/g catalyst/min), reaching a productivity of 5.3 g of H2/g catalyst/min. The addition of 0.5 wt% Co over Pt-based catalyst with low metal content (0.5 wt% Pt) resulted in an increase in the dehydrogenation productivity, cutting the amount of this noble metal in half.

Pillar 3 – Hydrogen End Uses – Transport: Apart from the fuel cell (FC) buses and fuel cell electric vehicle (FCEV) passenger cars supported by the previous programmes which are now considered ready for market deployment, other types of transport – such as heavy-duty vehicles, off-road and industrial vehicles, trains, shipping and aviation – are now receiving funding for further development and demonstration.

Heavy Duty Vehicles (Building Blocks) – Fuel cell stack and fuel cell system technology: The durability of PEM FC systems for transport and stationary applications needs to be further improved to facilitate the wider dissemination of hydrogen fuel cells in industry and transport. Low-TRL projects (**DOLPHIN**, **MORELIFE** and **IMMORTAL**) claim that the durability of their systems meets the SRIA targets, while experimental data are obtained at a small scale, under the major constraint of expensive and rare materials, mainly PGM metals, used in PEM FC technology. Started in 2023, three new projects – HIGHLANDER, MEAsureD and PEMTASTIC, will develop new, efficient and cost-effective membrane electrode assemblies (MEAs) suitable for HD applications, with advanced durability, while project RealHyFC will focus on stack design and operation to deliver a public open-design platform with demonstrated high efficiency and durability under heavy-duty application conditions.

Heavy Duty Vehicles (Building Blocks) – On-board vehicle hydrogen storage: State-of-the-art compressed hydrogen storage systems are made up of carbon fibre composite reinforced vessels. A key question is weither the tank's costs can be decreased by reducing the amount of carbon fibre used while maintaining the storage performance and safety. Liquid cryogenic hydrogen is envisaged as a solution to storing large amounts of hydrogen in heavy duty vehicles and maritime vessels and in future rail and aeronautical applications.

Figure 14. Geographical distribution of heavy-duty vehicles from Clean Hydrogen JU projects



Source: Clean Hydrogen JU.

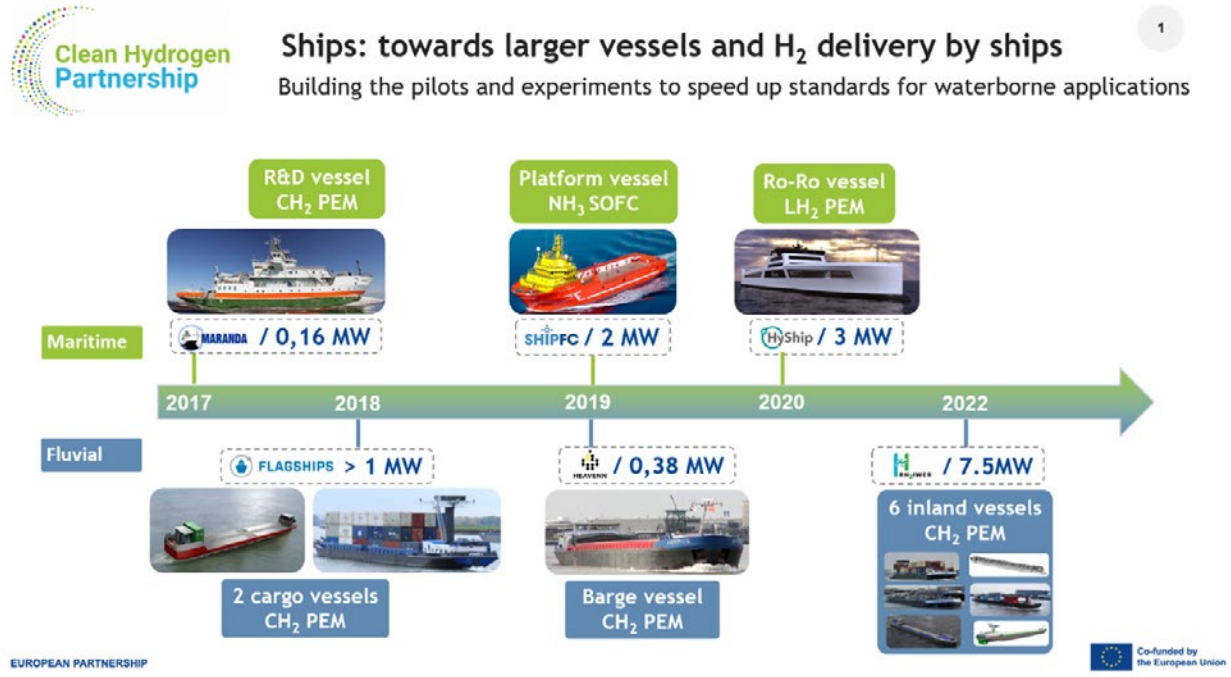
Heavy-duty vehicles: Fuel cell hydrogen trucks (FCET) are considered one of the best ways to decarbonise heavy-duty road freight transport. FCETs are potentially best suited for longer-range missions and the heaviest goods, enabling better connectivity to more remote areas than other solutions such as battery or catenary trucks ([21]). Demonstration activities on heavy-duty trucks started in 2018 with the project **REVIVE** and grew in 2019 with the project **H2HAUL**. These **two** projects will deploy 29 fuel cell trucks and bin-lorries at 13 sites in 7 European countries (Figure 14).

Furthermore, project H2Accelerate TRUCKS (started in 2023), together with several hydrogen refuelling infrastructure projects supported by the Connecting Europe Facility – Transport (CEF-T), aiming to facilitate the deployment of 150 trucks across 8 EU member states.

Waterborne applications: Several ongoing projects aim to demonstrate fuel cell powered vessels. The bunkering of hydrogen (or ammonia) is to be developed together with fuel cell ships. The bunkering technology must be adapted to both liquid and compressed hydrogen and some pilot initiatives for hydrogen supply in ports and offshore have been launched. There is a strong trend towards larger vessels and hydrogen delivery by ships, as shown in the Figure 15. Demonstration projects are important to speed up the development of standards for waterborne applications.

In addition, the Clean Hydrogen JU contracted a "Study on hydrogen in ports and industrial coastal areas" to assess the hydrogen demand in ports and industrial coastal areas, enabling the creation of a "European Hydrogen Ports Roadmap" ([22]). The study provides new directions of research and innovation, guidance for regulation, codes and standards; and proposals of policies and regulations to boost hydrogen applications in ports. The study concluded in 2023 and all reports have been published ([23]).

Figure 15. Clean Hydrogen Partnership projects on maritime applications



Source: Clean Hydrogen JU.

Projects are building knowledge of hydrogen safety, hazards, and risk assessments; for instance, **FLAGSHIPS** is developing e-tools (publicly accessible from the HYRESPONDER E-laboratory repository ([24]) to support the safety assessment of a design choice specific to waterborne/maritime fuel cells and hydrogen application. FLAGSHIPS has also held several safety workshops with the consortium members and is contributing to the development of safety approval practices. This knowledge on regulations built by waterborne projects should

([21]) Decarbonisation of heavy duty transport: zero emissions heavy goods vehicles, JRC, 2021
([22]) https://www.clean-hydrogen.europa.eu/media/publications/study-hydrogen-ports-and-industrial-coastal-areas_en
([23]) https://www.clean-hydrogen.europa.eu/media/publications/study-hydrogen-ports-and-industrial-coastal-areas-reports_en
([24]) https://hyresponder.eu/e-platform/e-laboratory/

be consolidated by the E-SHYIPS project (Pillar 5). In 2023, the project **RH2IWER** started, which will demonstrate further FC powered container vessels in the context of inland waterway shipping.

Rail applications: The hydrogen and fuel cell technology for rail applications has been trialled across Europe, Asia, North America, the Middle East, Africa and the Caribbean, since 2005 ([25]), showing that FCH technology can meet the requirement for rail applications. **FCH2Rail** is developing a hybrid, bi-modal drive system for trains powered by electrical supply from the overhead line with and by a hybrid pack.

Aeronautical applications: HYCARUS and SUAV were pioneer JU projects integrating hydrogen and fuel cells in aeronautic applications. HYCARUS developed a PEMFC and hydrogen storage as an auxiliary power unit (APU) for non-essential applications, which passed performance and qualification tests in a demonstrator. Building on HYCARUS's experience, the Clean Hydrogen JU project **FLHYSAFE** aims to design and demonstrate the feasibility of using a PEMFC system as an Emergency Power Unit. Three projects on aeronautical applications, from the 2022 Clean Hydrogen JU Call for proposals, have started in 2023:

- BRAVA is developing a 300kW fuel cell stack;
- NIMPHEA will study and develop suitable high temperature fuel cells for aviation application; and
- COCOLIH2T will develop a conformable liquid hydrogen storage system for aeronautic application.

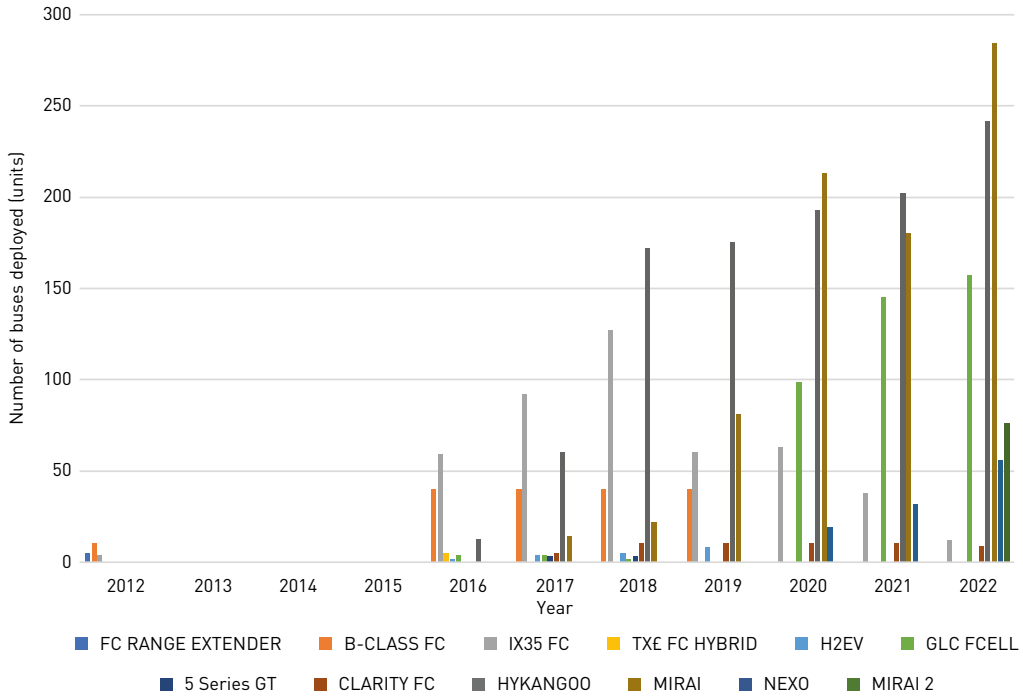
In 2020, the "Hydrogen powered aviation" study ([26]) concluded that hydrogen – as a primary energy source for propulsion, for fuel cells, and for direct burning in thermal (gas turbine) engines, or as a building block for synthetic liquid fuels – could feasibly power aircraft with entry into service by 2035 for short-range aircraft. The "Hydrogen-Powered Aviation Research and Innovation" technical workshop took place in April 2023 with the objectives of checking the progress made so far in implementing the synergies between the two programmes' roadmaps and identify priorities remaining to be addressed by the Clean Aviation and Clean Hydrogen JUs as of 2024.

Buses and cars: Europe as a whole had 219 fuel cell buses in operation at the end of 2021, being one of the most active regions in deploying hydrogen buses. This technology requires investment in infrastructure and maintenance, a factor that slows down its growth. After China, European countries have the largest number of fuel cell bus manufacturers, an indicator of technological progress and innovation ([27]). This is partly due to the significant contribution of Clean Hydrogen JU demo projects (**CHIC**, **HIGHVLOCITY**, **HYTRANSIT**, **3EMOTION**, **JIVE** and **JIVE2**), focusing on the large-scale demonstration of fuel cell buses in Europe since 2010 (Figure 16). In addition, these bus demos have improved public acceptance of fuel cell buses in Europe. Whereas fuel cell buses are established in urban contexts, there is a need to advance the technology with regard to longer distances to allow the buses to cover interurban and regional routes.

Considering projects 3EMOTION, JIVE and JIVE2 for the Programme Review, 258 Clean Hydrogen JU buses were in operation and reporting data throughout 2022 in 17 cities. Considering the bus demonstration projects that were reporting in TRUST between 2016 and 2022, a total distance of over 14.8 million km was accumulated, with almost 6.9 million km accumulated in 2022 alone. In the last 6 years, over 1.4 million tonnes of hydrogen have been consumed, of which 44% were consumed in 2022.

[25] Study on the use of fuel cells and hydrogen in the railway environment, FCH 2 JU, 2019
[26] Hydrogen-powered aviation: A fact-based study of hydrogen technology, economics, and climate impact by 2050
[27] https://fuelcellbuses.eu/suppliers#29

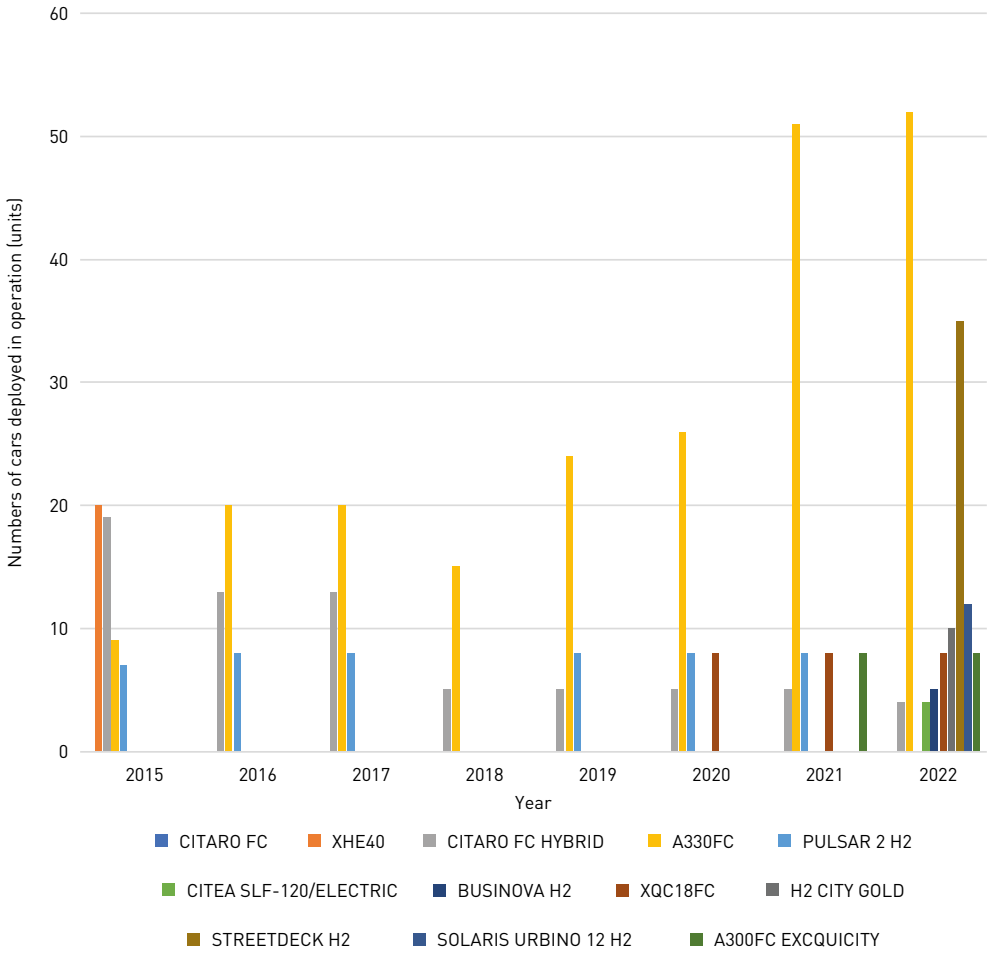
Figure 16. Number of deployed vehicles in operation reporting data from each model by year



Source: Clean Hydrogen JU.

The technical specifications of the vehicles (fuel cell power capability, storage capacity, range, and hydrogen consumption) have improved globally over the last few years. A major contribution of the Clean Hydrogen JU projects is the achievement of a large-scale deployment of fuel cells cars in Europe. Figure 17 shows the details of the fuel cell car models deployed within the projects over the years. It is noticed that the early deployments that started with the H2MOVES SCANDINAVIA, HYTEC, SWARM and HYFIVE projects have seen exponential growth with the H2ME initiative (H2ME and H2ME2) and the ZEFER project. In 2022 (data from 2021), 594 FCEVs were in operation and reporting data from the H2ME, H2ME2 and ZEFER projects in Europe. The deployment data from 2022 will be analysed in detail in the projects' review section. It is worth mentioning that the gap observed between 2013 and 2015 is an artificial one due to the lack of data reporting during that period. HYTEC, SWARM and HYFIVE projects were deploying vehicles over 2013-2015, and we can observe the cumulative deployment from these projects in 2016.

Figure 17. Number of deployed vehicles in operation reporting data from each model versus year



Source: Clean Hydrogen JU.

Demonstration projects are recurrently suffering from local authorities' lack of experience; and from the absence of standardised processes for reviewing and approving HRS permit authorisation. However, difficulties encountered when requesting permits for HRS are diminishing, with the lead-time for commissioning an HRS in Germany decreasing from 24 to 12 months. The Clean Hydrogen JU funded project MultHyFuel is contributing to easing HRS permitting issues.

The Clean Hydrogen JU projects under Pillar 3 had significant results to show in the last 18 months, as detailed below.

- **HEAVEN** managed to deliver the Hy4 prototype, which is fuelled with liquid hydrogen. It achieved the world's first flight completed on a passenger plane using liquid hydrogen as fuel on a fuel cell powertrain. It managed to double the flight range (1500 km) with a tank capacity of 16kg of LH_2, doubling a previous flight made using gaseous H_2. Its first 4 test flights were completed in September 2023.
- **GAIA** managed to deliver a high Beginning of Life (BoL) power density of 1.80 W/cm2 at 0.6 V without increasing platinum loading, reducing the Pt-specific power density from 0.45 g Pt/kW (e.g., value achieved by project VOLUMETRIQ) to 0.25 g Pt/kW. GAIA received the best success story award during the 2022 Programme Review Days.
- **THOR** project has brought out several innovations, such as the integration of optical fibres into the tank wrapping, the design optimisation of the winding pattern and boss, and the creation of leak-before-burst technology. The use of embedded optical fibres, for monitoring both the tank's temperature during filling and the tank's remaining strength, will open the discussion for the reduction of the small safety factor ([28])

[28] Small safety factor means that it will be possible to optimise the composite wrapping thickness, hence reducing the amount of carbon fibre and resins.

in type-approval regulations. This knowledge is very valuable for liquid hydrogen storage vessels and shall be preserved and transferred to future on-board vehicle storage projects.

- Of the 14 refuse FCETs from project **REVIVE**, 6 are already in operation. The HRSs in Gothenburg and Groningen started operation in 2021, while the Breda and Antwerp HRSs opened in April and May 2022 respectively.
- **3EMOTION** has deployed all 29 FCBs: 10 buses in London, 7 in Versailles, 6 in Rotterdam and the South Holland province, 3 in Pau and 3 in Aalborg, demonstrating the operability of buses from **4** different manufacturers with 2 different fuel cells systems. The buses at some sites of **3EMOTION** met the targets for Hydrogen Consumption (average of 8 kg H_2/100 km), Warranty Time (15 000 h) and Bus Cost (< EUR 850 000).
- Combined **JIVE** and **JIVE 2** are deploying over 300 FCBs in 22 cities across Europe; the largest deployment in Europe to date. JIVE has ordered all 142 planned buses and 132 are in operation, while JIVE 2 has ordered 122 buses out of 156 originally planned, has 98 buses in operation and expects to have the committed fleet delivered by mid-2024.
- The H2ME initiative (**H2ME** and **H2ME2** projects) is the largest European deployment for hydrogen mobility to date, planning to deploy more than 1100 vehicles in 10 countries and 50 HRS from 10 suppliers in 6 countries. The project H2ME 2 alone has deployed 759 vehicles and 15 new HRSs.
- The 180 FCEVs in operation (60 in Paris, 60 in London and 60 in Copenhagen) under project **ZEFER** are demonstrating viable business cases for captive fleets of FCEVs (taxis, private hire and police services).
- Based on data collected in TRUST on the performance of 727 vehicles running in 2022 (FCEVs and plug-in hybrids), the deployed FCEVs (472) drove over 8 million km with a reported consumption of 91.7 tonnes of hydrogen. The 2022 figures continued the upward trend from the figures of 2021 where 405 FCEVs drove 6.4 million km with a consumption of 71.7 tonnes of hydrogen. This shows the growing usage of FCEVs after the easing of restrictions. In total, vehicles funded by the Clean Hydrogen JU have now driven almost 38.7 million km and consumed over 518.3 tonnes of hydrogen since 2016, avoiding emissions of about 1 420 tonnes of CO_2.

The Clean Hydrogen JU funded 112 HRS [29], including cars, buses and MHVs demo projects (planned, deployed and discontinued units). In 2022, 83 HRSs were deployed.

Pillar 4: Hydrogen End Uses – Clean Heat and Power:

The overall goal of this Pillar is t development of renewable and flexible heat and power generation systems for different end users – from domestic systems to large-scale power generation plants. Although preferential funding is given to systems using 100% hydrogen, the use of up to 20% hydrogen mixture solutions in gas grids is also proposed for support in the SRIA during the transition phase. Such solutions can be stationary fuel cells, gas turbines, boilers and burners. The former MAWP 2013-2020 objectives were to accelerate the commercialisation of FCH technologies for stationary fuel cells, in particular increasing the efficiency and the durability of fuel cells for sustainable power production, while reducing costs. The SRIA has also included the new activity area named "Gas turbines, boilers and burners". The first Research Innovation Action topic related to gas turbines was published in 2022. The two projects funded under this topic started in early 2023 (FLEX4H2 [30], HELIOS [31]).

The Research Areas relevant to Pillar 4 are the following:

m-CHP: Project PACE represents this area, exploring the possibility of deploying both PEMFC and SOFC fuelled with natural gas for fuel cell micro-Cogeneration for small stationary applications.

Commercial Size Systems: This research area contains two demonstration projects focused on fuel cell-based systems for power and heat solutions in the mid-sized power ranges of up to 100 kW, namely ComSos and E2P2, both exploring SOFC technology. Three other projects look at the next generation systems: SO FREE and CH2P using SOFC technology and EMPOWER using high-temperature PEMFC technology. In

[29] Including 2 deployed and discontinued stations
[30] https://www.clean-hydrogen.europa.eu/projects-repository/flex4h2_en
[31] https://www.clean-hydrogen.europa.eu/projects-repository/helios_en

addition, AMON, a new project that focuses on the development of the next generation ammonia fuel cell system started in 2023.

Industrial Size Systems: Then industrial size CHP Research Area includes projects dealing with large scale items, usually on the MW scale; it is represented by project GRASSHOPPER, which is addressing the challenge of setting up a cost-effective and flexible power plant, powered by MW-size FC.

Off-grid/back up/gensets: This Research Area contains the demonstration projects focused on off-grid applications, both in remote locations and in temporarily powered event areas. The current assessment period includes three projects: REMOTE, ROREPOWER and EVERYWH2ERE. The projects are exploring the application of PEM, SO and Alkaline hydrogen technologies (FC and electrolysers) for off-grid applications, but also for urban areas.

Other research areas: This includes two projects, WASTE2WATTS and RUBY, dedicated to the use of biogas for SOFC-CHP systems and the use of advanced diagnostics, monitoring and controls for fuel cells (SOFC and PEMFC).

A number of important achievements of Clean Hydrogen JU projects under Pillar 4 are reported below.

- Project **PACE** accomplished excellent results in comparison with those of the SoA; 3 091 units were sold and installed out of which 2 502 units are commissioned, demonstrating already 5 years of operational time. A 15-year system lifetime is expected with (i) a > 50 % reduction in stack replacement or no stack replacement during a 10-year service plan and (ii) a high availability of 96–99 %.
- Project **ComSos** has already achieved two MAWP targets, namely Electrical Efficiency of more than 50% and NOx emissions of less than 40 mg/kWh. CAPEX target can be achieved through automated mass production (more than 100 units a year per manufacturer).
- **EVERYWH2ERE** managed to successfully demonstrate 25 kW and 100 kW container "plug-and-play" gensets, suitable for use in construction sites, at music festivals and at urban public events. The project managed to obtain CE marking for the gensets, facilitating the local operating permit processes.
- The standardisation of the interface of stack modules and systems by project **SO-FREE** can accelerate the use and acceptance of SOC technology, its market penetration and its cost competitiveness. By integrating activities carried out in different Member States, the project contributes to strengthening the European industries in this area.
- **RoRePower** project managed to install 41 off-grid units at sites located in remote areas with harsh climate conditions (from -40°C to +50°C) and was able to provide demonstration data. It has achieved several AWP targets, such as electrical efficiency of > 35% (up to 53% measured in some cases), operation in harsh conditions at -40°C, and long-term desulphurisation (15 months).

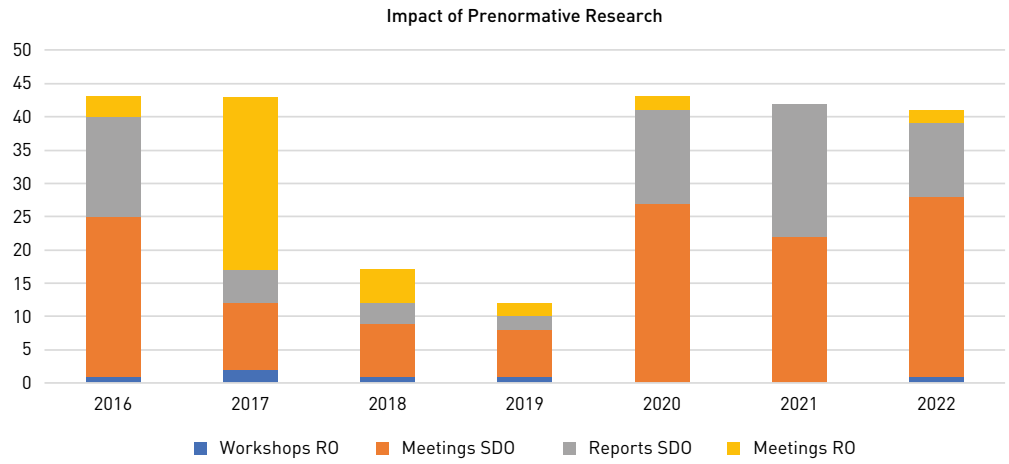
Overall, projects under Pillar 4 help manufacturers to significantly increase manufacturing capacities and move towards product industrialisation; they fostered market development at the national level (e.g. PACE project) and increased the competitiveness internationally, brining innovation and reduced cost (COMSOS project). Despite all regulatory and standardisation difficulties, PACE also helped to train a large number of now highly skilled workers. All in all, these are excellent results.

The SRIA introduced also new research areas and the Clean Hydrogen JU already started supporting projects under them in 2023, namely:

- Turbines, boilers and burners: Projects FLEX4H2 and HELIOS aim to investigate -emission combustion of hydrogen to fuel modern gas turbines at high firing temperatures and pressures.
- Fuel Cells: Project 24_7 ZEN aims to design and build a reversible SOEC/SOFC system of 33-100kW, compatible with electricity and gas grids.

Pillar 5 – Cross-Cutting Issues: The cross-cutting activity area contains specific supporting activities, structured around three research areas: (i) Sustainability, life cycle sustainability assessment (LCSA), recycling and eco-design, (ii) Education and public awareness, and (iii) Safety, Pre-Normative Research (PNR) and Regulations, Codes and Standards (RCS). The last of these areas is characterised by a high degree of publicly available outputs and of inter-projects collaboration (Table 3). Figure 18 shows the various categories of impact of the Research Areas Safety, PNR and RCS.

Figure 18. Overview of the various categories of impact of the Research Areas Safety, PNR and RCS



Source: Clean Hydrogen JU.
NB: SDO: Standard developing organisations, RO: Regulatory organisations

Clean Hydrogen JU projects under Pillar 5 managed to demonstrate a number of important achievements:

- **BEST4HY** already delivered some promising laboratory results: a Pt recovery of more than 90%, an anode recovery for SOFC of more than 80%, and a La and Co recovery of more than 80%.
- **AD ASTRA** has produced a set of validated models able to predict the degradation of SOC and the Remaining Useful Life of the cell, keeping a record of 20 peer-reviewed publications.
- **THYGA** experts contributed to revisions of the existing standards and/or drafting of new standards based on PNR results. The affected standards are part of the European RCS framework covered by the Gas Appliances Regulation (Regulation (EU) 2016/426). For example, one of them is the standard EN 437 'Test gases – Test pressures – Appliance categories', which needs substantial modification before being used for certifying gas appliances when working at high hydrogen concentrations.
- **HYTUNNEL-CS** has created three sets of recommendations: (i) recommendations for intervention strategies and tactics for first responders, related to the scope of the HyResponder project, (ii) recommendations for the inherently safer use of hydrogen vehicles in underground transport systems, targeting local and national administration and stakeholders; and (iii) recommendations for standardisation bodies.

Table 3. Standardisation impacts of PNR/RCS/Safety projects

RCS/PNR PROJECT	RCS BODY/DOCUMENT ADDRESSED	IMPACT ON RCS FRAMEWORK
AD ASTRA	IEC/TC 105, AHG1, working towards a NWIP for a standard on AST protocols for SOFC and PEMFC	The project has published protocols for SOFC degradation assessment, which can be used by IEC/TC 105. A partner is a member of AHG11 and is responsible for the integration of the project results into an IEC TR document. The expected NWIP was not submitted because the group concluded that it is too early for an international standardisation of testing procedures. The SOFC and SOEC technology still requires widespread acceptance. Nevertheless, AHF11 will continue to exist, collecting new evidence and paving the way for a future standard.
PRHYDE	New ISO 19885-3 Gaseous hydrogen — Fuelling protocols for hydrogen-fuelled vehicles — Part 3: High flow hydrogen fuelling protocols for heavy duty road vehicles	PRHYDE has provided results to ISO/AWI 19885-3 which is being prepared by the ISO/TC 197 WG24, led by one of the PRHYDE partners.
THYGA	Gas Appliances Regulation 2016/426 (Regulation (EU) 2016/426). Its harmonised standards are under the mandate of several CEN/TC: TC238 / Gas appliances: TC48, TC49, TC58, TC62, TC106, TC109, TC131, TC180, TC299	An assessment of the applicability of the GAR regulation to H2NG blends was completed. The project provided recommendations to modify EN 437 and review several related harmonised standards mentioned by the Gas Appliances Regulation.

RCS/PNR PROJECT	RCS BODY/DOCUMENT ADDRESSED	IMPACT ON RCS FRAMEWORK
HYTUNNEL-CS	UN-ECE GTR13; CEN/CENELEC JTC6 WG 3 "Safety"; ISO TC 197; First responders Standardisation bodies Local/national stakeholders	Three important sets of recommendations reports have been issued on hydrogen behaviour in parking garages and accessing tunnels and underpasses. These recommendations target standardisation bodies, stakeholders and first responders. There is, however, no engagement with specific standardisation bodies.
e-SHYIP	IMO IGF code, guidelines for hydrogen storage on ships	Recommendations to be considered by IMO, when updating the IGF Code. However, the project still does not have a convincing way to intervene at the IMO MEPC level in place and this reduces the otherwise potentially high impact.
MULTHYFUEL	Guidelines for the design and construction of multi-fuel refuelling stations	The work will facilitate the permitting process for multi-fuel stations. It is updating HyLaw which is a repository of applicable administrative and legal permitting rules.
HyRESPONDER	Not yet identified European standardisation body	The project is checking the possibility of transforming the European Emergency Response Guide into a standard.

NB: AWI, approved working item; CEN, European Committee for Standardization; CENELEC, European Committee for Electrotechnical Standardization; IEC, International Electrotechnical Commission; IGF, International Code of Safety for Ships Using Gases or Other Low-flashpoint Fuels; IMO, International Maritime Organization; ISO, International Organization for Standardization; TC, Technical Committee; WG, Working Group.

In 2023, three new projects in the area of Safety and PNR (ELVHYS, THOTH2 and SHIMMER) and another in public awareness (HYPOP) were initiated.

Pillar 6 – Hydrogen Valleys: The Hydrogen Valley concept has gained momentum and is now one of the main priorities of the European Commission for scaling-up hydrogen deployments and creating interconnected hydrogen ecosystems across Europe. Under the REPower EU Plan ([32]) the EC has budgeted and additional EUR 200 million for the Clean Hydrogen JU aiming to double the number of Hydrogen Valleys and accelerate hydrogen projects.

In the beginning of 2024, 13 valleys funded with a total of EUR 151.8 million by the Clean Hydrogen JU (9 valleys following the Call for Proposals 2022 and 4 valleys following the Call for Proposals 2023). The projects should be able to mobilise additional private and public investments of at least 5 times the amount of funding provided by the EU ([33]). In addition to the support provided through its Calls for Proposals, the Clean Hydrogen JU is helping to create a pipeline of hydrogen projects, bringing ideas to projects (including Hydrogen Valleys) via its dedicated Project Development Assistance (PDA) initiative. Building on the success of the pilot PDA initiative, the Clean Hydrogen JU AWP 2022 included the procurement for the implementation of the "Project Development Assistance (PDA) for Regions II" with a clear focus on countries targeted by the Cohesion Fund, and on outermost regions and islands. Following an Expression of Interest, in January 2023, the Clean Hydrogen Partnership selected 15 regions, which are now receiving support in the framework of the latest PDA II initiative and working on the development of hydrogen projects.

The Hydrogen Valley Platform ([34]), initially launched in 2021 under the umbrella of Mission Innovation's 'Renewable and clean hydrogen' innovation challenge, was relaunched in May 2023. An accompanying report ([35]) summarised the findings and presented identified best practices for successful project development and recommendations for policy makers on how to provide a favourable policy environment that paves the way to reach the Hydrogen Valleys' full potential as enablers of the global hydrogen economy. As of May 2023, there were 81 valleys globally, more than 60 of which were in Europe, representing an investment of EUR 84.978 million (30 May 2023) ([36]).

[32] Communication from the Commission on REPowerEU Plan
[33] https://hydrogeneurope.eu/clean-hydrogen-partnership-invests-e105-4m-in-9-h2-valleys/
[34] https://h2v.eu/
[35] https://h2v.eu/media/7/download
[36] The majority of projects still awaiting final investment decision (https://h2v.eu/)

Pillar 7 – Hydrogen Supply Chains: As indicated in the SRIA, Pillar 7 aims to define and support the activities needed to strengthen the overall supply chain related to hydrogen technologies, recently identified by the European Commission as a strategic value chain for Europe. According to the MAWP, the overall goal of the projects in this Research Area is to enable efficient manufacturing of large volumes of PEM and SO fuel cell technologies with improvements in respect to current production costs, FC performances and environmental impact. Noticeable improvements have been made by FC products created using innovative manufacturing methods. Even though improvements can be detected for many KPIs linked with performance – such as efficiency, FC stack durability, FC module availability, Minimum Pt, CRMs/PGMs recycled from scraps and wastes – it seems that CAPEX is a crucial parameter with currently achieving results far from the expected values.

Recent outcomes under this Pillar can be summarised as follows:

- Project **LOWCOST-IC** managed to increase robustness by improving the mechanical contact between the SOFC and the interconnect, while achieving low cost (> 80% cost reduction for the raw materials used). The project developed novel robust contact layers based on – Mn-Co and Mn-Cu – spinels. Mn-Cu spinels in particular possess exceptionally high mechanical robustness (in the best case 15 times higher robustness than the SoA). Substantial progress has been made towards the target of reducing the Ohmic resistance across the interconnect to < 15mΩcm2 at 750°C and < 20 mΩcm2 at 850°C (evaluated after 3,000 hours). A demonstration of stable operation for > 3000 hours and 50 cycles with the new contact layers and coated interconnects in multiple 1 kW stacks were performed.
- The main European SO stack manufacturers (Sunfire, Haldor Topsoe, Elcogen and Ceres Power) are currently using the model developed by **LOWCOST-IC**. New and cheaper materials are being investigated with the aim of leading to SOFC cost reduction. Also, state-of-the-art large-scale roll-to-roll manufacturing methods are being used for interconnect coating and shaping, and a fast drop-on-demand (DoD) printing technology is being used for application of the contact layer. In addition, the diagnostic tools to investigate material degradation processes developed by the LOWCOST-IC project can be implemented in commercial products.

A new project, AMPS, aiming to further automate and speed-up SOFC and SOEL manufacturing, started in 2023.

1.2.4. Information on quantitative and qualitative leverage effects

A key objective and measure of the public-private partnership impact lies in the capacity to leverage funding from sources other than the EU.

The Horizon 2020 and the Horizon Europe Regulations define the contribution of the Members of the Clean Hydrogen JU (EU, Industry Grouping, Research Grouping) to the funding of the partnership in several ways:

- The contribution of the Union consists of a financial contribution to administrative expenditure and operational expenditure,
- The contribution of Members other than the Union (Industry Grouping and Research Grouping), consists of financial contribution to administrative expenditure and in in-kind contribution (IKC), the latter being composed of in-kind contribution to operational activities (IKOP) and in-kind contribution to additional activities (IKAA).

Tables 4 and 5 provide an overview of the status of the various types of contributions to the funding of the partnership from the Members other than the Union under the two programmes H2020 and Horizon Europe, depending on the status of contributions. In these tables, the target (minimum) value is set in the Regulation, the 'committed' value represents the value of in-kind contribution pending certification, and the 'validated / certified' value represents the value of contribution validated (for FC) or fully certified (for IKC):

Table 4. Contributions from Members other than the EU under H2020 (situation as of 31 December 2023) (million EUR)

NATURE		TARGET	SITUATION AS OF 31 DECEMBER 2023	
			COMMITTED	VALIDATED / CERTIFIED
Financial contributions (FC) to administrative expenditure	Industry Grouping	16.34		15.65
	Research Grouping	2.66		2.54
Total FC from Members other than the EU		**19.00**		**18.19**
In-Kind contributions to Operational Activities (IKOP)	Industry Grouping	76.00	159.09 [37]	66.28 [38]
	Research Grouping		0.13 [37]	2.55 [38]
In-Kind contributions to Additional Activities (IKAA)	Industry Grouping	285.00		1,039.05
	Research Grouping			
Total in-kind contributions from Members other than the EU		**361.00**	**159.22**	**1,107.88**
Total contributions from Members other than the EU		**380.00**	**159.22**	**1,126.07**

The Council Regulation establishing the FCH 2 JU set the minimum target leverage effect over the whole 2014–2020 period as 0.57 (EUR 380 million compared with the EU contribution of EUR 665 million). In practice, industry and research, members' overall contributions have already reached a much higher level (EUR 1.1 billion) than the minimum targets set forth in the legal basis (EUR 380 million) or the EU contribution to the H2020 programme (EUR 665 million). This represents an actual leverage effect of 1.70 (EUR 1 126 million compared to the EU contribution of EUR 665 million), far exceeding the initial target of 0.57.

Due to high amount of certified IKAA, the IKAA planning and certification exercise was discontinued in 2021 for H2020, shifting focus to the Horizon Europe programme, its strategic policy objectives and its quantitative targets. Moreover, for simplification under H2020, certification of IKOP is only due after the end of the project; therefore, the certified value of IKOP will not be available before the end of the projects. The amount of IKOP to be certified in the upcoming years is estimated at an additional EUR 159 million.

This demonstrates the huge success of the H2020 programme in the sector and a continuous willingness to invest and grow.

The Council Regulation establishing the Clean Hydrogen JU sets more ambitious targets for the contributions from Members other than the EU (Table 5):

Table 5. Contributions from Members other than the EU under Horizon Europe (situation as of 31 December 2023) (million EUR)

NATURE		TARGET	SITUATION AS OF 31 DECEMBER 2023	
			COMMITTED	VALIDATED / CERTIFIED
Financial contributions (FC) to administrative expenditure	Industry Grouping	25.97 [39]		0
	Research Grouping	4.23 [40]		0
Total FC from Members other than the EU		**30.19**		**0**
In-Kind contributions to Operational Activities (IKOP)	Industry Grouping		100.47 [41]	0
	Research Grouping		0.46 [37]	0
In-Kind contributions to Additional Activities (IKAA)	Industry Grouping		552.96	240.43
	Research Grouping			
Total in-kind contributions from Members other than the EU		**969.81**	**653.89**	**240.43**

[37] Cumulated IKOP foreseen for open H2020 projects at 31.12.2023 based on budget and membership at 31.12.20 23.
[38] Cumulated IKOP validated (certified) for H 2020 projects up to 31.12.2023, as it appears in our 2023 accounts.
[39] Rounded figures coming from the breakdown, 25.97 and 4.23. Original figures are 25 965 980 + 4 227 020 = 30 193 000. Total contribution from members: 30 193 000.
[40] Rounded figures coming from the breakdown: 25.97 and 4.23. Original figures are 25 965 980 + 4 227 020 = 30 193 000.
[41] Cumulated IKOP foreseen for open HE projects at 31.12.2023 based on budget and membership at 31.12.2023

NATURE	TARGET	SITUATION AS OF 31 DECEMBER 2023	
		COMMITTED	VALIDATED / CERTIFIED
Total contributions from Members other than the EU	**1,000.00**	**653.89**	**240.43**

The Horizon Europe Regulation does not establish leverage effect targets but requires that the financial and in-kind contributions from Members other than the Union equal at least 50 % and may reach up to 75 % of the aggregated JU budgetary commitments. Expressed in terms of leverage, this means an overall objective of at least 1:1 matching between the contribution of the Union and of Members other than the Union (i.e. a leverage effect of at least 1).

As in H2020, the committed IKOP will only be certified towards the end of the programme, using certificates that are due with the last reporting period of the projects. In 2023, through the signature of 29 new grant agreements from the 2022 Horizon Europe Call, private members committed around EUR 101 million in IKOP. Furthermore, the Governing Board of the Clean Hydrogen JU approved the first IKAA plan related to Horizon Europe for the year 2022 totalling more than EUR 500 million. The IKAA is certified on an annual basis, so by end of 2023 the final certified IKAA for the year 2022 amounted to EUR **240,429,088.41** and, at the time of drafting this Annual Activity Report, the IKAA certification exercise for the previous year was still ongoing ([42]).

1.3. Calls for proposals, grant information and other funded actions

1.3.1. Information on Calls for proposals 2023

As part of AWP 2023, the 2023 Call for proposals (HORIZON-JTI-CLEANH2-2023-1) was published on 17 January 2023, with an indicative budget of EUR 195 million. The deadline for the submission of proposals was 18/04/2023. The Call included 26 topics, distributed among the areas of activity of the Clean Hydrogen JU and its SRIA as follows:

- Renewable Hydrogen Production: 7 Topics
- Hydrogen Storage and Distribution: 5 Topics
- End-Uses Transport: 3 Topics
- End-Uses Heat and Power: 4 Topics
- Cross-cutting: 3 Topics
- Hydrogen Valleys: 2 Topics
- Strategic Research challenges: 2 Topics

On 26 January 2023, a public Info Day took place on-line.

At the deadline, the 2023 Call for proposals received 132 proposals, with 122 proposals satisfying the eligibility and admissibility criteria. The distribution of the 122 proposals, according to areas and call topic, is provided in Table 6.

([42]) According to Article 11 of the COUNCIL REGULATION (EU) 2021/2085 of 19 November 2021, the private members shall report the value of their in-kind contributions to their respective governing board by 31 May each year.

Table 6. Proposal statistics: eligibility and admissibility of proposals received in the 2023 call for proposals

AREA	TOPIC	SUBMITTED	INADMISSIBLE	INELIGIBLE	ELIGIBLE
Renewable Hydrogen Production	HORIZON-JTI-CLEANH2-2023-01-01	24	2	0	22
Renewable Hydrogen Production	HORIZON-JTI-CLEANH2-2023-01-02	3	0	0	3
Renewable Hydrogen Production	HORIZON-JTI-CLEANH2-2023-01-03	7	0	0	7
Renewable Hydrogen Production	HORIZON-JTI-CLEANH2-2023-01-04	11	2	0	9
Renewable Hydrogen Production	HORIZON-JTI-CLEANH2-2023-01-05	8	0	1	7
Renewable Hydrogen Production	HORIZON-JTI-CLEANH2-2023-01-06	0	0	0	0
Renewable Hydrogen Production	HORIZON-JTI-CLEANH2-2023-01-07	1	0	0	1
Hydrogen Storage and Distribution	HORIZON-JTI-CLEANH2-2023-02-01	4	1	0	3
Hydrogen Storage and Distribution	HORIZON-JTI-CLEANH2-2023-02-02	2	0	0	2
Hydrogen Storage and Distribution	HORIZON-JTI-CLEANH2-2023-02-03	2	0	0	2
Hydrogen Storage and Distribution	HORIZON-JTI-CLEANH2-2023-02-04	3	0	0	3
Hydrogen Storage and Distribution	HORIZON-JTI-CLEANH2-2023-02-05	1	0	0	1
Hydrogen End Uses: Transport	HORIZON-JTI-CLEANH2-2023-03-01	1	0	0	1
Hydrogen End Uses: Transport	HORIZON-JTI-CLEANH2-2023-03-02	7	0	0	7
Hydrogen End Uses: Transport	HORIZON-JTI-CLEANH2-2023-03-03	1	0	1	2
Hydrogen End Uses: Heat and Power	HORIZON-JTI-CLEANH2-2023-04-01	2	0	0	0
Hydrogen End Uses: Heat and Power	HORIZON-JTI-CLEANH2-2023-04-02	8	0	0	8
Hydrogen End Uses: Heat and Power	HORIZON-JTI-CLEANH2-2023-04-03	2	0	0	2
Hydrogen End Uses: Heat and Power	HORIZON-JTI-CLEANH2-2023-04-04	4	0	0	4
Cross-cutting	HORIZON-JTI-CLEANH2-2023-05-01	2	0	1	1
Cross-cutting	HORIZON-JTI-CLEANH2-2023-05-02	4	0	0	4
Cross-cutting	HORIZON-JTI-CLEANH2-2023-05-03	1	0	0	1
Hydrogen Valleys	HORIZON-JTI-CLEANH2-2023-06-01	8	1	0	7
Hydrogen Valleys	HORIZON-JTI-CLEANH2-2023-06-02	20	0	1	19
Strategic Research challenge	HORIZON-JTI-CLEANH2-2023-07-01	3	0	0	3
Strategic Research challenge	HORIZON-JTI-CLEANH2-2023-07-02	3	0	0	3
	Total	**132**	**6**	**4**	**122**

Therefore, 24 out of the 26 topics have received eligible and admissible proposals.

The 122 eligible and admissible proposals submitted gathered 1 403 participations from legal entities established in 43 different countries. A breakdown by country where the legal entity is established, is provided in Table 7.

Table 7. Distribution of participation and requested EU contribution by country

COUNTRY	NUMBER OF PARTICIPANTS	REQUESTED EU CONTRIBUTION (EUR)
AT	28	23 706 344.27
BE	72	35 570 997.52
BG	12	1 739 135.00
BR	2	0.00
CA	1	0.00
CH	39	1 051 843.75
CY	20	7 657 625.00
CZ	9	2 860 093.50

COUNTRY	NUMBER OF PARTICIPANTS	REQUESTED EU CONTRIBUTION (EUR)
DE	146	83 138 101.14
DK	48	37 415 323.13
EE	9	4 184 912.00
EG	2	61 250.00
EL	53	28 539 463.75
ES	138	70 928 807.04
FI	42	34 829 575.73
FR	176	102 251 987.56
HR	9	9 459 686.25
HU	8	13 397 162.85
IE	6	1 641 831.25
IL	22	9 479 898.25
IT	154	101 163 167.52
KR	1	0.00
KZ	1	77 875.00
LB	1	220 000.00
LT	5	2 729 503.75
LU	10	5 509 721.25
LV	17	4 897 750.00
MD	1	27 500.00
NL	68	43 926 954.07
NO	44	26 420 310.88
PL	48	30 253 494.57
PT	35	14 738 711.82
RO	17	20 686 498.10
RS	4	1 160 968.50
SA	1	0.00
SE	21	13 701 973.51
SI	13	6 981 868.75
SK	21	11 360 009.38
TR	37	17 394 884.38
UA	10	1 792 153.50
UK	50	22 992 085.61
US	1	0.00
ZA	1	300 125.00
Grand Total	**1 403**	**794 249 593.58**

The distribution of the 1 403 legal entity participation is broken-down by entity in Table 8.

Table 8. Distribution of participation and requested EU contribution by type of entity

ENTITY TYPE	NUMBER OF PARTICIPANTS	REQUESTED EU CONTRIBUTION (EUR)
Higher or Secondary Education	272	111 850 844.00
Other	80	28 677 969.94
Private for Profit	715	498 950 843.16
Public Body	61	18 269 206.98

ENTITY TYPE	NUMBER OF PARTICIPANTS	REQUESTED EU CONTRIBUTION (EUR)
Research Organisation	275	136 500 729.50
Grand Total	**1 403**	**794 249 593.58**

Out of the 1 403 participations of legal entities, 281 are SME (20.0%) accounting for 22.2% of the total requested EU contribution (EUR 176 000 368.66).

Moreover, 792 of these participations correspond to "newcomers" (56.5%), entities that are first time a beneficiary of a grant awarded by an individual joint undertaking or its preceding initiative.

Out of the 122 eligible and admissible proposals, 73 proposals (59.8 %) passed all the call's evaluations thresholds and were placed in either the main lists or reserve lists. The exact distribution of the retained proposals and the budget per topic is provided in the Table 9.

Table 9. Retained proposals and requested EU contribution per topic for the 2022 call for proposals

TOPIC	ELIGIBLE PROPOSALS	MAIN LIST	RESERVE LIST	CUMULATIVE REQUESTED EU CONTRIBUTION (MAIN LIST)	AVAILABLE BUDGET IN TOPIC
HORIZON-JTI-CLEANH2-2023-01-01	22	5	14	14 994 356.75*	6 000 000.00
HORIZON-JTI-CLEANH2-2023-01-02	3	2	1	5 873 005.00*	3 000 000.00
HORIZON-JTI-CLEANH2-2023-01-03	7	1	3	2 492 868.75	2 500 000.00
HORIZON-JTI-CLEANH2-2023-01-04	9	1	4	2 498 813.25	2 500 000.00
HORIZON-JTI-CLEANH2-2023-01-05	7	1	2	9 999 964.63	10 000 000.00
HORIZON-JTI-CLEANH2-2023-01-06	0	0	0	0.00	10 000 000.00
HORIZON-JTI-CLEANH2-2023-01-07	1	0	0	0.00	15 000 000.00
HORIZON-JTI-CLEANH2-2023-02-01	3	2	0	39 650 346.53 (*)	20 000 000.00
HORIZON-JTI-CLEANH2-2023-02-02	2	1	0	3 999 073.75	4 000 000.00
HORIZON-JTI-CLEANH2-2023-02-03	2	1	0	1 999 585.00	2 000 000.00
HORIZON-JTI-CLEANH2-2023-02-04	3	1	1	4 991 009.88	5 000 000.00
HORIZON-JTI-CLEANH2-2023-02-05	1	1	0	4 997 745.01	5 000 000.00
HORIZON-JTI-CLEANH2-2023-03-01	1	1	0	4 990 769.76	10 000 000.00
HORIZON-JTI-CLEANH2-2023-03-02	7	1	4	7 499 171.50	7 500 000.00
HORIZON-JTI-CLEANH2-2023-03-03	2	0	0	0.00	8 000 000.00
HORIZON-JTI-CLEANH2-2023-04-01	0	1	1	3 999 084.50	4 000 000.00
HORIZON-JTI-CLEANH2-2023-04-02	8	1	5	2 994 200.00	3 000 000.00
HORIZON-JTI-CLEANH2-2023-04-03	2	2	0	11 999 879.48 (*)	6 000 000.00
HORIZON-JTI-CLEANH2-2023-04-04	4	1	2	5 993 812.38	6 000 000.00
HORIZON-JTI-CLEANH2-2023-05-01	1	1	0	1 499 431.25	1 500 000.00
HORIZON-JTI-CLEANH2-2023-05-02	4	1	1	2 999 252.50	3 000 000.00
HORIZON-JTI-CLEANH2-2023-05-03	1	1	0	2 998 857.50	3 000 000.00
HORIZON-JTI-CLEANH2-2023-06-01	7	1	0	19 996 911.75	20 000 000.00
HORIZON-JTI-CLEANH2-2023-06-02	19	4	0	35 998 182.66 (**)	18 000 000.00
HORIZON-JTI-CLEANH2-2023-07-01	3	1	0	9 997 627.50	10 000 000.00
HORIZON-JTI-CLEANH2-2023-07-02	3	1	2	9 995 705.00	10 000 000.00
Grand Total	**122**	**33**	**40**	**212 459 654.33 (*)**	**195 000 000.00**

(*) In these topics, the call leftovers were used to promote proposals from the reserve to the main lists.
(**) In this topic, the 2023 RePowerEU budget was used to promote proposals from the reserve list to the main list.

It is important to note that, as all the actions of the Clean Hydrogen JU contribute to the Horizon 2020 and Horizon Europe objectives to address climate action, the total of the cumulative requested EU contribution mentioned above (EUR 212 million) should be considered to be contributing to the HE (and H2020) objective to contribute at least 35% of expenditure to climate objectives ([43]).

1.3.2. Information on Grant Agreement Preparation (GAP)

1.3.2.1. Calls 2022

In January 2023, the Clean Hydrogen JU informed the applicants of the outcome of the evaluations of the second deadline of the call HORIZON-JTI-CLEANH2-2022-2 (deadline 20/09/2022). All consortia were informed of the evaluation results at the same time, 115 days after the closure of the call, well in advance of the time-to-inform (TTI) target fixed in the General Annexes to the Horizon Europe – Work Programme 2023-2024 (153 days).

Two proposals have made requests for review (redress) under this call, neither of which led to a re-evaluation of or change in the ranked lists established in the evaluation process.

Shortly after the information letters were sent, the Clean Hydrogen JU invited 26 proposals from the main list of call HORIZON-JTI-CLEANH2-2022-2 and from the reserve lists of the 2022 call (HORIZON-JTI-CLEANH2-2022-1 and HORIZON-JTI-CLEANH2-2022-2) to the grant agreement preparation stage, following additional decisions for the optimal implementation of the budget and related leftovers.

All 26 GAs were signed in 2023, with 15 of them signed within the 245 days of the time to grant (TTG) target fixed in the General Annexes to the Horizon Europe – Work Programme 2023-2024. The remaining 11 GAs refer to complex action and/or consortium which required more time for grant preparation, such as those from the flagship or hydrogen valley topics (Table 10).

Table 10. Information on grant agreement preparation of calls HORIZON-JTI-CLEANH2-2022-1 (reserve lists) and HORIZON-JTI-CLEANH2-2022-2 (main and reserve lists)

CALL	PROPOSAL NUMBER	ACRONYM	RANKING STATUS	TTI	TTS	TTG
HORIZON-JTI-CLEANH2-2022-1	101101420	MEAsureD	RESERVE	92	109	201
HORIZON-JTI-CLEANH2-2022-1	101101343	PEACE	RESERVE	92	117	209
HORIZON-JTI-CLEANH2-2022-1	101101337	PressHyous	RESERVE	92	117	209
HORIZON-JTI-CLEANH2-2022-2	101111882	AMPS	MAIN	115	130	245
HORIZON-JTI-CLEANH2-2022-2	101111893	CANDHy	MAIN	115	110	225
HORIZON-JTI-CLEANH2-2022-2	101112220	EPHYRA	MAIN	115	132	247
HORIZON-JTI-CLEANH2-2022-2	101111784	HERAQCLES	MAIN	115	110	225
HORIZON-JTI-CLEANH2-2022-2	101111899	HOPE	MAIN	115	133	248
HORIZON-JTI-CLEANH2-2022-2	101111933	HYPOP	MAIN	115	130	245
HORIZON-JTI-CLEANH2-2022-2	101112055	HYScale	MAIN	115	133	248
HORIZON-JTI-CLEANH2-2022-2	101111972	LH2CRAFT	MAIN	115	119	234
HORIZON-JTI-CLEANH2-2022-2	101111984	LuxHyVal	MAIN	115	276	391
HORIZON-JTI-CLEANH2-2022-2	101111927	NAHV	MAIN	115	187	302
HORIZON-JTI-CLEANH2-2022-2	101112026	PilotSOEL	MAIN	115	110	225
HORIZON-JTI-CLEANH2-2022-2	101111904	RealHyFC	MAIN	115	110	225
HORIZON-JTI-CLEANH2-2022-2	101111888	SHIMMER	MAIN	115	122	237
HORIZON-JTI-CLEANH2-2022-2	101112144	SINGLE	MAIN	115	110	225

([43]) In order to support EU's commitment to make it the world's first climate-neutral continent by 2050, Horizon Europe will direct a minimum of 35% of the funding available to climate objectives.

CALL	PROPOSAL NUMBER	ACRONYM	RANKING STATUS	TTI	TTS	TTG
HORIZON-JTI-CLEANH2-2022-2	101111964	UnLOHCked	MAIN	115	110	225
HORIZON-JTI-CLEANH2-2022-2	101112118	ANDREAH	RESERVE	115	154	269
HORIZON-JTI-CLEANH2-2022-2	101112169	CRAVE-H2	RESERVE	115	120	235
HORIZON-JTI-CLEANH2-2022-2	101112054	HYSouthMarmara	RESERVE	115	155	270
HORIZON-JTI-CLEANH2-2022-2	101112098	TH2ICINO	RESERVE	115	155	270
HORIZON-JTI-CLEANH2-2022-2	101112047	BalticSeaH2	RESERVE	115	127	242
HORIZON-JTI-CLEANH2-2022-2	101112039	SH2AMROCK	RESERVE	115	314	429
HORIZON-JTI-CLEANH2-2022-2	101112056	TRIERES	RESERVE	115	149	264
HORIZON-JTI-CLEANH2-2022-2	101111903	ZAHYR	RESERVE	115	320	435

NB: TTS, time to sign.

The 26 projects listed above include 370 participations from 312 entities for a total Clean Hydrogen JU max contribution of EUR 191 362 865.55. This amount was distributed by participant category as shown in Table 11.

Table 11. Breakdown of participation and contribution by participant category (in EUR)

ENTITY TYPE	NUMBER OF ENTITIES	REQUESTED EU CONTRIBUTION
Higher or Secondary Education	53	14 282 983.59
Other	24	5 829 887.00
Private for Profit	215	142 284 121.97
Public Body	15	4 902 318.46
Research Organisation	63	24 063 554.53
Grand Total	**370**	**191 362 865.55**

The 26 projects include 87 SME participants (19.7%) amounting to EUR 48 553 836.39 of funding. 201 of the 312 entities correspond to "newcomers" (64.4%), i.e. entities that are for the first-time beneficiaries of a grant awarded by an individual joint undertaking or its preceding initiative.

In terms of country participations, participants from 30 EU Member States, Associated Countries or Third countries are participating in the 26 projects and have received funding. In addition, entities from 5 third countries are participating. The figures below indicate the distribution of the participants and the Clean Hydrogen JU contribution by country.

Table 12. Number of entities participating and Clean Hydrogen JU contribution by country

COUNTRY	NUMBER OF ENTITIES PARTICIPATING	REQUESTED EU CONTRIBUTION (EUR)
AT	4	1 759 180.00
AU	1	0.00
BE	10	1 928 722.25
BG	13	7 865 722.67
CH	2	0.00
CY	3	108 915.07
CZ	4	950 161.25
DE	23	11 096 183.63
DK	9	4 545 129.50
EE	14	4 909 015.13
EG	1	0.00
EL	36	27 759 792.63
ES	25	8 971 524.44
FI	25	20 420 667.50
FR	21	21 828 038.50
HR	11	7 432 463.58
HU	1	38 125.00
IE	14	6 503 562.49
IT	41	19 940 146.99
KR	1	0.00
LT	1	245 750.00
LU	13	6 666 023.64
LV	4	738 750.00
MA	1	0.00
MK	1	30 700.00
NL	38	14 751 088.50
NO	5	2 456 048.75
PL	5	785 356.25
PT	1	566 125.00
SE	5	1 437 593.00
SI	16	9 288 471.90
TR	12	7 682 250.00
UA	2	337 112.88
UK	5	0.00
ZA	2	320 245.00
Grand Total	**370**	**191 362 865.55**

1.3.2.2. Call 2023

In July 2023, the Clean Hydrogen JU informed the applicants of the outcome of the evaluations of the call HORIZON-JTI-CLEANH2-2023-1 (deadline at 18/04/2023). All consortia were informed of the evaluation results at the same time, 104 days after the closure of the call, well in advance of the TTI target fixed in the General Annexes to the Horizon Europe – Work Programme 2023-2024 (153 days).

Twelve proposals made requests for review (redress) under this call, none of which led to re-evaluation or change in the ranked lists established in the evaluation process.

In July 2023, immediately after the information letters were sent, the Clean Hydrogen JU invited 25 proposals from the main lists to grant agreement (GAs) preparation, and in October 2023 another 7 proposals from the reserve lists were invited, following a further decision for the optimal budget implementation including leftovers.

In total, 27 out of 32 GAs were signed in 2023, after an average 224 days – that is within the 245 days of time to grant (TTG) target fixed in the General Annexes to the Horizon Europe – Work Programme 2023-2024. The remaining 5 GAs were already signed in January-March 2024, three of them after the TTG of 245 days, after approval of the requests by the consortium to extend the GA preparation. These three GAs refer to complex actions and/or consortium that required more time for grant preparation, such as those from the flagship and hydrogen valley topics (Table 13).

Table 13. Information on grant agreement preparation of call HORIZON-JTI-CLEANH2-2023-1

CALL	PROPOSAL NUMBER	ACRONYM	RANKING STATUS	TTI	TTS	TTG
HORIZON-JTI-CLEANH2-2023-1	101137955	ACHIEVE	MAIN	104	127	231
HORIZON-JTI-CLEANH2-2023-1	101137808	AdvancedH2Valley	MAIN	104	128	232
HORIZON-JTI-CLEANH2-2023-1	101137799	CLEANER	MAIN	104	130	234
HORIZON-JTI-CLEANH2-2023-1	101137743	DelHyVEHR	MAIN	104	130	234
HORIZON-JTI-CLEANH2-2023-1	101138008	ECOHYDRO	MAIN	104	133	237
HORIZON-JTI-CLEANH2-2023-1	101137802	ELECTROLIFE	MAIN	104	128	232
HORIZON-JTI-CLEANH2-2023-1	101137925	ENDURE	MAIN	104	127	231
HORIZON-JTI-CLEANH2-2023-1	101137798	EUH2STARS	MAIN	104	121	225
HORIZON-JTI-CLEANH2-2023-1	101137604	EXSOTHyC	MAIN	104	127	231
HORIZON-JTI-CLEANH2-2023-1	101137610	H2AL	MAIN	104	129	233
HORIZON-JTI-CLEANH2-2023-1	101137786	H2MAC	MAIN	104	116	220
HORIZON-JTI-CLEANH2-2023-1	101137965	H2MARINE	MAIN	104	127	231
HORIZON-JTI-CLEANH2-2023-1	101137611	H2tALENT	MAIN	104	212	316
HORIZON-JTI-CLEANH2-2023-1	101137988	HyAcademy.EU	MAIN	104	130	234
HORIZON-JTI-CLEANH2-2023-1	101137867	HYGHER	MAIN	104	116	220
HORIZON-JTI-CLEANH2-2023-1	101137792	HYIELD	MAIN	104	133	237
HORIZON-JTI-CLEANH2-2023-1	101137575	HyPEF	MAIN	104	130	234
HORIZON-JTI-CLEANH2-2023-1	101136656	HyPowerGT	MAIN	104	127	231
HORIZON-JTI-CLEANH2-2023-1	101137586	IMAGHyNE	MAIN	104	141	245
HORIZON-JTI-CLEANH2-2023-1	101137770	NHyRA	MAIN	104	139	243
HORIZON-JTI-CLEANH2-2023-1	101137629	NICOLHy	MAIN	104	116	220
HORIZON-JTI-CLEANH2-2023-1	101137600	NOAH2	MAIN	104	116	220
HORIZON-JTI-CLEANH2-2023-1	101137889	PH2OTOGEN	MAIN	104	128	232
HORIZON-JTI-CLEANH2-2023-1	101137592	PilgrHYm	MAIN	104	116	220
HORIZON-JTI-CLEANH2-2023-1	101137701	X-SEED	MAIN	104	135	239
HORIZON-JTI-CLEANH2-2023-1	101137912	AEMELIA	RESERVE	104	65	169
HORIZON-JTI-CLEANH2-2023-1	101137581	CONVEY	RESERVE	104	130	234
HORIZON-JTI-CLEANH2-2023-1	101137892	FrHyGe	RESERVE	104	164	268
HORIZON-JTI-CLEANH2-2023-1	101138002	HyCoFlex	RESERVE	104	115	219
HORIZON-JTI-CLEANH2-2023-1	101137866	Hy-SPIRE	RESERVE	104	121	225
HORIZON-JTI-CLEANH2-2023-1	101137893	REDHY	RESERVE	104	70	174
HORIZON-JTI-CLEANH2-2023-1	101137915	SEAL-HYDROGEN	RESERVE	104	70	174

NB: TTS, time to sign.

The 32 projects listed above include 397 participations from 321 entities for a total Clean Hydrogen JU requested contribution of EUR 198 119 643.78. This amount was distributed by participant category shown in Table 14.

Table 14. Breakdown of participation and contribution by participant category (in EUR)

ENTITY TYPE	NUMBER OF ENTITIES	REQUESTED EU CONTRIBUTION
Higher or Secondary Education	65	23 669 042.50
Other	18	6 212 683.75
Private for Profit	217	125 320 402.53
Public Body	13	2 943 526.50
Research Organisation	84	39 973 988.50
Grand Total	**397**	**198 119 643.78**

The 32 projects include 83 SME participants (20.9%) and amount to EUR 53 084 292.37 of funding. 184 of the 321 participants correspond to "newcomers" (57.3%), i.e. entities that are for the first-time beneficiaries of a grant awarded by an individual joint undertaking or its preceding initiative.

In terms of country participations, participants from 23 EU Member States or Associated Countries are participating in the 32 projects and have received funding. In addition, entities from 5 third countries are participating. Table 15 indicates the distribution of the participants and the Clean Hydrogen JU contribution by country.

Table 15. Number of entities participating and Clean Hydrogen JU contribution by country

COUNTRY	NUMBER OF ENTITIES PARTICIPATING	REQUESTED EU CONTRIBUTION (EUR)
AT	7	12 448 003.77
BE	19	5 972 895.00
BG	2	276 875.00
BR	2	0.00
CH	13	51 843.75
CZ	1	435 000.00
DE	44	21 476 371.76
DK	14	7 207 438.26
EE	3	1 921 681.25
EL	7	2 049 420.00
ES	41	20 930 060.14
FI	4	3 031 893.50
FR	112	65 726 452.86
HU	1	4 203 069.85
IT	42	20 522 566.13
LU	4	2 545 751.25
NL	12	4 958 833.63
NO	11	8 234 068.00
PL	4	1 416 962.50
PT	24	8 825 760.88
RO	2	563 687.50
SA	1	0.00
SE	4	3 632 196.25

COUNTRY	NUMBER OF ENTITIES PARTICIPATING	REQUESTED EU CONTRIBUTION (EUR)
SI	1	154 250.00
TR	3	1 360 062.50
UA	3	174 500.00
UK	15	0.00
US	1	0.00
Grand Total	**397**	**198 119 643.78**

1.3.3. Other funded actions

Operational calls for tenders in 2022

In accordance with its 2023 AWP, the Clean Hydrogen JU launched operational procurement procedures via either open calls for tenders or direct contracts with Members on the following topics:

"European Clean Hydrogen Knowledge Hub"

The objective of this contract is to develop a unique digital platform that will encompass and enrich the information and data in the available tools/platforms of the Clean Hydrogen JU. The Hub is expected to provide the necessary tools and capabilities to better collect and manage the knowledge concerning its activities and funded projects, and to facilitate access to non-confidential information to its members and the wider public. The goal is to gradually turn the Clean Hydrogen JU into the central knowledge repository and access point for hydrogen in Europe and turn the Programme Office into a knowledge intensive organisation.

The procurement was launched and awarded on the basis of an open call for tender for services. The contract resulting from the open procedure was signed on 22/12/2023 for a period of 36 months and a budget of EUR 2 100 200.00. It included provisions for a set of deliverables per task, with the main deliverable being the Knowledge Hub platform itself; additional deliverables include the collaboration platform, the database of the underpinning online platform, the new website, manuals, dashboards, knowledge management tools, visualisations, annual reports and communication materials.

"European Hydrogen Safety Panel (EHSP)"

The Clean Hydrogen JU launched this call for tenders with a view to concluding a single service framework contract for the setup, organisation, management, and coordination of the European Hydrogen Safety Panel (EHSP) and its activities. The objective of the call for tender is for the Clean Hydrogen JU to make use of the support services to setup, manage, organise and coordinate the EHSP and its activities, contributing to ensuring that the EHSP and the Clean Hydrogen JU are in the position to achieve their objectives.

The procurement activities were carried out in the form of an open call for tender for services.

The evaluation of the offers received in response to the call for tender was still ongoing in December 2023, and the procedure will be concluded in 2024.

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

The objective of this contract is to set up, coordinate and communicate on the activities of a multi-disciplinary group of experts (10-15 experts approximatively) with knowledge and experience in the sustainability and circularity of hydrogen-based technologies, their related value chains and other cross-cutting issues. This experts' team will be called the European Hydrogen Sustainability and Circularity Panel (EHS&CP). The group will act as an independent advisory group, supporting the Clean Hydrogen JU in relevant decision-making, including the adoption of sustainability and circularity aspects at both the project level (i.e. JU-funded grants) and the JU programme level.

The procurement activities were awarded further to an open call for tender for services.

The contract resulting from the open procedure was signed on 29/08/2023 for a period of 18 months and a total budget of EUR 683 625.00.

"Study on Opportunities for cooperation on clean hydrogen with neighbouring countries and regions, in particular Ukraine". The call for tender was proposed in the form of a direct contract for services with member Hydrogen Europe, in line with Article 43.4 of the Financial Rules of the Clean Hydrogen JU.

The study was transferred to the public procurements to be carried out in 2023. The study was added to the AWP 2022 in the third annual quarter, via the second Amendment to the AWP 2022, adopted through Governing Board Decision CleanHydrogen-GB-2022-06 of 05/08/2022.

The procedure was launched in the course of 2023, following the finalisation of the technical specification. In December 2023, the evaluation phase was on-going, in the form of negotiations with the tenderer, as per the rules applicable to this specific procedure.

1.4. Evaluation procedures and outcomes

The evaluation of proposals of the call HORIZON-JTI-CLEANH2-2023-1 was carried out between May and June 2023. The proposals were evaluated by a total of 59 external experts. In addition, four Vice-Chairs were appointed to assist with the management of the entire evaluation process, including the quality control task. The evaluation procedure had one observer (i.e. independent external expert to advise on the conduct and fairness of the evaluation sessions, the application of the evaluation criteria and ways to improve the processes).

Of the 59 individual external experts, 18 were female (30.5%). Regarding the nationality of experts, 20 nationalities were represented as shown in Table 16.

Table 16. External experts by gender and country of nationality

COUNTRY	NUMBER OF FEMALE EXPERTS	%	NUMBER OF MALE EXPERTS	%	TOTAL
Morocco	0	0.00 %	1	100.00 %	1
Türkiye	0	0.00 %	1	100.00 %	1
United Kingdom	1	25.00 %	3	75.00 %	4
Belgium	0	0.00 %	1	100.00 %	1
Croatia	1	100.00 %	0	0.00 %	1
France	2	28.57 %	5	71.43 %	7
Germany	1	20.00 %	4	80.00 %	5
Greece	2	33.33 %	4	66.67 %	6
Ireland	2	66.67 %	1	33.33 %	3
Italy	1	14.29 %	6	85.71 %	7
Netherlands	0	0.00 %	1	100.00 %	1
Poland	1	50.00 %	1	50.00 %	2
Portugal	2	40.00 %	3	60.00 %	5
Romania	2	100.00 %	0	0.00 %	2
Spain	2	25.00 %	6	75.00 %	8
Sweden	1	100.00 %	0	0.00 %	1
Canada	0	0.00 %	1	100.00 %	1
India	0	0.00 %	1	100.00 %	1
Russian Federation	0	0.00 %	1	100.00 %	1
United States	0	0.00 %	1	100.00 %	1
Grand Total	**18**	**30.5%**	**41**	**69.5%**	**59**

1.5. Follow-up activities linked to past calls

1.5.1. Knowledge Management

1.5.1.1. Annual Programme Review

The annual Programme Review Exercise is the main knowledge management activity of the Clean Hydrogen JU. Its purpose is to monitor the implementation of the Clean Hydrogen JU Programme to ensure that it is aligned with the strategy and objectives set out in its founding regulation, as further elaborated in its SRIA for 2021-2027.

The Annual Programme Review can be separated into four main activities: (i) The annual data collection exercise, (ii) the JRC Annual Programme Technical Assessment (and Report), (iii) the Programme Review Report and (iv) the Programme Review Days.

The annual data collection exercise ([44]) from projects was performed via the internally developed data collection platform TRUST (Technology Reporting Using Structured Templates) and a new form, the Project Fiche, which replaced the previous survey used to collect additional qualitative information.

Projects were invited to provide their data in 2023 concerning results generated in 2022. The data collected allow for 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. Most importantly, the data collected form one of the main inputs for the JRC's Annual Programme Technical Assessment.

In terms of the innovation mentioned for 2023, the Project Fiche was introduced as a means to centralise all information for each project across the Commission and JU platforms, while also containing historical information for each project and making it possible to follow changes over time for variables. The overall objective of the new Project Fiche was to integrate all important project related information and data available in the different platforms and tools and the stand-alone information coming from the projects or the project officers following them.

The Project Fiches were originally prepared in Excel format for the scope of the Data Collection. Due to the limitations of this format, the Clean Hydrogen JU developed internally a custom platform in 2024 to better manage and store the Project Fiches, using the open-source SuiteCRM platform. SuiteCRM was implemented to replace the old method of data gathering utilising Excel files, ensuring a more streamlined and contemporary approach. This new platform will be used with TRUST for the 2024 Data Collection.

A second innovation introduced in 2023 was the way the opinions of the wider scientific community on the strategic and technological priorities to be addressed by the Clean Hydrogen JU ([45]) were collected. The Clean Hydrogen JU conducted a survey ([46]) for this purpose between 9 June and 31 July 2023. The survey was also used a way to gain the input of the community to the planned SRIA revision in 2023. Based on the findings, a number of areas were highlighted where the SRIA could contribute further according to the respondents. A summary of the findings can be found in the *Programme Review Report 2023*.

Following the conclusion of the annual data collection exercise, the JRC performed its detailed assessment and produced a report, the Annual Programme Technical Assessment, with observations on the major accomplishments of the projects, the difficulties encountered and an evaluation of the performance of the Programme against the KPIs.

In parallel, the Clean Hydrogen JU prepared its Programme Review Report ([47]) for 2023, based on the findings of the JRC report, complemented by an analysis of its funded activities and the views of the wider scientific community. It also included a section on relevant studies commissioned by the Clean Hydrogen JU and major reports of international bodies and one on the observed technological, economic and societal barriers to

([44]) https://www.clean-hydrogen.europa.eu/knowledge-management/annual-data-collection_en#data-collection-methodology
([45]) As requested by Article 82 (d) of the SBA.
([46]) https://www.clean-hydrogen.europa.eu/media/news/wider-scientific-community-consultation-survey-2023-06-09_en
([47]) https://op.europa.eu/en/publication-detail/-/publication/00f833fa-7ec4-11ee-99ba-01aa75ed71a1/language-en/format-PDF/source-296436320

market entry ([48]). The contents of the Programme Review Report, allow it to go beyond the simple monitoring of the Programme, also becoming an important input (or feedback-loop) for the next Annual Work Programmes and the identification of research areas and topics for the forthcoming Calls.

Finally, the Annual Programme Review closes with the EU Hydrogen Research Days event, integrated into the Hydrogen Week (for more information, see Section 2.1). The event took place fully online on 15-16 November 2023 and was attended by a large audience, mostly coming from the research and private company community active in the hydrogen sector. During its sessions, a number of projects had the chance to present their progress, while there were also panels and presentations assessing the progress and achievements in the various pillars of the Clean Hydrogen programme and discussing ways forward and key issues concerning research and innovation in the clean hydrogen field.

1.5.1.2. European Hydrogen Observatory (EHO)

The Clean Hydrogen JU contributes to the monitoring of the deployment of hydrogen technologies, to the adoption of related policies and to academic activities and research results through the European Hydrogen Observatory (FCHO) ([49]). 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 fuel cell and hydrogen technologies on the EU market and the absence of a coordinated methodology on how to monitor their market evolution.

The Observatory was created for the use of policy makers, industry stakeholders and the general public equally, and is the main public portal for European hydrogen data. Initiated under FCH 2 JU, as the Fuel Cells and Hydrogen Observatory, EHO continues its activity as of November 2021 under the support of the Clean Hydrogen Partnership. An official re-launch took place on 29 September 2023, to mark the new brand, website and functionalities.

EHO focuses on technology and market statistics, socio-economic indicators, policies and regulations, and financial support. It has been seeing a steadily increasing number of visitors since then, with the largest share of them in recent l months entering via direct entry to the website, indicating its acknowledgement as an important source of information for hydrogen.

The Observatory website is being continuously developed and expanded with additional data sets and key information for the hydrogen sector's stakeholders. Moreover, increasing emphasis is placed on the improved visualisations and tools that it can offer.

1.5.1.3. Knowledge Management Tools and Clean Hydrogen Knowledge Hub

The Programme Office of the Clean Hydrogen JU continued to use and further develop the tools used to collect and monitor information, most notably the data collection platform TRUST and the TIM tool developed by JRC. These were complemented by the tools provided by DG RTD (CORDA, COMPASS, CORTEX, etc) and the databases and tools developed internally to better manage information for supporting the operations of the Clean Hydrogen JU.

As all the above-mentioned tools and platforms are independent and accessed separately, in 2023 the Programme Office published a Call for Tenders ([50]) for a new unique digital platform, the Clean Hydrogen Knowledge Hub, which will gather, encompass and analyse information and data coming from the Clean Hydrogen JU projects and the available internal tools/platforms of the Clean Hydrogen JU. The Clean Hydrogen Knowledge Hub is expected to provide the necessary tools and capabilities to better collect and manage knowledge, and to facilitate access to nonconfidential information to its members and the wider public.

It will be a single platform that will not only address many of the aspects regarding the access to and handling of data, but also bring together information and data from the available tools/platforms into a new integrated system. The Clean Hydrogen JU aspires for this platform to 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

([48]) As requested by SBA Article 74 (a)
([49]) https://observatory.clean-hydrogen.europa.eu/
([50]) https://etendering.ted.europa.eu/cft/cft-document.html?docId=154165

users to navigate through them based on their access rights. Apart from the Clean Hydrogen JU staff, other Hub users are expected to be policy makers (including the European Commission and national and regional authorities), decision makers, international organisations, academics, members of industry and the general public, all with different roles and access levels. The related contract was signed in December 2023 and the duration of the contract is 3-years, with the first and most critical deliverable planned for December 2024.

1.5.2. Feedback to Policy

The Clean Hydrogen JU is contributing to the activities of several services in the European Commission and therefore to the continuous update and development of different policies in line with its objectives (e.g. R&I, energy, transport, climate and industrial policies). 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 and 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 ([51])) and other international bodies, active participating in meetings, providing written technical input and ensuring that fuel cells and hydrogen technologies are properly represented. It also involves providing feedback from projects and studies to the EC in contribution to relevant energy, transport, industrial, R&I and clean air policy files.

In 2023, the Clean Hydrogen JU Programme Office continued to reinforce the collaboration with policy makers in the European Commission by providing input in response to ad-hoc requests or in a more structured manner.

The new Framework for Feedback to Policy is the main initiative to support evidence-informed policy design and evaluation. Prepared and piloted by the Common Implementation Centre, the new Framework aims to support and coordinate the process within the Climate, Energy and Mobility cluster in Pillar II of the Programme. A new structure was set in 2022-23, with the establishment of Joint Teams and new processes and tools to support implementation, to be further developed and enhanced in 2024.

The European Hydrogen Observatory (EHO) maintained by the Clean Hydrogen JU is also an important resource in the context of the feedback to policy, as it contains useful information on hydrogen technologies, deployment, policies and funding and research-related information (publications, patents and trainings). This will be enhanced by the planned work on the Clean Hydrogen Knowledge Hub (see Section 1.5.1 for more information).

In addition, the outcomes of the study on the sustainable supply chain and industrialisation of hydrogen technologies (expected to be delivered at the beginning of 2024) are important to policy makers (e.g. DG GROW and the Clean Hydrogen Alliance) for monitoring the progress on the competitiveness of clean energy technologies. The results of this study are expected to contribute to the Draghi report on the future of European competitiveness, while the database of EU entities involved in the hydrogen supply chain is to be integrated into the European Hydrogen Observatory.

([51]) The Horizon Feedback to Policy Group is 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.

1.6. Openness, cooperation, synergies and cross-cutting themes and activities

1.6.1. Support to EU Policies

Hydrogen Guarantees of Origin

The Clean Hydrogen JU continued to work on developing a Guarantee of Origin (GO) Scheme for Green and Low-Carbon Hydrogen, an effort that started back in 2014 with the first 'CertifHy' project. The latest procurement procedure was launched in 2020 and a Framework Contract signed in order to pursue the following key objectives:

- Support and accelerate the establishment of harmonised and mutually recognised GO schemes for renewable and non-renewable hydrogen across Member States while ensuring compliance with article 19 of the RED II.
- Design a hydrogen certification system that is able to demonstrate compliance with RED II targets on the share of renewables following the specific requirements that are applicable in each case.

In 2023, procurement continued regarding this work in what can be considered the third phase of CertifHy. In particular, CertifHy has continued to lead in the efforts for a harmonized market for hydrogen disclosure, notably through the Association of issuing Bodies (AIB). CertifHy joined the AIB as an observer through its consortium leader Hinicio, while also taking a board position within the AIB. CertifHy has been able to capitalize on its expertise through the following actions:

- Contribute to the update of the AIB EECS Rules, through the AIB's Gas Scheme Group. It also provides guidance to issuing Bodies on the implementation of their future GO scheme for hydrogen and helps them towards the establishment of their Domain Protocol. With CertifHy's involvement, the Domain Protocol template was updated to include gaseous energy carriers. This template forms the basis for elaborating the rules and practicalities in every Domain's GO's and was a crucial step up to implementing the EECS Gas Scheme and starting to transfer GOs for hydrogen over the AIB hub.
- Make amendments to the CertifHy Non-Governmental Certificates (NGC) Scheme so that it complies with the EECS Rules, especially with regards to its administration and operation.
- Create a framework for Members States seeking to implement their own national H2 GO Scheme for disclosure purposes (required by Article 19 of RED II) ([52]). In the absence of any well-established international standard for GHG footprint assessment, CertifHy provided guidance through its work with the CertifHy Stakeholder Platform.
- Actively participate in discussions about a harmonised approach for reporting requirements in the Union Database (UDB) for demonstrating compliance with RED II and targets for transport fuels that will ensure a link with GOs used for disclosure. CertifHy actively contributed to these discussions through the AIB Gas Scheme Group. This ensured that CertifHy's experience in operating the NGC scheme was taken into account.

Addressing the second core objective of the procurement procedure, CertifHy developed the documents that make up its Scheme for RFNBOs to demonstrate compliance with RED II requirements and submitted the scheme to the European Commission in March 2023 for formal recognition as a Voluntary Scheme ([53]), ([54]). The CertifHy Consortium developed the first version of the CertifHy Voluntary Scheme (VS) for RFNBOs which was presented to CertifHy's Working Group 1 for review and approval.

Where appropriate and possible, the drafting sought alignment and synergies with the Non-Governmental Certification (NGC) Scheme – for example, on the requirements for Certification Bodies. However, the

[52] At the time of writing, many Member States were still waiting for an updated CEN Standard, but some, such as the Netherlands, were moving ahead without this, such as The Netherlands. For example, VertiCer (formerly Vertogas), has been appointed as H2 GO Issuing Body in the Netherlands, and used the CertifHy NGC scheme regarding renewability and greenhouse gas (GHG) footprint methodology.
[53] https://www.certifhy.eu/news/certifhy-rfnbo-vs-for-recognition-eu-commission/
[54] https://energy.ec.europa.eu/topics/renewable-energy/bioenergy/voluntary-schemes_en

requirements for recognition as a Voluntary Scheme are in some parts specific to the criteria and requirements imposed by the European Commission.

In parallel, CertifHy has been raising certain key questions around the interpretation of the RED II Delegated Acts to the European Commission (EC) through dedicated workshops that the Commission organised for all Voluntary Scheme operators. This has been a unique chance for CertifHy to raise questions on how the regulations should be put into practice for assessing on the ground projects. It has also been a chance for CertifHy to showcase the value of its expertise in interpreting technical requirements and to bridge the gap between policy and concrete examples of policy implementation.

SET Plan

The Clean Hydrogen JU continued following and contributing as necessary to the SET – Plan activities, in particular Action 8 on "Renewable Fuels and Bioenergy" where the Clean Hydrogen JU is participating in the Core Group and the recently launched horizontal/cross-thematic Action on Green Hydrogen (name still to be finalised) that forms part of the revised SET Plan ([55]). The Clean Hydrogen JU is participating in the Temporary Working Group that is working on finalising the Implementation Plan and the Declaration of Intent (DoI) covering the strategic targets of this Working Group.

Support to Transport Policies

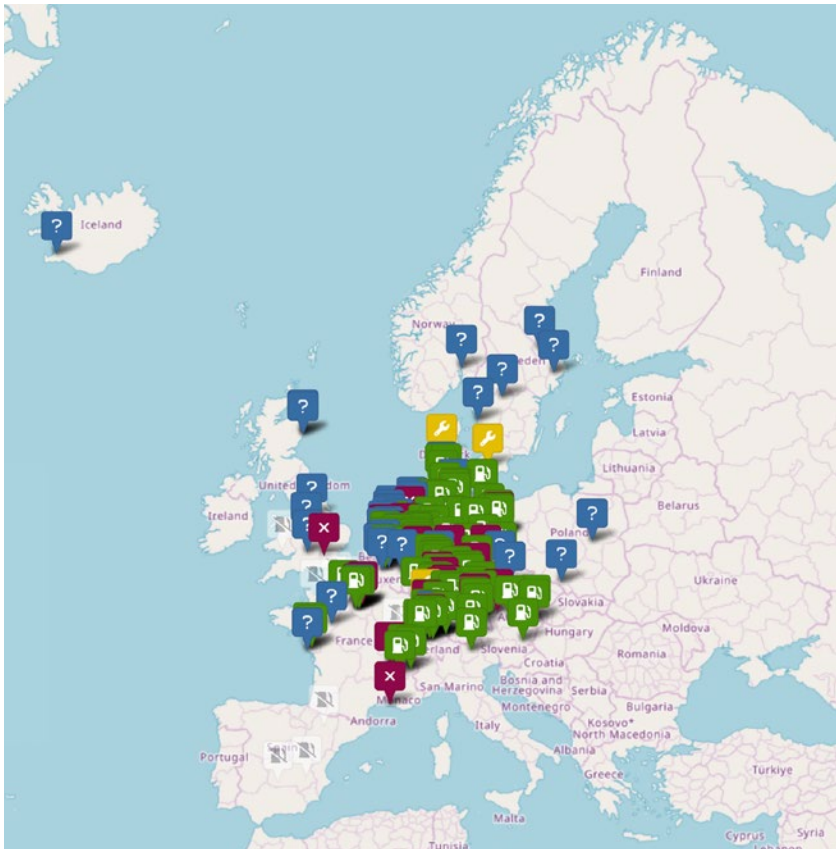
In the context of the study on hydrogen for ports and industrial coastal areas, the second report -released on 20 September 2023 – aimed to inform relevant port stakeholders (including policymakers) of the required non-technical (policy, regulatory, governance, strategic, etc.) enablers, areas of priority for research and innovation projects and required safety regulations, codes, and standards for the timely development of hydrogen related activities and infrastructures in EU port ecosystems. This report includes a review of the EU policy context and legal framework; DG ENER, as a member of the study advisory board, and DG MOVE as contributor, made suggestions to the report.

The third report of the same study was published on 18 December and examined four different case studies highlighting the techno-economic feasibility of developing a range of hydrogen-related activities and infrastructures in the vicinity of ports. After performing a separate economic analysis for each case, the report presents the anticipated benefits of introducing hydrogen in these ports and makes recommendations on how to improve each business cases.

The Clean Hydrogen JU also supports the e-HRS availability system (E-HRS-AS), which establishes and validates hydrogen availability signal at 139 HRS in Europe, out of the 190 HRS with public access (Figure 19). This action is supporting the roll-out of the AFIR, which plans the deployment of 1tH2/d HRS every 200 km on the TEN-T core network and one HRS in every urban node by the end of 2030. Moreover, the E-HRS-AS is the data provider for DG MOVE's EAFO ([56]) and TENtec ([57]) platforms. EAFO is the European Commission's key reference portal for alternative fuels, infrastructure and vehicles in Europe, and supporting the European Commission in the monitoring of the implementation of AFIR. TENtec provides a comprehensive overview on the European Commission's work in relation to the Trans-European Transport Network (TEN-T) and aims to raise citizens' awareness of the benefits of the TEN-T policy development.

[55] https://energy.ec.europa.eu/topics/research-and-technology/strategic-energy-technology-plan_en
[56] https://alternative-fuels-observatory.ec.europa.eu/
[57] https://ec.europa.eu/transport/infrastructure/tentec/tentec-portal/site/index_en.htm

Figure 19. Map of available HRSs in Europe



Source: https://h2-map.eu/

In the context of aviation research, the Clean H2 JU together with Clean Aviation JU, organised a workshop on 25 and 26 April to analyse and assess the status of research activities and analyse gaps that should be addressed in the future. The workshop saw the participation of more than 80 experts from the aviation industry, research centres and universities. DG RTD was invited to give a keynote speech and DG MOVE also attended the workshop. The workshop highlighted the need to continue research on liquid hydrogen infrastructure at the aircraft and airport level. These outcomes were provided to the responsible DGs for their use in the definition of the future annual work programmes.

Support to Industrial Policy

During 2023, the Clean Hydrogen JU continued taking part as an observer of the Steering Committee of the European Clean Hydrogen Energy Alliance.

Furthermore, 2023 was the European Year of Skills, aiming to address skills shortages in the European Union and boost the EU skills strategy, which will help reskill millions of people and focus on digital and green technology skills. In March 2023, the European Commission released the "EU Net-Zero Industry Act" (NZIA) proposal ([58]) as a means to execute the Commission's "Green Deal Industrial Plan for the Net Zero Age" ([59]), released in February 2023. The NZIA aims to ensure the deployment and competitiveness of technologies associated with decarbonisation by strengthening Europe's net-zero technology products manufacturing ecosystem, and the proposed regulation sets out a variety of actions and instruments to strengthen the competitiveness of Europe's net-zero technology manufacturing ecosystem. One of the regulations is focused on enhancing skills, and the Act will ensure the availability of a skilled workforce for the clean energy transition by supporting the set-up of specialised European Academies on strategic net-zero technologies, among which hydrogen technologies are included. In 2023 the Clean Hydrogen JU has worked in close contact

([58]) 2023/0081 (COD)
([59]) COM(2023) 62 final

with DG GROW in view of aligning the activities of the Clean Hydrogen JU to maximise the JU's contribution to the NZIA goals. Discussions are ongoing but, as an example of the result of this work, the scope and work plan of "The European Hydrogen Academy" project (HYACADEMY.EU) have been enlarged to support the European Commission's ambition and the NZIA goals.

One of them is focused on enhancing skills, and the Act will ensure the availability of a skilled workforce for the clean energy transition by supporting the setting up of specialised European Academies on strategic net-zero technologies, technologies, among which hydrogen technologies are included.

Finally, the knowledge platforms supported by the Clean Hydrogen JU – currently the European Hydrogen Observatory and the Hydrogen Valleys platforms and when implemented – the European Knowledge Hydrogen Hub, will allow the capture, use and sharing of know-how, information and experience from the funded research and innovation activities with the European Clean Hydrogen Alliance, with the ultimate goal being to become a sustainable tool serving research and industrial communities and the 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 identify hydrogen solutions at high Market Readiness Levels, solutions mature enough for market deployment.

The support that the Clean Hydrogen JU is providing to the European Commission activities with public authorities (national and regional) are described in later sections.

1.6.2. Collaboration with JRC – Rolling Plan 2023

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 was signed in the spirit and as a continuation of the previous Framework Contract on 29/11/2022.

The scope of the new 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, the Clean Hydrogen JU can call on JRC to perform specific actions for individual projects, through which the JRC provides added value to programme objectives.

The support activities the JRC performs for 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 the involvement of representatives of Hydrogen Europe and Hydrogen Europe Research. For the annual rolling plan of year 2023, an indicative budget of EUR 815 000 from the Clean Hydrogen JU operational budget was set out.

The annual Rolling Plan 2023 describes the annual activities and their related deliverables provided by JRC to Clean Hydrogen JU against payment. In line with the JRC's mission, these support activities have primarily contributed to the formulation and implementation of the Clean Hydrogen JU strategy and activities in the areas of RCS, safety, harmonisation of testing protocols, and technology monitoring and assessment.

JRC's support to formulation and implementation of Regulations, Codes and Standards (RCS) strategy

The JRC supports the industry-led Regulations, Codes and Standards Strategy Coordination (RCS SC) Task Force. In 2023 JRC supported the PO in the preparation of the first meeting of the RCS SFC Task Force, which was kicked-off on 19 April 2023 and participated also in its meeting in June 2023. It also submitted a report to the Programme Office on the international progress in the area of RCS by international bodies.

JRC direct contribution to implementing RCS strategy (Harmonisation)

The electrolysis harmonisation activities were continued, with the JRC following the progress with international standardisation for fuel cells and electrolysers. In May 2023, the report "EU harmonised testing protocols for

high-temperature steam electrolysis" ([60]) was published following the public stakeholder consultation on the Clean Hydrogen JU website.

In addition, the JRC continued to support the research community in the manufacturing and testing of the ZERO CELL single cell test hardware. In August 2023, the JRC conducted initial tests on the PEM fuel cell single cell test hardware as manufactured by IFA of TU Wien. Tests for Ballard Power were conducted during May 2023 when issues with the automatic scripting of testing were encountered preventing to successful testing. Other organisations (TU Delft, KTH, Univ Ljubljana, Precison Resource Technical Center Canada, NPL, TU Graz, TU Chemnitz and TU/e) that have expressed their interest in using this testing hardware, have so far not requested such verification and initial performance testing.

JRC's contribution to programme monitoring and assessment

In collaboration with the Knowledge Management team, JRC has populated and revised the Tools for Innovation (TIM) system with customized FCH Technology fields.

The JRC has performed the 2023 Annual Programme Technical Assessment (APTA). The purpose of the APTA is to ensure that the Clean Hydrogen JU Programme is aligned with the strategy and objectives set out in its Council Regulation and the SRIA. The 2023 Annual Programme Technical Assessment has included all projects up to 2020 Calls for Proposals that were ongoing in the period January 2022-March 2023. The current Programme Assessment therefore covers 81 projects in total, of which one began under FP7 and 80 projects under H2020. The JRC's 2023 APTA Report summarises the findings from the assessment of the projects using 7 Pillars, aligned with the SRIA Pillars. The report has similar structure as the 2022 APTAR report and contained more data and information from the historical analysis JRC conducted. This was done for 3 of the 7 Pillars. The historical analysis was included in the 'Technology progress and state of the art' chapter.

The progress the projects made towards achieving the MAWP 2020 state of the art (SoA) targets for the Key Performance Indicators (KPIs) was assessed, in addition to progress towards the SRIA 2024 targets. Recommendations specific to each Pillar were provided, as well as general and cross-cutting recommendations were given in the final chapter.

The Clean Hydrogen JU also asked the JRC for support on the gap analysis that the Clean Hydrogen JU needs to perform. Currently, due to a lack of a dedicated keyword structure, mapping the research activities mentioned in the SRIA to the scope of the ongoing projects or call topics is difficult. Therefore, the JRC delivered a keyword structure, based on the SRIA, for the purpose of mapping. A corresponding tool is currently being developed by the Clean Hydrogen JU.

JRC's contribution to sustainability

In 2023, the JRC continued to support the Clean Hydrogen JU by offering ongoing advice and delivering reports aiming to assist the Clean Hydrogen JU and its funded projects in evaluating, reporting, and mitigating the environmental impact of hydrogen technologies.

The JRC delivered two reports on the supporting activities it provided to projects: a report including the outcomes of the regular review and assessment of the life-cycle-based deliverables of all ongoing JU projects, and the summary of the activities performed in supporting the projects resulting from the call 2020: SH2E, Best4Hy, and eGHOST projects. To support projects improving the communication of the environmental sustainability of the Clean Hydrogen JU projects, the JRC has provided a checklist for ensuring a minimal level of completeness and documentation of LCA studies of hydrogen-related projects.

To support the social sustainability activities, JRC delivered a report with a conceptual framework for assessing and monitoring social risks and impacts related to hydrogen technology and their value chains and a scientific paper aiming to unveil the potential social hotspots along the value chains of hydrogen technologies in Europe.

The JRC also delivered a report on the activities performed with regard to the LCI data collection process and on the development and use of a "Hydrogen node" in the LCDN infrastructure. The JRC finalized the investigation initiated with the 2022 JRC assessment on the environmental impact of delivering hydrogen. A report was provided comparing the environmental impact of different hydrogen delivery options within Europe.

([60]) https://publications.jrc.ec.europa.eu/repository/handle/JRC129387

JRC's contribution to safety dimension and safety awareness

In 2023, the JRC has continued to work on maintaining, updating and upgrading the public European Hydrogen incidents and Accidents Database HIAD. Unlike previous years, the Rolling Plan 2023 did not set out any specific deliverable on this topic, because JRC work was considered part of the Task 3 of the European Hydrogen Safety Panel (EHSP). However, the EHSP stopped its activities at the end of 2022. JRC has therefore performed the expected activities by itself. This consisted of two parallel work-streams targeting two objectives: (i) to prepare the uptake of ownership of the databases by the Clean Hydrogen JU, and (ii) to guarantee the continuity of business (continuous quality improvement, events collection, input and validation, engagement with the users, assessment and dissemination activities).

The confidential database HELLEN was used till 2022 as a repository for incidents reported by Clean Hydrogen JU projects. In 2023, the Clean Hydrogen JU decided to phase out this repository, which was available only to the JRC and the Programme Office. The collection of the projects' events reports continued, and the anonymised and generalised versions of them were input to the Hydrogen Incidents and Accidents Database (HIAD). The same operation was executed with all the event reports received in the previous years. The JRC will keep a confidential repository, just to keep track of the flow of information provided.

1.6.3. Synergies

1.6.3.1. Synergies at the programming level

This section explains how the synergies at the programming level, including activities to prepare new initiatives or calls for proposals were implemented during 2023.

Synergies implemented via Call for Proposals

Since the early stages of the preparation of the topics included in the call for proposals 2023, the Clean Hydrogen JU has interacted with the members of its Stakeholder Group and with a number of European partnerships and other entities responsible for different EU programmes. Given that only a limited number of European partnerships are represented under the Stakeholders Group – an advisory body to the Governing Board of the Clean Hydrogen JU – this cooperation took on different formats but managed to take all of their views into account, to the extent possible, in the design of the call for proposals. In addition and to the extent possible, the Clean Hydrogen JU took into account information received internally during the preparation of the Horizon Europe Work Programme 2023-24. All these allowed to identify synergies ([61]) although on an ad-hoc basis and avoid potential overlaps during the drafting process of the Call. As a result, a number of the projects supported under the Call 2023 have included specific activities aiming to materialise these synergies ([62]).

For all flagship topics, and especially for Hydrogen valleys, applicants were encouraged (in the topic description) to 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 to cluster with other projects within Horizon Europe or funded under other EU, national or regional programmes, or projects with loans through the EIB or other promotional or commercial banks. As a result, the proposals received under the Hydrogen valleys topics provided early funding and financing strategies including public funding, private organisations own funds and bank loans.

In addition, and still for the Hydrogen Valleys topics, the call for proposals 2023 included a provision for the awarding of Seals of Excellence to applications exceeding the evaluation thresholds set out in this work programme but that could not be funded due to a lack of budget available to the call. The Seal of Excellence is seen as a tool to improve the chances of proposals that were not selected but were sound alternative funding in other Union programmes, including those managed by national or regional Managing Authorities.

([61]) Including ENTSO-G, EURAMET, Clean Aviation JU, Zero Emission Waterborne Transport partnership, Processes4Planet and Clean Steel partnerships, European Innovation Council, etc.

([62]) For more information on the synergies identified in the topics included in the Clean Hydrogen JU Call for Proposals 2023, see the Clean Hydrogen Partnership Annual Work Programme 2023

This successful collaboration was not restricted just to Call 2023, but an effort was made to enlarge this co-operation and these synergies with other European Partnerships and programmes for the coming years. In 2023, this included ad-hoc dialogues but also wider consultations concerning call 2024 topics with the States Representatives Group and Stakeholders Group of the Clean Hydrogen JU. The Clean Hydrogen JU has also been active in trying to understand the overlaps and possible synergies with the funding provided in other parts of Horizon Europe (in particular with Custer 4 and 5 of the Horizon Europe WP23-24). As a result, a wide variety of synergies were included in the AWP2024 of the Clean Hydrogen. Partnership ([63]).

Other synergies at programming level

Outside the Call for Proposals, the Clean Hydrogen JU have exchange with other Commission services and partnerships, to better plan joint activities and identify opportunities for synergies. This included regular exchanges between the Clean Hydrogen JU and the Clean Aviation JU for the coordination of the activities that both JUs are implementing. As an example, in April 2023 a joint workshop on hydrogen-powered aviation was organised by the Clean Hydrogen JU and Clean Aviation JU. The workshop comprised a plenary session, where the status of the hydrogen-powered aviation roadmap was presented, along with six technical sessions. These technical sessions focused on various aspects, including H2 aircraft architectures, on-board liquid hydrogen storage, H2-burn gas-turbines powertrain system, H2 Fuel-Cell integrated powertrain system, refuelling processes, airport infrastructures and ground operations, and safety and certifications. Considering the Strategic Research and Innovation Agendas of the Clean Aviation and Clean Hydrogen Joint Undertakings, along with the hydrogen-powered aviation roadmap, participants identified potential gaps and barriers within the roadmap. This resulted in a set of key recommendations, among which the most important ones were the need for addressing research on liquid hydrogen infrastructure at airports and within aircrafts, and the lack of suitable personnel and facilities for testing liquid hydrogen technologies.

In 2023, the Clean Hydrogen JU had several exchanges with those responsible for the Marie Skłodowska-Curie action's (MSCA) Staff Exchanges programme ([64]). As a result, means of collaboration were discussed which led to a presentation of the funding opportunities under the MSCA Staff Exchanges programme at the EU Hydrogen research Days in November 2023 ([65]).

In addition, the Clean Hydrogen JU has continued supporting Commission services as necessary. This includes internal feedback provided to DG CLIMA during the preparation of the Hydrogen Bank activities. In 2023, the Clean Hydrogen JU also participated in the discussions of the Green Hydrogen technical group of the SET-Plan (see above). Regarding skills, the Clean Hydrogen JU has had regular exchanges with colleagues in DG GROW responsible for the skills part of the Net-Zero Industry act ([66]). This is of relevance in the context of the activities the Clean Hydrogen JU is supporting on education and training and in particular in the context of the Hydrogen Academy project ([67]) supported by the Clean Hydrogen JU. In addition, during 2023, the Clean Hydrogen JU continued taking part as an observer of the Steering Committee of the European Clean Hydrogen Energy Alliance.

[63] https://www.clean-hydrogen.europa.eu/system/files/2024-01/Clean%20Hydrogen%20JU%20AWP%202024%20-%20all%20chapters_Final_For_Publication.pdf
[64] https://marie-sklodowska-curie-actions.ec.europa.eu/actions/staff-exchanges
[65] https://www.clean-hydrogen.europa.eu/knowledge-management/annual-programme-review/eu-hydrogen- research-days/eu-research-days-2023-presentations-and-recordings_en
[66] https://single-market-economy.ec.europa.eu/industry/sustainability/net-zero-industry-act_en
[67] https://www.clean-hydrogen.europa.eu/projects-repository/hyacademyeu_en

Photo: Joint Clean Aviation and Clean Hydrogen joint workshop on H2-powered aviation in Brussels on 25 – 26 April 2023. Copyright: Clean Hydrogen Partnership

At the Member States level, the Clean Hydrogen JU has continued exchange with national representatives (e.g. German NOW) on key strategic areas such as Hydrogen Valleys, and also with representatives of other Member States, either via the Clean Hydrogen JU States Representative Group (SRG) e.g. feedback provided during the process of drafting the 2024 Clean Hydrogen JU AWP/Call or though bilateral exchanges.

The above are just a few examples of a wide and diverse set of activities that the Clean Hydrogen JU has proactively pursued to ensure its programme is aligned and designed to maximize the synergies and collaboration with others. Specific activities with and for national and regional authorities are included in the subsequent section.

1.6.3.2. Collaborations with other programmes, agencies and partnerships to deliver synergies (at implementation level)

In 2023, the Clean Hydrogen JU remained proactive in defining and implementing collaborations with other EU Programmes, European partnerships, EU agencies, initiatives and actions with the potential for synergy with its research and innovation agenda.

In particular, regular exchanges with other European partnerships have taken place either through the Stakeholders Group or bilaterally on an ad-hoc basis between the teams working in the Clean Hydrogen JU and those supported by other partnerships and/or programmes. This includes, as also mentioned above, regular exchanges between the Clean Hydrogen JU and the Clean Aviation JU for the coordination of the activities that both JUs are implementing, bridging the gap between the projects supported by each of the Clean Hydrogen JUs or use of common experts for the evaluation of the hydrogen for aviation topics of both JUs.

In addition, dedicated meetings with the Zero Emission Waterborne Transport Partnership have taken place to update each other on ongoing projects. To a lesser extent, the Clean Hydrogen JU has met representatives of the EU Rail JU, Process4Planet and 2Zero Partnerships. Exchanges with these and other partnerships and EC services (on the matter of synergies), have also taken place via the Clean Hydrogen JU participation in the Clean Planet Inter-Partnerships Assembly managed by the EC. Regarding these activities, the Clean Hydrogen JU was asked to present as a best practice example of synergies.

Exchanges have also taken place at the working level with Executives Agencies and Commission services implementing other parts of Horizon Europe and other Programmes. In particular, the Clean Hydrogen JU has continued participation in activities concerning hydrogen projects managed by others (e.g participation in project Kick-off-Meetings). This includes projects supported under the Process4Planet Partnership (P4P) managed by HADEA. With CINEA and following the signature of the Clean Hydrogen JU H2-ACCELERATE-TRUCKS project (deployment of 150 trucks) as well as of several hydrogen refuelling infrastructure projects supported by CEF-T, a join event took place in March 2023, to kick-off both these activities and formalise the collaboration among these projects. Also, with CINEA, there was some degree of coordination during the grant agreement preparation of two related and interlinked projects ([68]) looking at hydrogen releases in the atmosphere.

With the European Innovation Council, and building on the Letter of Collaboration signed in 2022, the Clean Hydrogen JU has continued having regular exchanges concerning research activities looking at the production of hydrogen using renewable energy sources. This included the co-organisation of a workshop on the use of seawater for renewable hydrogen production in June 2023 ([69]).

In relation to the Innovation Fund (DG CLIMA and CINEA), in February 2023, the Clean Hydrogen JU moderated a session bringing together hydrogen projects supported by the Clean Hydrogen JU with the objective of creating synergies between these projects and the Innovation Fund. In addition, some of the Clean Hydrogen JU projects took part in a "Hydrogen knowledge sharing" workshop organised by CINEA for hydrogen related projects supported under the Innovation Fund.

1.6.3.3. Supporting regions and Member States

With the goal of setting up a structured cooperation mechanism between the Clean Hydrogen JU and Managing Authorities of Member States and Regions, in 2023 the Clean Hydrogen JU continued with these activities under a dedicated contract, with a view to facilitating the identification and implementation of synergies on research and innovation activities between the Clean Hydrogen JU and managing authorities of Member States and Regions. In 2023, after an exercise to understand the state of the art on the Hydrogen R&I policies of the Member States and third countries associated with Horizon Europe, a Call for Expression of Interest ([70]) was launched to select 10 regional or national Managing Authorities (MA) to foster a structured cooperation with the Clean Hydrogen JU tailored to the needs of each MA. A meeting with the selected MAs took place during the 2023 edition of the Hydrogen Week. Following this, the work to develop the Memoranda of Cooperation started. The signing of the MoC is planned for Q2 2024.

Moreover, the Project Development Assistance (PDA) for Regions, with a focus on Cohesion Countries, Outermost Regions and Islands, has continued during 2023 ([71]). As a result, 15 regions have received support to develop detailed hydrogen project plans.

Finally, in supporting the Commission with activities under Mission Innovation 2.0, the Clean Hydrogen JU has continued to develop the Hydrogen Valley platform ([72]). In particular, the platform was relaunched in May 2023 ([73]). It currently features 90 hydrogen valleys worldwide, of which at least 60 are in Europe.

In addition to the above, 2023 saw a large number of ad-hoc dialogues with national and regional authorities across the EU with an interest in the Clean Hydrogen JU activities, and in particular seeking opportunities for Hydrogen Valleys. In this regard, the Clean Hydrogen JU has met with individuals and with network representing stakeholders such as the European Regions Research & Innovation Network ([74]). In addition, the Clean Hydrogen JU has participated in ad-hoc requests including participation to events organised by the

[68] Projects supported under the topics HORIZON-CL5-2023-D1-01-03 "Climate impacts of a hydrogen economy & HORIZON-JTI-CLEANH2-2023-05-03: Pre-Normative Research on the determination of hydrogen releases from the hydrogen value chain.
[69] https://eic.ec.europa.eu/events/person-workshop-seawater-sourcing-renewable-hydrogen-and-chemicals-2023-06-08_en
[70] https://www.clean-hydrogen.europa.eu/media/news/call-expression-interest-receiving-technical-assistance-generate-synergies-clean-hydrogen-2023-06-06_en
[71] https://www.clean-hydrogen.europa.eu/media/news/15-european-regions-will-receive-project-development-assistance-2023-01-15_en
[72] https://h2v.eu/
[73] https://www.clean-hydrogen.europa.eu/media/news/relaunch-hydrogen-valley-platform-2023-05-16_en
[74] https://errin.eu/

ERA-LEARN platform ([75]) (including participation in the European Partnership Stakeholder Forum 2023 ([76])). In addition, the Clean Hydrogen JU has provided to networks animated by DG ENER. This includes the Energy and Managing Authorities Network of the European Commission ([77]) as well as the Hydrogen Energy Network ([78]) (HyENet). Finally, the Clean Hydrogen JU has regularly taken part in the General Assembly of the Hydrogen Valleys S3 Partnership ([79]).

1.6.4. 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.

Whilst most of the Pre-Normative Research (PNR) activities in the Clean Hydrogen JU Programme will be implemented as part of the activities within Horizontal Activity 1: Cross-cutting Issues (JU SRIA, Section 3.6), a strategic and coordinated approach is needed at the Programme level. To this end, the Clean Hydrogen JU set up in 2022 a Regulations, Codes and Standards Strategy Coordination (RSC SC) Task Force, composed of representatives of the European Commission, Hydrogen Europe and Hydrogen Europe Research secretariats, and the Clean Hydrogen JU 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 Europe and beyond, with the focus but not limited to Standards.

In 2023, the RCS SC Task Force held regular meetings with a view to reaching an agreement on the practical work of the Task Force bearing in mind its role and priorities and the tasks entrusted to it (JU SRIA, Section 4.3). As a result, there is a common understanding that the focus of RCS Task Force activities is twofold:

i. Coordinate to identify the PNR needs of strategic importance in Europe that can be addressed as topics in the subsequent JU calls for proposals

ii. Design and deploy a batch of measures to increase the impact of the RCS-/ PNR-related activities at the programme and the project level in standardisation.

Concerning the identification of PNR needs, in 2023, Task Force members started to review relevant reports where different organisations had flagged the gap/need for PNR activities related to hydrogen and fuel cell technologies in the EU. These include the reports ([80]) ([81]) published by the CEN-CENELEC Sector Fora on Energy Management Working Group on Hydrogen (SFEM WG H2) ([82]), or the "Roadmap on Hydrogen Standardisation" ([83]) published by the European Clean Hydrogen Alliance (ECH2A) ([84]), to name but a few. The RCS SC Task Force will conclude the review in 2024, aiming to identify out of all PNR needs, what priorities can be addressed within the Clean Hydrogen JU Programme in the upcoming years.

On the other hand, in 2023, the Task Force assessed a set of potential measures to increase the impact of the Clean Hydrogen JU projects on relevant RCS. As a result of this work, the Task Force endorsed a few measures that have been included in the AWP 2025. For example, projects performing PNR activities have an additional information obligation to report up to 4 years after the end of the project if the results of the project have effectively contributed to European or international standards, and projects resulting from Innovation Actions should consider providing a public report – including the Legal and Administrative Processes (LAP) and the Regulations, Codes, and Standards related to the technologies and/or applications

([75]) ERA-LEARN https://www.era-learn.eu is a support platform for the R&I partnership community, funded as a support action (CSA) by Horizon Europe. The current phase is a 4-year initiative (2023-2027), following up on several previous phases of ERA-LEARN since 2009
([76]) https://www.era-learn.eu/news-events/events/partnerships-stakeholder-forum-2023
([77]) https://energy.ec.europa.eu/topics/funding-and-financing/energy-and-managing-authorities-network_en
([78]) https://energy.ec.europa.eu/topics/energy-systems-integration/hydrogen/hydrogen-energy-network_en
([79]) https://ec.europa.eu/regional_policy/policy/communities-and-networks/s3-community-of-practice/partnership_industrial_mod_hydrogen_valleys_en
([80]) https://op.europa.eu/en/publication-detail/-/publication/99f62cea-a877-11e5-b528-01aa75ed71a1
([81]) https://publications.jrc.ec.europa.eu/repository/handle/JRC117765
([82]) https://www.cencenelec.eu/areas-of-work/cenelec-sectors/energy-and-utilities-cenelec/hydrogen/
([83]) https://ec.europa.eu/docsroom/documents/53721
([84]) https://single-market-economy.ec.europa.eu/industry/strategy/industrial-alliances/european-clean-hydrogen-alliance_en

within the project scope, the barriers and/or gaps identified during the project implementation and any other relevant information – to share the lessons learnt and provide recommendations to support the update and/or development of suitable and enabling legal and regulatory frameworks.

In conclusion, the RCS SC Task Force activities in 2023 contributed to better steering and coordination of RCS-related matters in the Clean Hydrogen JU, increasing the impact of the Clean Hydrogen JU Programme in this field while setting out the path for the activities of the Task Force in the coming years.

1.6.5. European Hydrogen Safety Panel (EHSP)

The European Hydrogen Safety Panel (EHSP) initiative ([85]) was launched by the Clean Hydrogen JU in 2017. The mission of the EHSP is to assist the Clean Hydrogen JU both at the programme level and at the project level in assuring that hydrogen safety is adequately managed, and to promote and disseminate hydrogen safety culture within and outside the Clean Hydrogen JU Programme.

The EHSP is composed of a multidisciplinary pool of experts grouped in ad-hoc working groups (task forces) according to the tasks to be performed and to expertise. Collectively, the members of the EHSP have the necessary scientific competencies and expertise covering the technical domain needed to make science-based recommendations to the Clean Hydrogen JU.

In 2023, in view of the increased support expected from the EHSP in the Clean Hydrogen JU Programme, as anticipated in the AWP 2023, the Clean Hydrogen JU worked to conclude a service framework contract for the provision of support for coordinating and managing the EHSP, strengthening its coordination, activities, and impact. To this end, the Clean Hydrogen JU published a call for tenders ([86]) in August 2023 and after receipt of tenders, proceeded with the opening and evaluation. The award and signature of the framework contract are expected in 2024, alongside the first specific contract for the start of the activities.

1.6.6. European Hydrogen Sustainability and Circularity Panel (EHS&CP)

The Clean Hydrogen JU is contributing to bringing the EU hydrogen sector to the forefront of the sustainable and circular transition of hydrogen technologies and their associated value chains – for example, by looking at the entire life cycle, promoting circular design processes and preventing waste production.

To this end, the Clean Hydrogen JU has planned in the Work Programme 2023 to set up the European Hydrogen Sustainability and Circularity Panel (EHS&CP). This Panel will help the Partnership to integrate sustainability and circularity at the programme and project levels and to promote and disseminate knowledge to achieve a more sustainable and circular culture within and beyond the programme.

In 2023, the Clean Hydrogen JU concluded an open procurement process to establish a service contract to set up and manage the EHS&CP on behalf of the Clean Hydrogen JU. This service contract was signed in August 2023 with a few consulting partners led by Ecorys Europe together with TNO and Grant Thornton.

A call for expression of interest was launched in November 2023 to select 15 independent experts to work together as members of the EHS&CP. The final selection and the contracting of experts are expected to take place at the beginning of 2024, which will be followed by starting the activities of the EHS&CP.

Altogether, the EHS&CP will provide the Clean Hydrogen JU with a practical and direct support to ensure that the sustainability and circularity aspects are considered in the development and implementation of the R&I actions supported by the Programme, integrating and balancing the three dimensions of sustainable development – economic, social and environmental – and facilitating the transition to a circular economy.

1.6.7. International Cooperation

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, the establishment of links with other major FCH-

([85]) https://www.clean-hydrogen.europa.eu/get-involved/european-hydrogen-safety-panel-0
([86]) https://etendering.ted.europa.eu/cft/cft-display.html?cftId=14149

related programmes globally and with international organisations monitoring the developments in the hydrogen sector is important.

In particular, the international activities of interest include those carried out by the IEA under the Hydrogen Technology Collaboration Program (IEA Hydrogen) ([87]), the Technology Collaboration Programme on Advanced Fuel Cells (IEA AFC) and the International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE) ([88]).

In 2023, the Clean Hydrogen JU continued to collaborate closely with the EC representatives in the steering committees of these international agreements/associations, in particular within the IEA. It participated in the activities of Task 42 on 'Underground Hydrogen Storage'. It also participated in Task 41 on 'Analysis and Modelling of Hydrogen Technologies', which concluded in 2023 with the publication of its Final Report ([89]) in June.

The Clean Hydrogen JU continued to be the main contributor to the bi-annual country report update of the IPHE for the European Commission – coordinated by DG GROW and the joint questionnaire by the IEA, CEM Hydrogen Initiative and the IPHE. It also provided comments on and inputs to a number of important hydrogen publications, including the IEA *Global Hydrogen Review 2023*.

In addition, the Clean Hydrogen JU supported DG ENER in their discussions with the Ministry of Economy, Trade and Industry (METI) of Japan, particularly on safety aspects, exchanging information on the Clean Hydrogen JU activities in this field and in particular on the Hydrogen Incidents and Accidents Database (HIAD 2.0) managed by the JRC.

As part of the international cooperation activities, a new project, JUST-GREEN AFRH2ICA, was initiated in 2023, aiming to promote a just transition to green hydrogen in Africa.

Finally, the Clean Hydrogen JU continued to contribute to the successful and close collaboration with EC representatives on Mission Innovation – IC8, through the Hydrogen Valley Platform, a platform for exchanges between worldwide initiatives on hydrogen valleys. In 2023, the Mission Innovation Hydrogen Valley Platform officially relaunched, following a very successful event held on 8 May 2023. By the end of 2023 it has reached 90 Hydrogen Valleys from all over the world. Several improvements were made to the website, including the launch of a new member's area. Moreover, two workshops were organised for project developers, intended to help new stakeholders overcome initially identified barriers.

1.6.8. Openness

In addition to the cooperation and synergies mentioned in the above sections, specific activities were included in 2023 to preserve the openness of the Clean Hydrogen JU activities in line with the SBA and the Clean Hydrogen JU strategic document, SRIA.

More specifically, the Clean Hydrogen JU made no exception to the open calls' principle for either of its calls, and the call launched in 2023 by the Clean Hydrogen JU followed this same approach.

As per the rules stated in the Horizon Europe Regulation ([90]), any legal entity, regardless of its place of establishment and including legal entities from non-associated third countries or international organisations, may participate in actions under the Programme, provided that the conditions laid down in the Horizon Europe Regulation have been met together with any conditions laid down in the work programme or call for proposals.

In particular, the call for proposals in the AWP 2023, including evaluation and award procedures, were managed according to, and the proposals complied with, the General Annexes to the Horizon Europe Work Programme 2023-2024 that applied *mutatis mutandis* to the call covered in the AWP 2023 (with the exceptions introduced in the specific topic conditions).

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[87] http://ieahydrogen.org/
[88] http://www.iphe.net/
[89] https://www.ieahydrogen.org/download/17/task-reports/7426/iea-hydrogen-tcp-task-41_finalreport.pdf
[90] Regulation (EU) 2021/695 of the European Parliament and of the Council of 28 April 2021 establishing Horizon Europe – the Framework Programme for Research and Innovation, laying down its rules for participation and dissemination, and repealing Regulations (EU) No 1290/2013 and (EU) No 1291/2013 (Text with EEA relevance). OJ L 170, 12.5.2021, p. 1–68

In line with the SBA ([91]), an additional condition was included for some topics that at least one partner in the consortium must be a member of one of the Clean Hydrogen JU Private Members (Hydrogen Europe or Hydrogen Europe Research). This requirement concerned topics targeting activities where the industrial and research partners of the Clean Hydrogen JU were seen to apply a key role, such as large-scale demonstrations, ensuring a balance between commitment from partners and openness, in accordance with the SRIA of the Clean Hydrogen JU, namely Section 5.2. Conditions for participation and eligibility for funding. However, none of these additional conditions changed the open nature of the call.

When implementing the AWP2023, a number of measures were implemented to attract newcomers to the Clean Hydrogen JU activities.

Concerning the call for proposals, in addition to the general Info Day organised in Brussels, several dedicated Info Days took place in different countries, including those with a history of limited participation in EU R&I programmes.

This type of activity contributed to increasing the coverage of some of the topics – for example, the Hydrogen Valleys, for which the Call 2023 attracted proposals covering 18 countries within the EU-27 and Associated Countries to Horizon Europe (including 5 of the EU 13 countries).

In addition, activities under the Project Development Assistance, that the Clean Hydrogen JU launched in 2022, have continued supporting Cohesion Countries, Outermost Regions and Islands. A total of 15 regions out of which 10 are located in EU13 were supported during 2023.

As part of a tender to provide technical assistance to national and regional Managing Authorities, the Clean Hydrogen JU launched a Call for Expression of Interest to select 10 regional/national Managing Authorities (at least half coming from EU-13 countries) to sign a Memorandum of Cooperation with, aiming at providing technical support tailored to the needs and areas of interest of those managing authorities and exploring potential synergies between European and national/regional funding programmes.

1.7. Progress against Key Impact Pathways and Ju's Key Performance Indicators

1.7.1. Progress against Horizon 2020 legacy Key Performance Indicators

The legal basis of Horizon 2020 specified a list of compulsory Key Performance Indicators to be taken into account in its evaluation and monitoring system. They were intended to provide a solid and coherent basis for the monitoring and evaluation system of Horizon 2020, coupled with the focus on measuring the results and impacts of the Programme. In addition, the legal basis indicated a list of 14 cross-cutting issues that serve to monitor basis Horizon 2020 programme implementation on an annual and which were reported in the Annual Horizon 2020 Monitoring Report.

In terms of the scoreboard of common KPIs (Annex 5.5), the indicators reflecting the impact and outcomes of the H2020 Programme have been steadily increasing. There were 59 more publications in peer-reviewed journals, and there were 6 more patents awarded while there are still 8 patent applications pending. New products, processes, methods and prototypes were reported, most notably an additional 79 prototypes on top of the 512 already reported. Even more impressively, a significant increase was observed in the turnover of SMEs and their number of employees, with these numbers increasing by fourfold times compared with those of 2022.

Not surprising for a research funding programme, these very positive results highlight that the real outcomes of the Programme can only be seen in the first few years after its ending.

In terms of the indicators for monitoring cross-cutting issues (Annex 5.5.3), these have more or less stabilised after the end of H2020, as they concern mostly the participants in Calls and the Clean Hydrogen JU beneficiaries for the H2020 projects.

([91]) Recital 16 and Article 15(2)(a) of the SBA

1.7.2. Progress against General Horizon Europe Key Impact Pathways Indicators (KIPs)

Horizon Europe (HE) incorporates a novel approach to capturing and communicating impacts via the Key Impact Pathways (KIPs) ([92]). The objective of this approach is to enable policy makers and the wider public to gain regular insights into the effects and benefits of the Programme over time in relation to European science, economy and the wider society.

The nine Key Impact Pathways ([93]) cover areas of scientific, societal and technological/economic impact. A full list of these KPIs can be found in the table of Section 5.5. The KIPs do not aim to represent the full set of pathways that can lead to impacts of the Framework Programme – which would, in most cases, be non-linear – but instead they reflect key dimensions on which information is collected over time to track and report progress. All of the KIPs focus on the impact of the Horizon Europe Programme as a whole.

The KIPs will be calculated and reported via the Horizon Europe Dashboard, based on the continuous reporting of the projects. For 2023, there were very limited results to report, as the first grants of the Clean Hydrogen JU were only signed in December 2022.

1.7.3. Progress against HE Common JUs Key Performance Indicators

Horizon Europe introduces common criteria for all Partnerships:

1. Directionality and Additionality;
2. Coherence and Synergies;
3. Transparency and Openness;
4. International visibility and positioning;
5. Flexibility of implementation.

An independent Commission Expert Group has developed a set of indicators to monitor progress towards the performance of European Partnerships, including the Clean Hydrogen JUs, in relation to these criteria. The common indicators are complementary to the KIPs and individual partnership KPIs.

In its first interim report ([94]), the Expert Group focused on developing a framework on reporting and monitoring the progress made by all forms of European partnerships – individually ('partnership-specific indicators') and as a whole ('common indicators'), while making sure it is aligned with the Horizon Europe monitoring system and its Key Impact Pathways.

In particular, the Expert Group has proposed a set of Horizon Europe Common JU KPIs, including recommendations to make them operational, such as methodologies and the identification of the data required to monitor these indicators. The aim of these indicators is to monitor quantitative and qualitative information and aspects, which should be able to capture the full value the partnerships, an aspect not well developed in the past. This framework should enable monitoring across the partnerships landscape and allow their evaluation as an integral component of Horizon Europe and put into perspective with other Horizon Europe modalities and instruments. This will allow to assess European Partnerships and their impact in their proper policy context.

On May 2022 the Commission released its Biennial Monitoring Report 2022 on Partnerships under Horizon Europe (BMR 2022) ([95]). The report provides an overview of the new Partnership landscape under Horizon Europe and establishes the basis for assessing the partnerships' progress in future reports.

([92]) The General HE KPIs are available here: Regulations establishing HE - Annex V (page 65) https://eur-lex.europa.eu/eli/reg/2021/695/oj

([93]) For a more detailed description and methodology of the KIPs see: European Commission, Directorate-General for Research and Innovation, Nixon, J., Study to support the monitoring and evaluation of the framework programme for research and innovation along key impact pathways: indicator methodology and metadata handbook, Nixon, J. (editor), Publications Office of the European Union, 2022, https://data.europa.eu/doi/10.2777/44653

([94]) A robust and harmonised framework for reporting and monitoring European Partnerships in Horizon Europe, 2021, RTD, https://europa.eu/!b3TBfW

([95]) European Commission, Directorate-General for Research and Innovation, Performance of European Partnerships: Biennial Monitoring Report (BMR) 2022 on partnerships in Horizon Europe, Publications Office of the European Union, 2022, https://data.europa.eu/doi/10.2777/144363

The reporting on the HE Common JU KPIs can found in the table of Annex 5.5.4. The methodology followed was based on the guidance of DG R&I in 2023, provided through a series of four meetings dedicated for this purpose. The subsequent sections provide additional qualitative information for the reported indicators, split by the criterion they address.

1.7.3.1. Additionality

The main added value of European Partnerships derives from the additional private and/or public R&I investments in EU priorities (additionality) that can be translated into a leverage effect resulting from the Union intervention. The alignment of these investments and contributions with common objectives (directionality) and the achievement of impacts that cannot be created by other Horizon Europe or national actions alone are a main justification for using a partnership approach.

There are two HE Common JU KPIs measuring the criterion of additionality, KPI-1 on the progress towards contributions from partners other than the Union and KPI-2 on additional investments triggered by the EU contribution, as presented in Annex 5.5.4.

For KPI-1 on Additionality, detailed information is provided in Section 1.2.4 'Information on quantitative and qualitative leverage effects.

In terms of KPI-2, the Clean Hydrogen JU supports three activities that aim to deliver additional investments:

1. Technical Assistance Study ([96]);
2. Project Development Assistance Study ([97]);
3. Provision of Seals of Excellence to successful Hydrogen Valley projects that could not be funded by the Clean Hydrogen JU.

These actions are described in more detail in Sections 1.6.3.1 and 1.6.3.3.

1.7.3.2. Directionality

Directionality addresses the focus of EU funding through the partnerships, but also the level of partnership alignment with the EU policies and priority areas and how the partnership contributes towards them.

There is one HE Common JU KPI measuring the criterion of directionality, KPI-3 on overall investments mobilised towards EU priorities, as presented in Annex 5.5.4. This indicator shows that 100% of the overall investment is mobilised towards the Green Deal and Europe's 2030 climate ambition.

1.7.3.3. International visibility and positioning

The partnerships act as global ambassadors for the European R&I system. They establish global relevance and achieve scientific and technological reputation in the international context and serve as hubs for international cooperation, where appropriate. To this end, it is expected that there should be a minimum level of international cooperation at partnership and project level, resulting in visibility for the European Partnership. The activities of the Clean Hydrogen JU in relation to international cooperation are presented in detail in Section 1.6.7.

There are two HE Common JU KPIs measuring the criterion of international visibility and positioning, KPI-4 on international actors involved and KPI-11 on the visibility of the partnership in national, European and international policy/industry cycles, as presented in Annex 5.5.4.

In terms of KPI-4, a very large number of actors were involved in the activities of the Clean Hydrogen JU, be it participation in proposal submissions, following events and workshops organised by the Clean Hydrogen JU or reading its publications. As this is a newly introduced KPI, the Clean Hydrogen JU can only report (like last year) only on the available data of total number of international applicants to the Clean Hydrogen JU Calls, which as can be seen in Annex 5.5.4, just for Calls 2022 and 2023, this has already exceeded the total number of international applicants over all FCH 2 JU Calls.

([96]) https://etendering.ted.europa.eu/cft/cft-display.html?cftId=11585
([97]) https://etendering.ted.europa.eu/cft/cft-display.html?cftId=9759

In terms of KPI-11, the Clean Hydrogen JU has organised or participated in a number of international and national events. It also produced and published different publications and supported hydrogen related web platforms to promote its work, increase its visibility and strengthen the public awareness of hydrogen technologies, obtaining a synergic effect. It has also obtained visibility through the media opportunities throughout various countries and increased social media efforts across different channels. The activities are summarised in Table 56 of Annex 5.5.4 and described in more detail in Section 2.1.

1.7.3.4. Transparency and openness

A European Partnership should aspire to be open and serve the interests of all relevant stakeholders. Consequently, the implementation of the partnership should include regular activities that allow new players to enter, participate in and benefit from its activities.

There are three HE Common JU KPIs measuring the criterion of transparency and openness, KPI-5 on the share and type of stakeholders and countries engaged, KPI-6 on the number and types of newcomer members in the partnership and KPI-7 on the number and types of newcomer beneficiaries, as presented in Annex 5.5.4.

As regards KPI-5, a large number of stakeholders from different countries and of different types were invited to and engaged in activities of the Clean Hydrogen JU, be it through participation in proposal submissions and projects, being members of the governance structure of the Clean Hydrogen JU or participating in the panels and groups supported by the Clean Hydrogen JU. In terms of reporting, the Clean Hydrogen JU reports (similar to last year) only on the total beneficiaries to the Clean Hydrogen JU Calls so far (i.e. Call 2022 and Call 2023), including the type and country of origin of the beneficiaries. As can be seen in the tables in Annex 5.5.4 the Clean Hydrogen JU already has 1432 beneficiaries from 65 countries, compared to the 1515 FCH 2 JU beneficiaries from 50 countries. The fact that in just its first 2 years the Clean Hydrogen JU has almost the same amount of beneficiaries as the whole FCH 2 JU Programme and with the participation of 15 more countries, confirms the high interest in the Clean Hydrogen JU Programme. In terms of the types of beneficiaries, there has been a change in participation since 2022, which can be attributed to the Hydrogen Valley topics that were included in Call 2022-2 and Call 2023. For these topics, there were high levels of interest from public organisations and other organisation types (apart from private companies, research centres and higher education schools), which lead to a higher number of participants than the whole FCH 2 JU Programme. This increased participation came with the loss of the participation of research centres and higher education schools.

In terms of KPI-7, in the past FCH 2 JU exhibited a very high number of new beneficiaries in funded projects, something expected considering the emerging hydrogen sector. More than 70% of the total beneficiaries of FCH 2 JU were new beneficiaries. Nevertheless, it is interesting to see that the Clean Hydrogen JU continues to attract new beneficiaries: more than one third of its beneficiaries in Call 2022 and Call 2023 were new, with two thirds of them being new private for profit companies.

KPI-6 'Transparency and openness' is not applicable to the Clean Hydrogen JU in its current definition as the Clean Hydrogen JU's membership is defined and fixed Article 75 of SBA. The actions of the Clean Hydrogen JU, especially the calls for proposals, are fully open.

1.7.3.5. Coherence and synergies

Partnerships do not act in isolation but in the broader landscape of R&I and sectoral policies. In order to improve their additionality and directionality, European Partnerships should seek and exploit synergies with related Horizon Europe and other Union initiatives as well as national/sectorial initiatives.

The activities of the Clean Hydrogen JU in relation to coherence and synergies are presented in detail in Section 1.6.3.

There are three HE Common JU KPIs measuring the criterion of coherence and strategies, on the number and type of coordinated and joint activities with other European Partnerships (KPI-8) and with other R&I initiatives (KPI-9), as well as KPI-10 on the complementary funding from other Union funds, as presented in Annex 5.5.4. Moreover, KPI-2 described under additionality also contributes to the measuring of this criterion.

KPI-8 reports on the number and type of coordinated and joint activities with other Partnerships. The Clean Hydrogen JU has been collaborating with all relevant Partnerships on ah-hoc basis, starting with the identification of possible synergies already in its SRIA. Moreover, it has been participating with other Partnerships in the inter-partnership assembly and working together with the other JUs in the implementation of the back-office arrangements, while a number of Partnerships are participating in its Stakeholder Group.

The Clean Hydrogen JU has also collaborated with three Partnerships (Clean Aviation, Zero Emission Waterborne Transport, KDT) to prepare call for proposals that their results could be taken up at a later stage from other Partnerships. In April 2023 a joint workshop on hydrogen-powered aviation was organised by the Clean Hydrogen JU and the Clean Aviation JU. As a result of the workshop, a set of key recommendations was made to address potential gaps and barriers in the hydrogen-powered aviation roadmap. The Clean Hydrogen JU has also continued participation in activities concerning hydrogen projects supported under the Process4Planet Partnership (P4P) managed by HADEA.

KPI-9 reports on the same topic, but for other R&I initiatives at EU, national, regional and sectorial levels. In terms of funding, as the first grants were signed only in December 2022, there haven't been any confirmed synergies in funding for any projects so far, although a number of Hydrogen Valleys projects have been signed (which by definition require synergies with other sources of funding).

In terms of formal collaboration and as part of its JU's PDA project, 15 regions have received support to develop detailed hydrogen project plans. In 2023, a Call for a Call for Expression of Interest was launched to select 10 regional or national managing authorities to foster a structured cooperation and implementation of synergies on research and innovation activities between the Clean Hydrogen JU and managing authorities of Member States and Regions.

A number of joint activities, in the form of ad-hoc collaboration, were performed with CINEA. A joint event was organised to formalise the collaboration between the Clean Hydrogen JU H2-ACCELERATE-TRUCKS project (deployment of 150 trucks) and several HRS projects supported by CEF-T, to formalise the collaboration among these projects. Also with CINEA, there was coordination during the grant agreement preparation of two related and interlinked projects looking at hydrogen releases in the atmosphere. The Clean Hydrogen JU continued its collaboration with EIC on activities looking at the production of hydrogen using renewable energy sources, including the co-organisation of a June 2023 workshop on the use of seawater for renewable hydrogen production. In relation to the Innovation Fund, the Clean Hydrogen JU and its projects participated in workshops on "hydrogen knowledge sharing", creating synergies between these projects and the Innovation Fund.

In terms of other coordinated and joint activities, in addition to the ones reported in AAR 2022, there were joint activities with the Marie Skłodowska-Curie actions (MSCA) Staff Exchanges programme. In addition, the Clean Hydrogen JU has fulfilled ad-hoc requests for participation, including participation in events organised by ERA-LEARN and provided regular updates for the Energy and Managing Authorities Network of the European Commission and for the Hydrogen Valleys S3 Partnership. Finally, in collaboration with Mission Innovation 2.0, the Clean Hydrogen JU has continued to support the activities of the Hydrogen Valley platform. It currently features 90 hydrogen valleys worldwide, of which 60 are in Europe.

In terms of KPI-10, there are no validated qualitative data to report yet, as the first grants from Call 2022 were only signed in December 2022, although – as mentioned above – significant complementary funding is expected, at least for the Hydrogen Valleys funded by the Clean Hydrogen JU.

1.7.4. Progress against JU-specific Key Performance Indicators [98]

1.7.4.1. Resources (input), processes and activities

In its first few years of activity the Clean Hydrogen JU took a number of actions and performed a number of activities, in line with its operational objectives and additional tasks described in the SBA, in order to put in place the building blocks for the specific and general objectives of the Clean Hydrogen JU. Three broad areas of activities are identified in the SRIA and the Clean Hydrogen JU's Strategy Map:

[98] Figures for Call 2023 do not include the 5 grants that were signed early 2024, one concerning a REPowerEU Hydrogen Valley.

- Supporting climate neutral and sustainable solutions

The Clean Hydrogen JU has aligned its work with its new objectives by using the majority of its Call 2022 and Call 2023 budget to support sustainable solutions. Already the budget of the projects supported by the Clean Hydrogen JU that have research objectives related to either end-use solutions in hard to abate sectors or on circular and sustainable solutions has reached 21% and 6% respectively of the total JU budget (including REPowerEU, so of the EUR 1.2 billion), surpassing the related targets for 2023.

- Research and Innovation for hydrogen technologies

Half (41 of 81) of the projects of the Clean Hydrogen JU are low TRL projects (TRL 2 or 3), and have already reached 13% of the total JU budget. It is worth mentioning that this is already 30% higher than the 10% minimum budget allocation set out in the SRIA, and thus this target is expected to be significantly surpassed.

At the same time, 19 grants were signed with demonstration or flagship projects (TRL 7 or 8), corresponding to 21% of the total Clean Hydrogen JU budget. This shows that the Clean Hydrogen JU focuses on both sides of the TRL scale, the early research side having plentiful low TRL projects and the demonstration side using a significant part of the budget.

- Supporting market uptake of clean hydrogen applications

The Clean Hydrogen JU performed a number of activities related to the monitoring of technology progress and economic and societal barriers to market entry, as part of its knowledge management activities. These are described in Section 1.5.1.

Moreover, it contributed to the development of regulations and standards, under the Commission's policy guidance and supervision, and supported the Commission, including through technical expertise, in its international initiatives on the hydrogen strategy. These are described in Sections 1.6.4 and 1.6.7.

Moreover, there are already three projects related to education and training, most notably the HyAcademy.EU from Call 2023, surpassing the target of two projects by 2023.

1.7.4.2. Outcomes

The activities planned and implemented through the Programme aim to achieve the two sets of specific objectives, as defined in the SBA. They both focus on the acceleration of the transition towards the goals set by the Green Deal, the enhancement of the research and innovation ecosystem, including SMEs and involving stakeholders in all MS, as well as the delivery of innovative technology solutions and their uptake by the market, with a view to local, regional and Union-wide deployment. The specific level objectives of the Clean Hydrogen JU identify what should be the main direct outcomes and results from the activities of the Clean Hydrogen JU. These should be contributing to the general level impacts of the Clean Hydrogen JU.

The specific objectives of the Clean Hydrogen JU were translated into five specific-level outcomes in the Clean Hydrogen JU's Strategy Map. The first two are:

- Limiting environmental impacts
- Improving cost-effectiveness

These two outcomes are linked to the R&I results coming from the projects. As the first grants were only signed in December 2022, no results are available yet to show the progress towards these objectives.

- Synergies with other partnerships

The Horizon Europe Programme places a lot of emphasis on developing synergies between EU Partnerships & Programmes, but also with Regional and National Programmes. Clean Hydrogen JU has been very active in setting up such synergies and collaborating with various Programmes. The related actions are presented in detail in Section 1.6.3.

In terms of the specific KPI following the progress in this area, the first synergy – between the Clean Hydrogen JU and CEF – has been materialised, within the H2Accelerate TRUCKS project and CEF. Together with the 11 grants given to hydrogen valleys, the number of synergies has already reached 12 surpassing even the 2025 target.

- Increasing Public Awareness

Increasing public and private awareness, acceptance and uptake is a key objective of the Clean Hydrogen JU. A public opinion survey was conducted in 2022 to examine public awareness and perception of hydrogen. Section 2.1 contains all the relevant details.

Additionally, in 2023 the Clean Hydrogen JU signed a grant with project HYPOP ([99]), aiming to raise public awareness and trust towards hydrogen technologies and present their benefits.

- Reinforcing EU scientific and industrial ecosystem, including SMEs

The Clean Hydrogen aims to 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.

The inherited JU projects ([100]) continue to show increased activity in terms of academic and research results. In 2023 there was an almost equal number of publications (111 in total) in peer-reviewed journals from the Clean Hydrogen JU projects, as well as six more patents were approved, bringing the total of patents approved to 21, while 8 more pending approval.

In terms of trainings, this outcome is again linked to the R&I results coming from the projects. As the first projects on education and training were only signed in 2023, no results are available yet to show the progress towards this objective.

In terms of the reinforcement of the industrial ecosystem and the specific KPI monitoring this, despite Call 2022-1 not including any projects promoting cross-sectoral solutions, Calls 2022-1 and 2023 led to 13 such grants being signed, 11 of them being hydrogen valleys. This way the target of 2025, of 15% of the total Clean Hydrogen JU budget being directed in such solutions, has almost already been met.

1.7.4.3. Impacts

The Clean Hydrogen JU is expected to contribute towards a number of EU policy objectives related to the clean energy transition and climate neutrality, most notably towards the Green Deal and the Hydrogen Strategy.

The set of KPIs under "impact" report the progress of the hydrogen sector at the EU level, to which the Clean Hydrogen JU is contributing. Targets for KPI-14 to KPI-17 are based on the related ambition set in the 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 actions of the Clean Hydrogen JU, helping to identify where more effort should also be placed by the Clean Hydrogen JU in the coming years. For all the KPIs, the source of the reported values is the European Hydrogen Observatory.

Considering these general objectives and placing them in the context of the macro level objectives of the Horizon Europe Programme related to major societal challenges, led to the following three major areas that the Clean Hydrogen JU should have an impact on, according to its Strategy Map:

- Action against climate change by drastically reducing greenhouse gas emissions

The development and scale-up of hydrogen technologies, replacing existing fossil use, will unquestionably have an impact on the reduction of greenhouse gas emissions. In order to assess the possible impact of supporting such activities, the Clean Hydrogen JU developed a complex methodology with the contractor of the European Hydrogen Observatory to calculate the expected avoided emissions. For the moment the indicator is off-track, are generally the deployment of hydrogen technologies in Europe is lagging behind to the ambitious EU targets.

- Transition to a clean energy system with renewable hydrogen as one of its main pillars

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([99]) https://www.clean-hydrogen.europa.eu/projects-repository/hypop_en

([100]) Due to the lag observed in producing publications and patents, the related indicator includes H2020 projects. In particular, for patents, due to the long time required for their approval, the reporting is cumulative over also the predecessor's lifetime; as observed in practice applications for patents are submitted towards the second half of a Programme. For the publications, they will be reported cumulatively as of 2022, with the initial publications stemming from H2020 projects.

The EU's hydrogen strategy ([101]) has put forward a comprehensive framework to support the uptake of renewable and low-carbon hydrogen to help decarbonise the EU in a cost-effective way and reduce its dependence on imported fossil fuels. Among its major targets, it set as strategic objectives to install at least 6 GW of renewable hydrogen electrolysers in the EU and the production of up to 1 million tonnes of renewable hydrogen by 2024, and 40 GW and 10 million tonnes respectively by 2030.

The Clean Hydrogen JU's activities will particularly contribute towards these two areas, considering the significant focus on both hydrogen production and hydrogen end-use (which is necessary to make the increase in the hydrogen production meaningful) and on the necessary distribution and storage of hydrogen.

The two indicators selected in the strategy map to best monitor the progress towards these goals are the deployment of electrolysers and the market uptake of clean hydrogen. The KPI values reported in Section 5.5.5 – and thus KPI 14 which is directly linked to them – are off track, 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 from 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. Although it may have a limited direct impact on these deployment figures due to its small budget and large ambition, the JU can play an important role in increasing the technology readiness of the hydrogen solutions, allowing their faster market uptake.

- Emergence of a competitive and innovative European hydrogen value chain.

The third area that the Clean Hydrogen JU actions should contribute to is the emergence of a competitive and innovative European hydrogen value chain. The total costs of hydrogen in end-uses should be significantly reduced to make hydrogen competitive as a fuel. This will be partly achieved by improving the performance of the hydrogen technologies, but also by scaling-up production and increasing the size of the sector across the value chain.

For this reason, two indicators in the strategy map will be used to monitor progress in this area, both developed in collaboration with the contractor of the European Hydrogen Observatory. The first indicator looks at the cost of producing renewable hydrogen, while the second looks at the developments in the sector in terms of the numbers of active companies and projects in the pipeline and electrolyser manufacturing capacity. Based on the latest statistics and trends / announcements, all indicators are either on track or expected to be on track in 2024.

1.8. Dissemination and information about project results

Closely aligned with the knowledge management objectives, the monitoring of the dissemination and exploitation activities of Clean Hydrogen JU projects under the H2020 programme ([102]) continued during 2023, while implementation of the new Programme under Horizon Europe started with the first call. Following the best practices already inaugurated by its predecessors, the Clean Hydrogen JU continues to support efforts to increase the impact of the R&I activities though the dissemination and exploitation of project results.

Dissemination and Exploitation Internal Guide: The Clean Hydrogen JU strongly and actively supported the initiatives of the EC to reinforce the Dissemination and Exploitation (D&E) of the results of the projects. In 2021, the Programme Office endorsed an internal D&E Guide to support the project officers in their project monitoring activities and to enhance and customise the D&E monitoring good practices that are implemented by the projects before and after their conclusion. The guide maps the steps undertaken by the Clean Hydrogen JU to reinforce the monitoring of the D&E at the project level. It complements the list of consecutive steps with detailed guidelines on each step to be performed by the Project Officers, that extends from the Call for Proposals and the Model Grand Agreement ([103]) provisions to the period of up to 4 years after the end of the project. This project-level approach is being complemented by a thorough mapping of overarching activities

([101]) This was further enhanced by the REPowerEU Plan, which was adopted though after the SRIA of the Clean Hydrogen JU and the setting of its relative targets.
([102]) The projects funded under H2020 programme have been progressed enough and are ready to disseminate and exploit their key results. Projects under Horizon Europe (Call 2022) are expected to start having substantial D&E activities in 2024.
([103]) https://ec.europa.eu/research/participants/data/ref/h2020/other/mga/jtis/h2020-mga-fch_en.pdf

that the Clean Hydrogen JU performs annually to support the D&E function at the programme level and increase the impact of the programme.

Finished projects – Continuation of D&E Activities: One of the main issues regarding the project implementation remains the continuation of the D&E activities of the project beneficiaries after the final reporting and the end of the funding period. According to Article 28.1 of the H2020 MGA and the Annex 5 of the Horizon Europe Lump Sum MGA, beneficiaries must take measures aiming to ensure the 'exploitation' of their results up to four years after the end of a project. However, it remains challenging for the Programme Office to follow up any D&E activities performed by the beneficiaries after the end of the project, although continuous reporting avenues on the Funding and Tenders platform remain accessible to the project for it to update information on D&E activities, including patents and scientific publications.

As also reflected in the internal D&E guide, the Programme Office reach out to the project coordinators of completed projects 18-24 months after the end of the project, to motivate the consortium to continue disseminating the results, to remind them about the existing EC tools and services (e.g. the Horizon Results Platform, the HR Booster etc) available to support them, and to encourage them to inform the Clean Hydrogen JU of any D&E activities performed and report them through continuous reporting. Communication with projects has been made in two stages:

- In May 2023, the 6 projects that ended in the second semester of 2021 were contacted: H2FUTURE, HYDRAITE, HyGRID, INN-BALANCE, CRESCENDO and ID-FAST.
- In December 2023, the 7 projects that finished in the first semester of 2022 were contacted: BIGHIT, CH2P, GAIA, GRASSHOPPER, HySTOC, MARANDA and NEPTUNE.

Horizon Groups: Under the new Dissemination & Exploitation (D&E) Strategy ([104]) for Horizon Europe established in and implemented since 2021, the governance structure consists of the following coordination groups:

- The Horizon Dissemination & Exploitation Group (D&E Group), and
- The Horizon Feedback to Policy Group (F2P Group).

The 7th D&E group meeting took place virtually in February 2023. The Clean Hydrogen JU is following the group closely and contributes to all the meetings.

As regards the F2P Group, the 7th meeting of the Coordination Group took place in March 2023, whereas a meeting related to the Horizon Europe Cluster 5 Feedback to Policy took place in April 2023. For more information, see Section 1.5.2.

Horizon Results Platform (HRP) ([105])**:** The HRP is a platform launched by DG-RTD in 2019, aiming to assist projects in presenting their prominent exploitable results to targeted audiences (e.g. business partners, angel investors, venture capital, policy makers or business development assistance) and help the result owners to exploit the results accordingly. By the end of 2023, 11 Clean Hydrogen JU projects have uploaded **26** results in total in the platform (Table 17). All Clean Hydrogen JU projects are continuously encouraged to upload their exploitable results, thus increase visibility and chances to exploit them.

Table 17. Clean Hydrogen project results in the Horizon Results Platform

PROGRAMME	PROJECT ACRONYM	THEMATIC PRIORITY	RESULTS TITLE	RESULT TYPE	RESULT ID
FP7	ENE.FIELD	ENERGY	Energy system benefits of FC micro-CHP	Policy Related Result	14200
FP7	ENE.FIELD	ENERGY	Environmental benefits of Fuel Cell micro-CHP	Policy Related Result	14259
FP7	ENE.FIELD	ENERGY	Fuel Cell micro-CHP consumer benefits and end-users' satisfaction	Policy Related Result	14273
FP7	UNIFHY	ENERGY	120 hours of continuos pure hydrogen production (99.99% H2) from biomass	Scientific or Technological R&D Result including ICT Hardware	30277

([104]) https://webgate.ec.europa.eu/fpfis/wikis/pages/viewpage.action?pageId=738755339&preview=/738755339/741311561/Dissemination_and_exploitation_strategy_Horizon_Europe%20_%20Endorsed_Nov2020.pdf
([105]) https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/horizon-results- platform

PROGRAMME	PROJECT ACRONYM	THEMATIC PRIORITY	RESULTS TITLE	RESULT TYPE	RESULT ID
H2020	HPEM2GAS	ENERGY	Scalable PEM electrolyser system	Scientific or Technological R&D Result including ICT Hardware	13890
H2020	HPEM2GAS	ENERGY	Project workshop	Other	13891
H2020	HPEM2GAS	ENERGY	products for electrochemical systems and development of components and MEAs	Scientific or Technological R&D Result including ICT Hardware	13892
H2020	HPEM2GAS	ENERGY	ionomer membranes for PEM water electrolysis application	Scientific or Technological R&D Result including ICT Hardware	13893
H2020	HPEM2GAS	ENERGY	Renewable power sources with cost-competitive electrolysis plants	Scientific or Technological R&D Result including ICT Hardware	13894
H2020	BIG HIT	ENERGY	BIG HIT: Demonstration of the use of hydrogen and RES locally, in an integrated manner	Scientific or Technological R&D Result including ICT Hardware	14554
H2020	Cell3Ditor	ENERGY	Multi-material 3D printer for advanced ceramic materials	Scientific or Technological R&D Result including ICT Hardware	14317
H2020	Cell3Ditor	ENERGY	Nanoscale Dispersions of YSZ, NiO-YSZ and LSM	Other	14499
H2020	QualyGridS	ENERGY	Standardized Testing protocols for electrolysers performing grid service	Other	14462
H2020	MEMPHYS	ENERGY	Effective Poison Mitigation Strategies for Hydrogen pumps with a Reformate Feed or contaminated hydrogen	Scientific or Technological R&D Result including ICT Hardware	21331
H2020	MEMPHYS	ENERGY	New approaches for operation, control and condition monitoring of electrochemical systems	Scientific or Technological R&D Result including ICT Hardware	21501
H2020	MEMPHYS	ENERGY	Cost analysis for electrochemical hydrogen purification (EHP) system	Other	21525
H2020	MEMPHYS	ENERGY	Toolbox for the evaluation of stamped metallic bipolar plates	ICT Software Digital solution	21665
H2020	MEMPHYS	ENERGY	Computation fluid dynamics model for electrochemical hydrogen separation and compression	ICT Software Digital solution	21675
H2020	MEMPHYS	ENERGY	Forming of metal plates for compression and purification stacks.	Scientific or Technological R&D Result including ICT Hardware	21845
H2020	INLINE	TRANSPORT	Automated endoscopic burr detection in tank valves	Scientific or Technological R&D Result including ICT Hardware	14271
H2020	INLINE	TRANSPORT	Assisted assembly station	Scientific or Technological R&D Result including ICT Hardware	14348
H2020	INLINE	TRANSPORT	Smart camera sensor with adaptive light control for assisted assembly	Scientific or Technological R&D Result including ICT Hardware	14581
H2020	Fit-4-AMandA	TRANSPORT	Commissioning of the mass manufacturing machine for automatic fuel cell stack assembling	Scientific or Technological R&D Result including ICT Hardware	13858
H2020	Fit-4-AMandA	TRANSPORT	BPP design for moulding verified	Scientific or Technological R&D Result including ICT Hardware	13859
H2020	TeacHy	ENERGY	MSc blended learning degree in Fuel Cell and Hydrogen Technologies	Services	29573
H2020	FCHgo	ENERGY	FCHgo educational toolkit for teaching hydrogen energy and fuel cell technology in schools	Other	19884

NB: ICT, information and communications technology; R & D, research and development.
Source: RTD.G.6

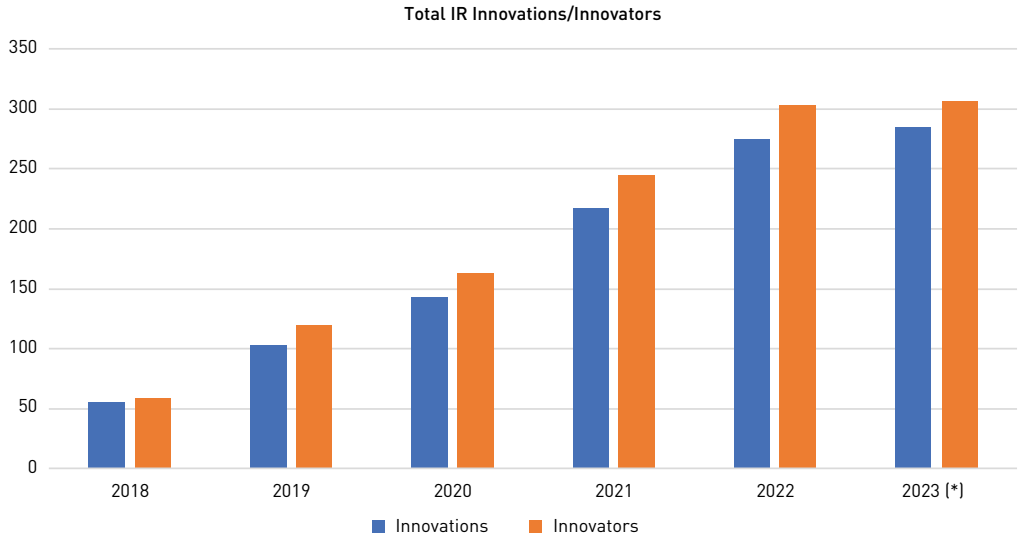
Innovation Radar (IR): The Innovation Radar is a European Commission initiative aiming to identify and increase the visibility of high potential innovations and innovators in EU-funded research and innovation

projects. Via the IR platform, innovations and innovators become accessible by the right audiences, encouraging the development of a dynamic ecosystem of incubators, entrepreneurs, funding agencies and investors that can help get EU-funded innovations moving to 'make it happen' faster and more efficiently.

In the project mid-term review, a dedicated expert analyses potential innovations related to the project objectives through a questionnaire incorporated into the workflow of Project Monitoring. The Innovation Radar expert provides concrete recommendations on the innovation aspects of the project and for individual innovator organisations within the consortium. These recommendations are also integrated into the formal review report.

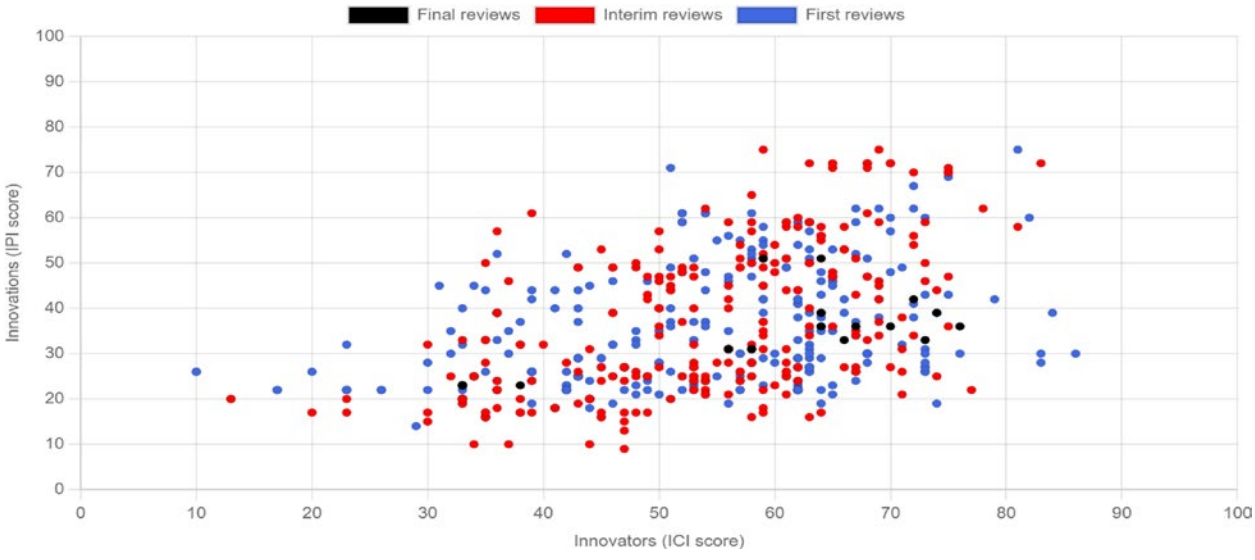
The Clean Hydrogen JU projects have been participating in the IR initiative since its pilot in 2018. So far, innovations of 101 JU projects have been analysed: a total of 285 innovations (more than half of which are considered "very innovative" or "obviously innovative and [having] easily appreciated advantages to customer"), coming from 228 innovators, have been analysed and uploaded to the platform (Figures 20 and 21). In 2023, 10 additional innovations coming from seven JU projects were added to the platform.

Figure 20. Total number of innovations and innovators in the Innovation radar



Source: IR Dashboard V2
(*) Estimated

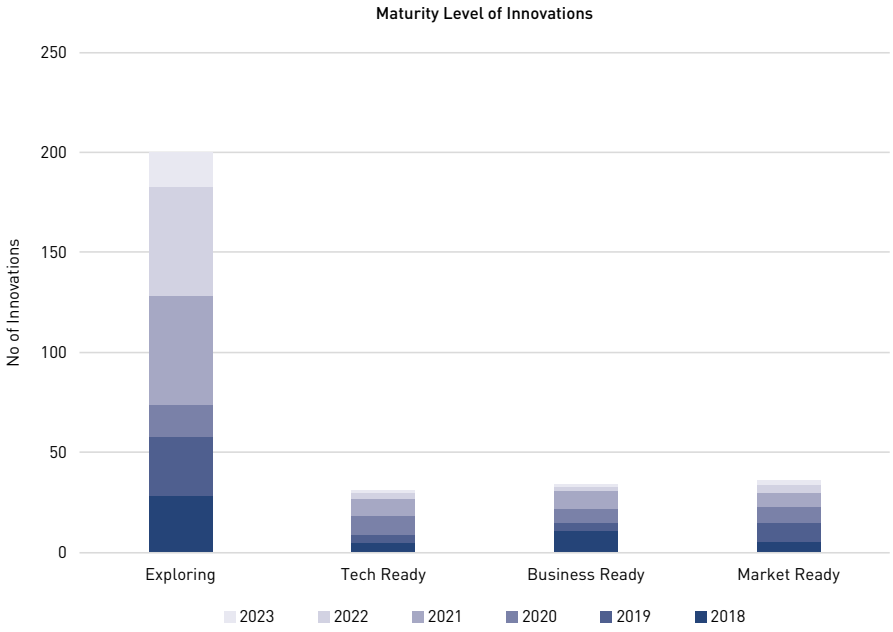
Figure 21. Classification of Clean Hydrogen Projects innovations based on their Innovator Capacity Score and the Innovation Potential Index



Source: IR Dashboard V2.

Based on the Innovation Radar methodology, innovations are classified between 'exploring', 'business ready', 'market ready' and 'tech ready' (Figure 22). This classification is meant to span the path between the most basic TRLs of 'exploration' to the most advanced and closest to the market, further research or standardization activities. A very positive result has also been the identification of at least 62 innovations that scored 50 points and above in the innovation potential indicator (IPI), making them ideal first candidates for follow-up actions for exploitation proposals.

Figure 22. Clustering of Innovations based on the maturity level



Since the pilot launch of the IR, the Clean Hydrogen JU has collected valuable feedback to communicate with EC (e.g. DG R&I, DG CONNECT etc) and has participated in the Innovation Radar R&I family meetings to support further improvement of Innovation Radar and explore how the information collected can be further utilised by other EC services that support further exploitation of research results (e.g. Horizon Results Booster, Horizon Results Platform etc.) ([106]).

D&E Activities of the on-going Projects: The Programme Office organised the EU Research Days and Programme Review 2022 (15-16 November 2023). It reflects the annual Programme Review performed by the JRC, based on the annual data collection exercise organised every year in Q1 to update the information and technological data on the projects that were ongoing during the reference period (2022). The tools to perform the data collection exercise consist of:

- the TRUST platform, used to collect descriptive and operational technological data related to the activities of the projects, including D&E activities for the first time after the replacement of the EU Survey questionnaire,
- the Project Fisch, introduced as an information repository file in a spreadsheet to integrate all important project-related information and data available across the different platforms and tools and stand-alone information coming from the projects or the project officers following them.

According to the data provided by 75 (out of 81) active projects on their D&E activities and the key exploitable results (KERs):

- 73 projects reported 640 dissemination activities;
- 38 projects reported 94 exploitation activities;

([106]) Furthermore, a service offered to the innovations analysed by the IR, the Dealflow.eu, is available to support the innovations/ innovators in further exploiting their results, especially in commercializing their innovations ("go-to-Market"), by facilitating access to clients and investors and providing high-end coaching services (e.g. venture-building, preparation for fundraising, networking, pitching to possible investors, etc).

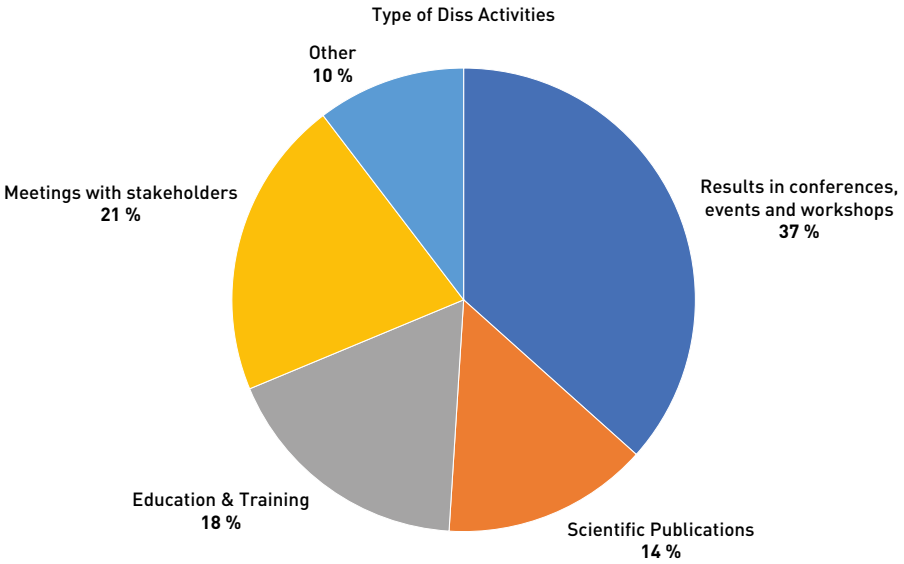
- 71 projects reported 131 key exploitable results.

Dissemination activities in 2022 showed a surge compared with 2021, which is mainly attributed to the changes in the methodology of collecting the data using TRUST templates.

In total the projects reported 206 new scientific publications and 8 new patent applications (see Annexes 5.3 and 5.4 respectively).

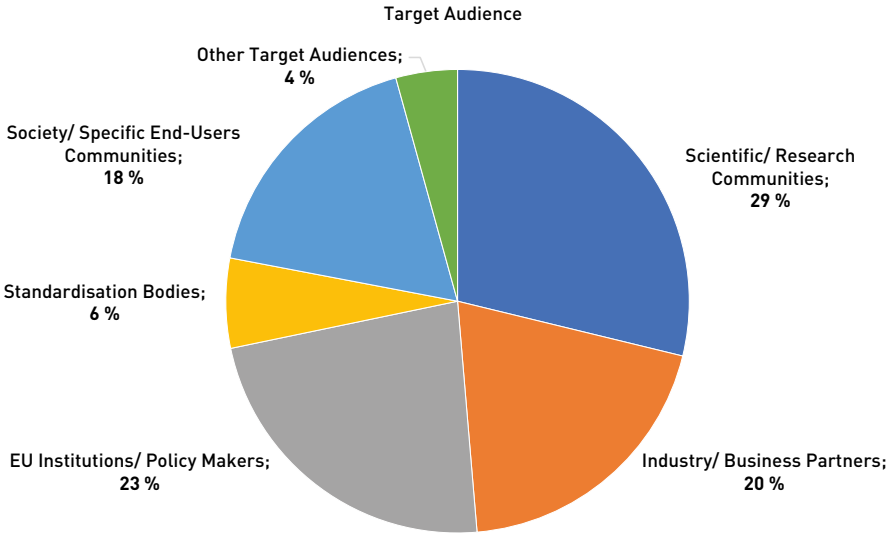
The types of reported dissemination activities consist of 4 main categories as shown in Figure 23: 37% of the activities were related to presentations of results in conferences, events and workshops, 21% to meetings with stakeholders, 18% to education and training and 14% to scientific publications.

Figure 23. Type of the dissemination activities performed by Clean Hydrogen JU projects in 2022



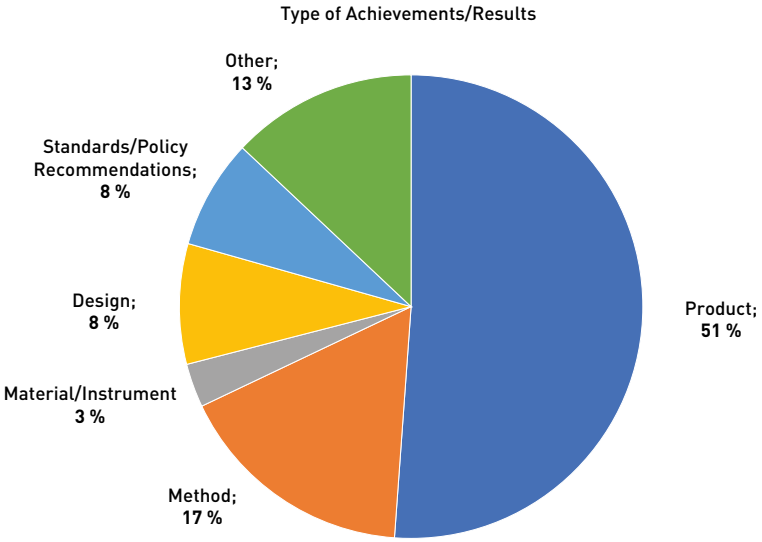
The dissemination activities had 5 main target audiences: 29% directed at scientific and research communities, 23% at EU institutions and policy makers, 20% at Industry and business partners, 18% at society and specific end-user communities and 6% at standardisation bodies (Figure 24).

Figure 24. Target audience of the dissemination activities performed by Clean Hydrogen JU projects in 2022



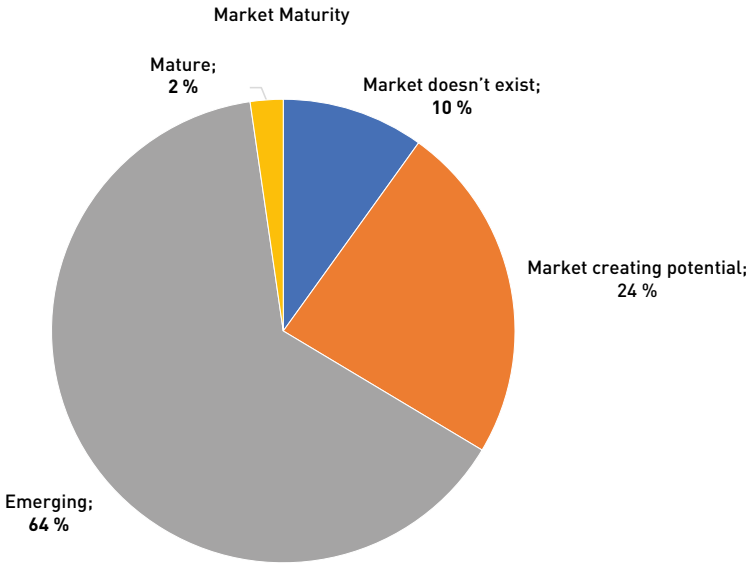
Achievements and results in the reference period are identified as products in 51% of cases, whereas methods account for 17%, design 8%, standards and policy recommendations 8% and material/instruments 3% (Figure 25).

Figure 25. Result type of the outcomes and projects results reported by the projects in 2022



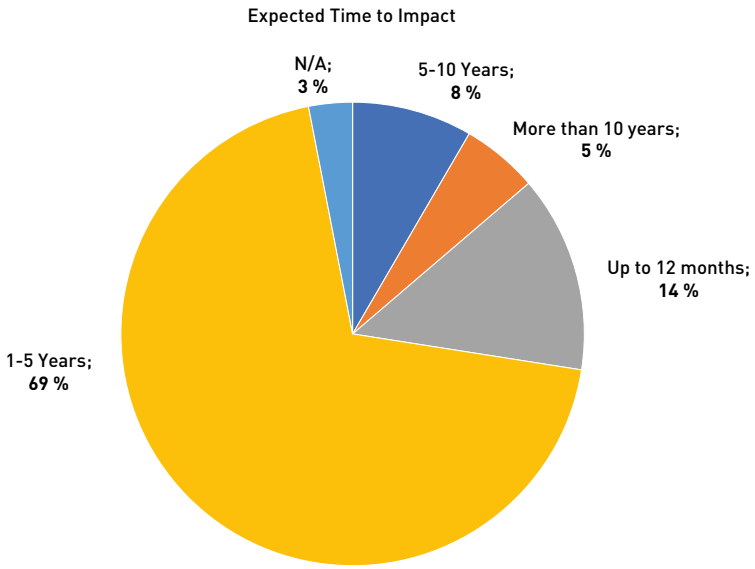
The market maturity analysis of the results and outcomes shows that almost 2 out of 3 of them (64%) are considered to be pointing to emerging markets, which is expected in terms of maturity of hydrogen technologies in general. Another 24% are flagged as having potential to create a market, while for 10% of them a market currently doesn't exist and only 2% of them are mature enough to be introduced into the market (Figure 26).

Figure 26. Market maturity linked to the results in 2022



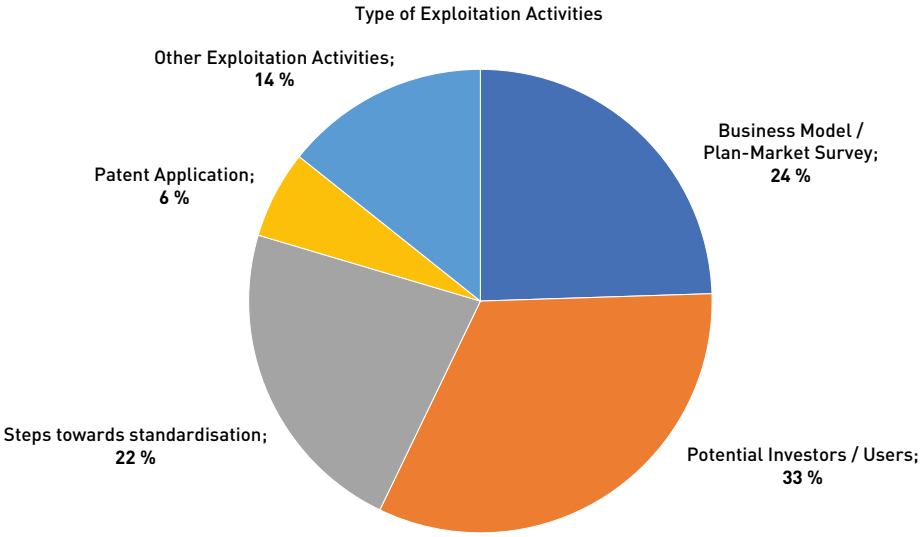
In terms of the expected impact the vast majority, almost 7 out of 10 (69%) of the results, are expected to have an impact in the next 1 to 5 years, while 14% are expected to have an impact within 12 months. The rest are more long-term: 8% are expected to have an impact in the next 5 to 10 years and 5% in more than 10 years (Figure 27).

Figure 27. Expected time to impact of the results reported in 2022



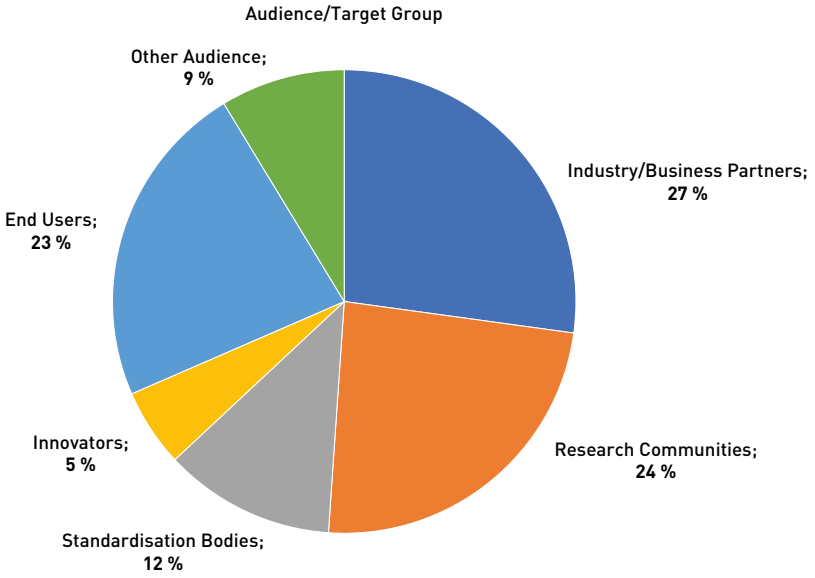
The **exploitation activities** performed by the projects to support the uptake of the results were quite diverse as well: 33% of them were about reaching out to potential investors and users, 24% were related to business models/plans and market surveys, 22% included steps towards standardisation and 6% focused on patent applications (Figure 28).

Figure 28. Types of exploitation activities performed by Clean Hydrogen JU projects in 2022



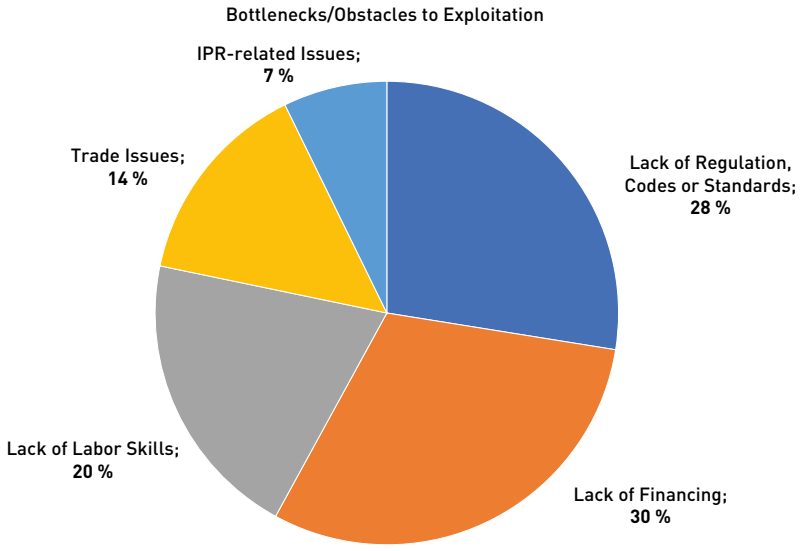
The target audiences of the exploitation activities are industry and business partners (27%), Research communities (24%), end users (23%), standardisation bodies (12%) and innovators (5%) (Figure 29). The vast majority (60.26%) were addressed to industry and-/or business partners, which indicates that these are the main user communities of the project results (especially those with low to medium TRLs) to advance to the next level. In addition, 15.38% of the activities targeted standardisation bodies and 8.97% research communities. Finally, some of them also targeted final users or innovators.

Figure 29. Target audiences of the exploitation activities performed by Clean Hydrogen JU projects in 2022



Finally, the main bottlenecks/obstacles identified by most of the projects in the efforts to exploit their results were the lack of financing (30%), the lack of regulations, codes and standards (28%), the lack of labour skills (20%), trade issues (14%) and IPR-related issues (7%) (Figure 30).

Figure 30. Bottlenecks and/or obstacles that hinder the exploitation of results



2. SUPPORT TO OPERATIONS

2.1. Communication activities

Throughout 2023, communication activities included the organisation of and participation in several events, the development of the programme's online tools and content on both the website and social media channels, and outreach campaigns and activities via traditional and online media. Equally important was the multi-annual communication strategy of the Clean Hydrogen JU (2022-2027) that was adopted by the Governing Board in December 2023. The strategy is implemented through annual communication plans (included in the AWPs).

2.1.1. European Hydrogen Week

The European Hydrogen Week, held in Brussels from 20-24 November, provided policymakers and industry with a forum to discuss the state of the hydrogen economy and for the Clean Hydrogen Partnership to present the innovative results of its various funded projects. More than 8,000 participants from the hydrogen community were on site. With more than 200 speakers in 27 sessions and over 200 exhibitors in the expo, the European Hydrogen Week was again the place to go to discuss policy, technology, and market opportunities. The week covered a comprehensive programme, including an exhibition, a policy conference and the B2B forum.

The **policy conference** at the 2023 European Hydrogen Week focused on strengthening the market and increasing both the scale and speed of the hydrogen economy, among important announcements by EU leaders regarding the launch of the world's first hydrogen bank.

Participants in the High-level policy conference – session 9
Source: Photo copyright – Clean Hydrogen Partnership

As part of the policy conference, the Clean Hydrogen Partnership coordinated six different sessions covering topics such as increasing funding impact, driving forward EU research and innovation in hydrogen technologies and empowering citizens, and two scientific workshops on Hydrogen production, distribution and storage and hydrogen end-uses.

The Clean Hydrogen Partnership was again present, with a booth within the **exhibition** of the European Hydrogen Week. Representatives of the Clean Hydrogen Partnership answered visitors' questions and provided information on various topics of interest, such as the call and funding schemes and all EU projects funded by the Clean Hydrogen Partnership.

A section of the exhibition was dedicated to EU projects. The **EU Projects pavilion** showcased several projects funded by the Clean Hydrogen Partnership: CAMELOT, MultHyFuel (Safety and Permitting for Hydrogen at

Multifuel Stations), HEAVEN (High powEr density FC System for Aerial Passenger VEhicle fueled by liquid HydrogeN), H2Haul project, JIVE/JIVE2, StasHH and Zero Emission Valley (ZEV).

Overall, attendees were able to meet more than 200 exhibitors, from industry to research, experience hydrogen and test hydrogen trucks and buses.

The **B2B Forum**, managed by Hydrogen Europe, complemented the 4-day programme. The forum covered the whole value chain through talks and discussions rounds and has been a source of inspiration and exchange.

2.1.2. Clean Hydrogen Partnership Awards

The sixth edition of the **Clean Hydrogen Partnership Awards** were presented as part of the European Hydrogen Week in Brussels on Wednesday 22 November 2023.The awards celebrated how European research and innovation continues to drive the clean energy revolution further and applauded the vision and drive of the pioneers in hydrogen technology. The award categories recognised the Best Innovation, Best Success Story, Best Project Outreach and the best European H2 Valleys of the Year.

Best Innovation Award

This was awarded to project HEAVEN – whose innovation brings us closer to emission-free aviation. The winner, HEAVEN ([107]), represents the first application of liquid hydrogen storage technology in aviation. The innovation was integrated with a hydrogen-electric fuel cell propulsion system in a light demonstrator aircraft that seats up to four people.

On 7 September, the project consortium successfully completed the world's first piloted flight of an electric aircraft powered by liquid hydrogen. The HY4 took off from Maribor airport, Slovenia. Of the four test flights conducted on the day, one lasted over three hours. The results indicate that using liquid, instead of gaseous hydrogen, doubles the range of the HY4 aircraft from 750 km to 1 500 km. This is a critical step towards the development of emissions-free, medium- and long-haul commercial flights. The award was handed over by Dr Bernd Biervert, Head of Clean Energy Transition Unit in DG Research & Innovation.

Best Success Story Award: clean power for heavy duty applications

The winner, StasHH ([108]) project, is helping to meet the growing demand for zero-emission heavy-duty transport through the standardisation of heavy-duty fuel cell modules. The standard is intended for European trucks, but can be transferred to all heavy-duty applications, both on land and sea.

StasHH has attracted significant attention and many vehicle manufacturers have asked to be involved. The project has established an advisory board that includes several multinational companies and is in contact with all other companies interested in the standard. Melissa Verykios, chair of the Clean Hydrogen Partnership governing board, presented the award.

Best Outreach Award: clean public transport

The award recognises project consortia that communicate their work to the public using a creative, well-planned campaign. The award winner, JIVE 2 ([109]) and its predecessor JIVE, are Europe's largest fuel cell bus deployment initiatives to date. They have demonstrated an unwavering commitment to increasing awareness of the technology, deploying buses and infrastructure across Europe, and making them commercially viable for bus operators to include in their fleets without subsidies. The fifth edition of the Zero Emission Bus conference in October 2023 also played a pivotal role in this recognition. One-fifth of the conference speakers represented JIVE project partners. The event served as a significant platform for sharing insights on and experiences of transitioning Europe's bus and coach fleets to zero emission. JIVE 2 has the goal of running 152 fuel cell buses in 14 cities in France, Germany, Iceland, the Netherlands, Norway, Sweden, and the UK, and achieving a maximum price of EUR 625 000 for a standard fuel cell bus.

[107] https://heaven-fch-project.eu/
[108] https://stashh.eu/
[109] https://www.fuelcellbuses.eu/projects/jive-2

European H2 Valley of the Year

Three hydrogen valley projects received this year's award for their outstanding efforts to develop integrated systems of hydrogen production, supply, storage and use in multiple sectors: Hydrogen Hub Noord-Holland ([110]), WIVA P&G ([111]) in Austria, and Green Hysland in Mallorca ([112]), Spain.

Green Hysland ([113]), which is funded by the Clean Hydrogen Partnership, aims to become Europe's first hydrogen island and a blueprint for other areas in Europe, producing green hydrogen from solar energy.

The Clean Hydrogen Partnership independent scientific advisory workshop took place as well during the High-Level Policy Conference, with two events dedicated to global technology trends and outlook and the need for a cross-sectoral approach.

As part of the European Hydrogen Week, several other side events took taken place, among which the following featured JU' projects and studies.

Winners of and participants in the Clean Hydrogen Partnership Awards – 2023 edition
Source: Photo copyright Clean Hydrogen Partnership

21 November 2024: Higgs – Closing Conference ([114]). The Closing Conference of the HIGGS Project addressed results and conclusions gained within the project. The following topics have been taken up: Experimental validation of gas grid components, technoeconomic validation of hydrogen injection and hydrogen integration in EU networks.

21 November 2024: **third European Hydrogen Ports Network event.** The event was organized in the framework of the 'Study on Hydrogen in Ports and Industrial Coastal Areas'. The aim of the study is to provide insights into the market potential and the emergence of the hydrogen economy, and it brings actors together to collaboratively seek solutions, exchange knowledge and accelerate deployment. The event showcased key findings of the study.

2.1.3. EU Hydrogen Research Days

The EU Hydrogen Research Days took place as part of the European Hydrogen Week on 15-16 November and were fully online events.

([110]) https://www.hydrogenhub.noordzeekanaalgebied.nl/#home
([111]) http://www.wiva.at/
([112]) https://greenhysland.eu/
([113]) https://greenhysland.eu/
([114]) https://www.clean-hydrogen.europa.eu/media/events/higgs-closing-conference-2023-11-21_en

They gave an overview of the progress of the projects funded by the Clean Hydrogen partnership focussing on the progress and achievements in the various pillars of the Clean Hydrogen programme. The days are also a platform for the wider scientific community to express its opinions on and views of the Programme of the Clean Hydrogen JU and other key issues concerning research and innovation in the clean hydrogen field. They were built around the following pillars: hydrogen production, distribution and storage, end-use applications in transport and heat and power, and cross-cutting technologies. They provided an excellent visibility platform for projects and technological developments achieved in the sector and networking opportunities for the participants.

All project posters presented during the week are published on the Clean Hydrogen website ([115]).

The events were recorded and all sessions can be found on YouTube ([116]).

2.1.4. Other events

The Clean Hydrogen Partnership organised or participated in several other events (exhibitions, workshops, seminars).

26 January 2023: Info Day for Call 2023

The Clean Hydrogen Partnership project officers informed attendees of this Info Day of the 2023 Call for proposals. The different presentations covered the topics in the call 2023, the rules for participation, information on call conditions, evaluation and submission, and the legal and financial aspects, among other things. It took place on 26 January as an online event. National info-days have also been organised in France, Spain, Italy, and Uinted Kingdom, with the participation of the Clean Hydrogen Partnership project officers.

The Clean Hydrogen Partnership at the high-level events with its booth in the adjacent exhibition
Source: Photo copyright – Clean Hydrogen Partnership

[115] https://www.clean-hydrogen.europa.eu/european-hydrogen-week/european-hydrogen-week-2023/european-hydrogen-week-2023-about-our-projects_en
[116] https://www.youtube.com/playlist?list=PLIYeKKxYfyk1b_YxBIGb3omKIHh3E17AB

1-2 February 2023: Hyvolution Paris 2023 [117]

More than 7800 people attended the Hyvolution 2023 in Paris. The Clean Hydrogen Partnership has been part of the exhibition and presented the details of the call for proposals in an info day targeting potential beneficiaries from France.

28 February – 1 March 2023: Workshop 'Towards an EU roadmap for hydrogen valleys – Regional actors and their role' [118]

The workshop [119] was organised by the Clean Hydrogen Partnership, the European Hydrogen Valleys Partnership and the North Netherlands region. Regional and local actors talked about opportunities and challenges in rolling-out and scaling-up Hydrogen Valleys in Europe. The workshop was by invitation only and targeted stakeholders of existing and future hydrogen valleys.

The two-day workshop preceded a high-level event organised by the European Commission in the afternoon of 1 March. The event, entitled "Repowering the EU with Hydrogen Valleys: showcasing innovative solutions" took place in-person on 1 March 2023 in Autoworld, Brussels. The event was organised by the European Commission's DG Research and Innovation, and supported by Hydrogen Europe, Hydrogen Europe Research and the Clean Hydrogen Partnership.

The Commission and key stakeholders signed a joint declaration highlighting the crucial role of sustained efforts in renewable hydrogen research and innovation on 1 March, during the high-level event.

17-21 April 2023: Hannover Messe 2023

As one of the most important international platforms and a hot spot for industrial transformation the Hannover Messer 2023 was an opportunity for the Clean Hydrogen Partnership to raise awareness of the activities of the partnership and to build a network in an international context. The Clean Hydrogen Partnership participated in the exhibition with a joint booth, alongside NOW – the German organisation managing the German National Innovation Programme for Hydrogen and Fuel Cell Technology.

25 – 26 April 2023 – Clean Aviation and Clean Hydrogen joint workshop on H2-powered aviation

Representatives of the European aeronautic and hydrogen industries and research communities gathered in Brussels on 25 – 26 April 2023, for a workshop jointly organised by the Clean Aviation and Clean Hydrogen Joint Undertakings (JUs).

The workshop comprised a plenary session, where the status of the hydrogen-powered aviation roadmap was presented, along with six technical sessions on topics including H2 aircraft architectures, on-board liquid hydrogen storage, H2-burn gas-turbines powertrain system, H2 Fuel-Cell integrated powertrain system, refuelling processes, airport infrastructures and ground operations, as well as safety and certifications.

Considering the Strategic Research and Innovation Agendas of the Clean Aviation and Clean Hydrogen Joint Undertakings, along with the hydrogen-powered aviation roadmap, participants identified potential gaps and barriers within the roadmap. This resulted in a set of key recommendations, including to accelerate the H2 technology maturation, integration and demonstration, increase alignment between the two partnerships and Horizon Europe Cluster 5 Work Programme, and gain more understanding on the climate impact of H2-powered aviation emissions (non-CO2 emissions).

Read more on the workshop's key messages and recommendations.

08 May 2023: Re-launch event of the Hydrogen Valleys Platform 2.0! [120]

The Mission Innovation Hydrogen Valley Platform has been revised and re-launched. The event was the official relaunch of the platform to the public and showcased all features and the overall platform design. The new

[117] https://www.clean-hydrogen.europa.eu/media/events/hyvolution-paris-2023-2023-02-01_en
[118] https://www.clean-hydrogen.europa.eu/media/events/workshop-towards-eu-roadmap-hydrogen-valleys-regional-actors-and-their-role-2023-02-28_en
[119] https://www.clean-hydrogen.europa.eu/media/events/workshop-towards-eu-roadmap-hydrogen-valleys-regional-actors-and-their-role-2023-02-28_en
[120] https://www.clean-hydrogen.europa.eu/media/events/re-launch-event-hydrogen-valleys-platform-20-2023-05-08_en

platform includes an extensive collection of primary data from the projects and provides comprehensive insights into the most advanced and ambitious Hydrogen Valleys around the globe.

07 July 2023: Webinar: What do Europeans know about hydrogen technologies? A state of play of public awareness, acceptance and uptake of hydrogen technologies ([121])

On 7 July 2023, this webinar event discussed the results of the public opinion survey on the public awareness of hydrogen technologies in Europe ([122]) and presented the objectives of HyPop, a new project in this field , funded by the Clean Hydrogen JU under its 2022 call for proposals. The event highlighted some practical implications for messaging and policy, including the role of different actors in promoting the uptake and adoption of hydrogen technologies.

29 September 2023: European Hydrogen Observatory Relaunch ([123])

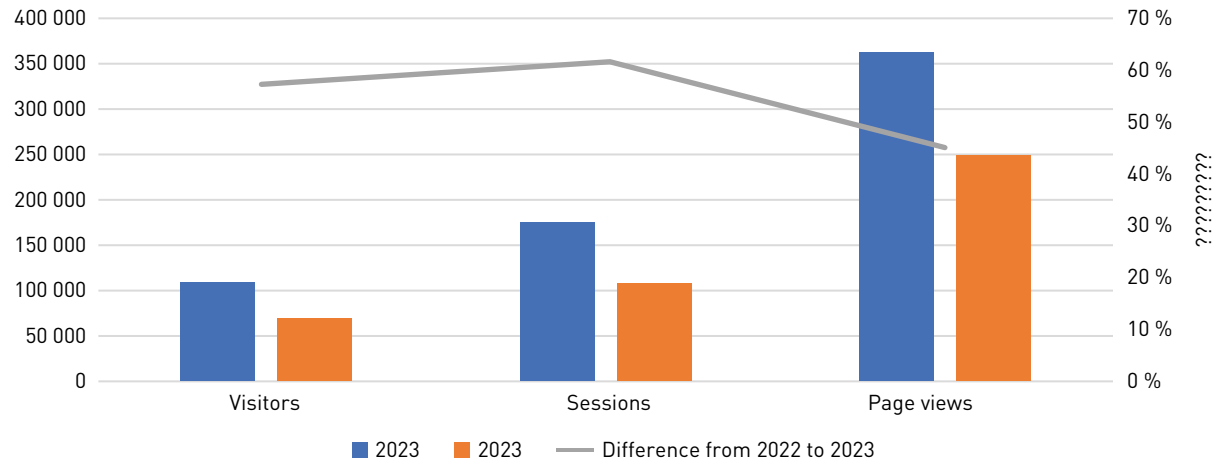
The event showed the new Observatory and involved a walkthrough of the platform. The observatory provides valuable insights and analysis regarding the deployment of fuel cell and hydrogen technologies in Europe by curating the latest data and statistics. It is a platform for collaboration and knowledge exchange, with the ultimate objective of accelerating the adoption of hydrogen technologies.

09-12 October 2023: ZEB and Busworld 2023 ([124])

The fifth edition of the European Zero Emission Bus Conference was held concurrently with Busworld Europe 2023 at Brussels Expo. Operators, policy-makers, manufacturers and representatives of industry from around the world met to discuss the decarbonisation of the bus and coach industry. The Clean Hydrogen Partnership contributed to the Conference Opening Day and the Panel on HRS Infrastructure: Challenges and Solutions' on Day 2.

2.1.5. Website developments and statistics

Figure 31. Visitors, sessions and page views



Year-over-year growth is observed, with Visitors increasing by 57.19 %, Sessions by 61.39 %, and Page views by 45.11 %, from 2022 to 2023

A full audit of the website was performed in 2023 to evaluate the Clean Hydrogen Partnership website and its email newsletters on key areas such as usability, functionality, and user experience. The website was assessed on navigation, content organisation, and technical factors, while the newsletters were examined

([121]) https://www.clean-hydrogen.europa.eu/media/events/webinar-what-do-europeans-know-about-hydrogen-technologies-state-play-public-awareness-acceptance-2023-07-07_en
([122]) https://www.clean-hydrogen.europa.eu/media/news/what-do-europeans-know-about-hydrogen-technologies-2023-07-07_en
([123]) https://www.clean-hydrogen.europa.eu/media/events/european-hydrogen-observatory-relaunch-2023-09-29_en
([124]) https://www.clean-hydrogen.europa.eu/media/events/zeb-and-busworld-2023-2023-10-09_en

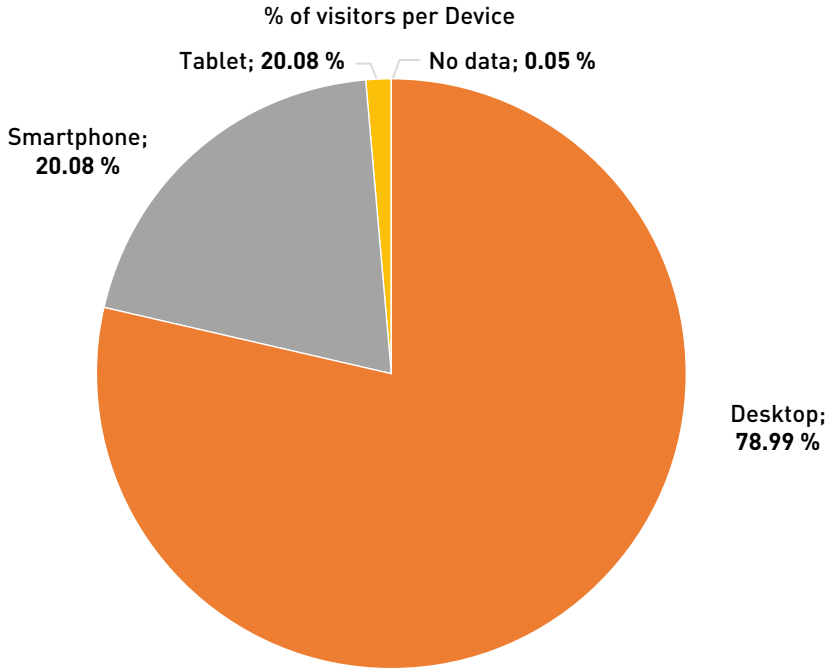
for design, call-to-action effectiveness, and performance metrics. The audit found that in general, the website and its associated email newsletters are largely effective in delivering a positive user experience. However, this audit has identified multiple areas for enhancement. A total of 82 recommendations were made of ways to address various aspects of the site, all aimed at boosting user engagement and overall satisfaction, and several started to be addressed in 2023.

Website statistics show a year-over-year growth with the number of visitors increasing by 57.19%, number of Sessions by 61.39%, and Page views by 45.11%, from 2022 to 2023 (Figure 31). The percentage of Returning Visitors also increased by 1.15% from that of 2022.

The website has recorded an increase in visitors of 57.19% compared to 2022.

Overall, 107 464 visitors engaged with the website during the year, starting strong in January, experiencing a decline towards the middle of the year and then showing a resurgence towards the end of the year.

Figure 32. Percentage of visitors per device



Visitor distribution by country shows the United States and Germany leading with over 10 000 users each, followed by Belgium, Spain and other European countries, along with notable user bases from India and Japan, reflecting a diverse and global audience. This distribution was almost the same in 2022. About 79 % of visitors visit the website using a desktop PC, followed by smartphone with 20 % and only a small proportion via a tablet (Figure 32).

2.1.6. Social media developments

In 2023, social media presence was strengthened. This was possible by actively posting relevant content, events and news. A particular focus was on taking up project postings and actively linking projects and stakeholders.

The **Twitter/X account** of the Clean Hydrogen Partnership had grown to 8 930 followers by the end of 2023. During the promotion of the EU Research Days and European Hydrogen week between 1 September and 30 November, it achieved 602 impressions per day, received 599 likes and gained 118 followers.

The **LinkedIn** page grew to 38 584 followers in 2023, with 7 314 unique visitors. The LinkedIn channel reaches a diverse target group. Most followers are accessing the channel from France, Belgium, the Netherlands and the United Kingdom. On LinkedIn, 119 posts were published between 1 September 2023 and 18 December

2023 as part of the promotion activities for the European Hydrogen Week and EU Research Days. Those posts made 284 453 impressions. The page gained 2 279 followers in that period.

The **YouTube channel** is the place for all videos related to the Clean Hydrogen Partnership. The two YouTube channels have been merged and only the main channel remains.

Several videos and recordings of events were uploaded on the YouTube channel in 2023, showcasing all major events run/attended by the Clean Hydrogen Partnership and some other events. Overall, 26 videos were added to the YouTube Channel from September 2023 to December 2023. The YouTube channel now has 554 subscribers.

Monthly newsletters based on the Newsroom platform provided by DG Connect were sent out throughout 2023 to 13 983 subscribers. In total 27 newsletters were sent out (25 news alerts containing important updates and 2 full newsletters, one in July and one in December).

2.1.7. Public outreach activities

Public opinion Survey: What do Europeans know about hydrogen technologies?

Europeans across all sociodemographic subgroups have a high level of awareness of hydrogen energy, with over 8 in 10 respondents (82%) declaring that they have seen, read or heard something about hydrogen (82%), according to a new public opinion survey conducted in autumn 2022 that analysed European citizens' attitudes towards and level of knowledge of hydrogen technologies.

69 % of the respondents believe that hydrogen is a sustainable energy source. In particular, hydrogen is considered positively in terms of its environmental impact with an average rating of 3.9 out of 10. In comparison, fossil energy is widely seen to have the most negative impact on the environment with an average rating of 7.7 out of 10. Most Europeans (70%) agreed that hydrogen has a role to play in reducing the energy dependence of their country.

Hydrogen is also seen as safe. Overall, almost 6 in 10 (59%) respondents in the EU believe that hydrogen is as safe as any other energy source. Only 17% disagreed with the claim that hydrogen energy was safe, but there was a high level of 'don't know' responses (24%), suggesting a key gap in current public knowledge.

The most widely known application is the use of hydrogen as fuel for transport (76%), followed by its use in certain industries to reduce their impact on the environment (56%). The use of hydrogen for heating is less well known, with only 42% aware of this application. Just over 1 in 10 (13%) respondents have experienced hydrogen energy in any of these three applications (vehicle fuel, industry use and domestic heating).

The survey also highlights a drive to receive more information, with 7 in 10 respondents interested in receiving more information about hydrogen energy.

Traditional media (e.g. television) and the internet 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 a television and 30% would discuss the issue with friends and relatives. Only 6% of respondents claim never to look for information about energy.

The study was conducted by Gallup International following a call for tenders launched back in 2021 by the predecessor of the Clean Hydrogen Partnership, the FCH JU.

More information about the survey results can be found in the Survey report and Executive summary, and in the country factsheets available on the website ([125]).

Webinar outcomes

The state of play of public awareness was explored in a webinar took placed on 7 July 2023, with the participation of industry, policy and research representatives.

([125]) https://www.clean-hydrogen.europa.eu/media/publications/awareness-hydrogen-technologies-survey-report_en

The event discussed the results of the public opinion survey on the public awareness of hydrogen technologies in Europe and presented the objectives of HyPop, a new project in this field, funded by the Clean Hydrogen JU under its 2022 call for proposals. Participants highlighted some practical implications for messaging and policy, including the role of different actors in promoting the uptake and adoption of hydrogen technologies.

The recording of and the presentations from the webinar are available on the website ([126]).

Media campaign

Throughout 2023 the Clean Hydrogen Partnership has increased its media outreach efforts, with the following objectives:

- Create a positive narrative around hydrogen, as an important part of the solution to the current energy challenges.
- Earn positive, quality coverage of the Clean Hydrogen Partnership and the breakthroughs and opportunities available in the hydrogen sector, especially in those countries lagging behind in the development of the sector.
- Communicate successfully about the 2023 call for proposals, provide information about the available funds and generate a high number of valuable applications.

Several interviews and articles resulting from press releases / pitches were published in various European media throughout the first half of 2023 (January – June 2023), up to the expiration of the contract concluded in this respect with a specialised company. Efforts focused on EU countries in Central, Eastern and Southern Europe, and in countries such as Spain, Italy and Greece where we followed the impact of recent projects funded by the Clean Hydrogen JU. A total of 28 media articles and interviews were published, reaching up to 6 942 354 people (total of declared monthly audience) (Table 18).

[126] https://www.clean-hydrogen.europa.eu/media/publications/awareness-hydrogen-technologies-survey-report_en

Table 18. Published media articles and interviews related to the Clean Hydrogen JU

NR.	DATE	TYPE	COUNTRY	MEDIA	TITLE (ORIGINAL LANGUAGE)	LINK	AUDIENCE/ MONTH
1	17/01/2023	online	RO	G4media.ro	€195million -competition for EU projects creating hydrogen energy	https://www.g4media.ro/195-de-milioane-de-euro-competitie-pentru-proiecte-in-ue-care-sa-creeze-tehnologii-in-domeniul-utilizarii-hidrogenului-ca-sursa-de-energie.html	8 800,00
2	17/01/2023	TV	RO	TVR Info	Banii, azi TV programme	N/A	590 000
3	17/01/2023	Online	RO	TVR Plus	First European money for hydrogen projects	https://www.tvrplus.ro/emisiuni/banii-azi-120-114	97 654
4	17/01/2023	Online	RO	Cotidianul	€195million -competition for EU projects creating hydrogen energy	https://cotidianonline.ro/195-de-milioane-de-euro	823 200
5	30/01/2023	Online	PL	Polski Przemysl	195 million euros for projects that support hydrogen	https://polskiprzemysl.com.pl/wiadomosci-ze-swiata/dofinansowanie-na-technologie-wodorowe/	23 887,00
6	30/01/2023	Online	PL	Business.newseria.pl	195 million euros for projects that support hydrogen technologies	https://biznes.newseria.pl/biuro-prasowe/energetyka/195-mln-euro-trafi-w-rece,b1642500324	21 177,00
7	30/01/2023	Online	PL	Logistyka.com.pl	195 million euros for projects that support hydrogen technologies	195 mln EURO trafi w ręce projektów, wspierających technologie wodorowe (logistyka.net.pl)	85 813,00
8	30/01/2023	Online	PL	ZielonaGospodarka.pl	195 million euros for projects that support hydrogen technologies	195 mln euro na projekty wspierające technologie wodorowe – ZielonaGospodarka.pl	29 000,00
9	30/01/2023	Online	PL	Innowacje.newseria.pl	195 million euros for projects that support hydrogen technologies	Partnerstwo Na Rzecz Czystego Wodoru właśnie ogłosiło nabór wniosków na 2023 rok – Energetyka – Newseria Innowacje	19 500,00
10	30/01/2023	Online	PL	smart-grids.pl	195 million euros for projects that support hydrogen technologies	https://www.smart-grids.pl/aktualnosci/finanse/4260-195-mln-euro-na-projekty-wspieraj%C4%85ce-technologie-wodorowe.html	22 100,00
11	31/01/2023	Online	PL	polskaekologia24.pl	195 million euros for projects that support hydrogen technologies	http://www.polskaekologia24.pl/zielone-technologie/informacje-o-dziale/2163/partnerstwo-na-rzecz-czystego-wodoru-wlasnie-oglosilo-nabor-wnioskow-na-2023-rok	15 100,00
12	02/02/2023	Online	PL	production-manager.pl	195 million euros for projects that support hydrogen technologies	https://www.production-manager.pl/2023/02/01/195-mln-eur-na-technologie-wodorowe/	20 450,00
13	18/02/2023	Online	RO	Antena 3	România poate lua 195de milioane euro, bani europeni pentru hidrogen.	https://www.antena3.ro/be-eu/romania-195-milioane-euro-bani-europeni-hidrogen-666135.html	8 200,00
14	18/02/2023	TV	RO	Antena 3	România poate lua 195de milioane euro, bani europeni pentru hidrogen.	N/A	259 000
15	18/03/2023	online	CZ	techsvet.cz	Last month to register clean hydrogen projects	https://techsvet.cz/komercni/posledni-mesic-na-prihlaseni-vodikovych-projektu/jakubreh/vodoroda/?fbclid=IwAR2NNCxIwYGKHkpy5l90dEhFe5LGdDgn516Qg1z5VxeKRJ_Gm6ZUBsR5XjI	729 800
16	08/03/2023	online	CZ	hybrid.cz	The EU will give away €195 million for hydrogen technology, but is it worth it?	The EU will give away €195 million for hydrogen technology, but is it worth it? (hybrid.cz)	78 000
17	08/03/2023	online	CZ	scienceweek.cz	EU to hand out €195m for hydrogen technology	https://www.scienceweek.cz/eu-rozda-195-milionu-eur-na-vodikove-technologie-ma-to-ale-vubec-cenu-iid-190017	5 000

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NR.	DATE	TYPE	COUNTRY	MEDIA	TITLE (ORIGINAL LANGUAGE)	LINK	AUDIENCE/ MONTH
18	08/03/2023	online	CZ	enviweb.cz		https://www.enviweb.cz/124537	5 000
19	21/03/2023	online	CZ	Mar energyhub.eu/cz	Last month to register clean hydrogen projects	https://www.energyhub.eu/cs/articles/764745/posl	5 000
20	21/03/2023	online	CZ	pro-energy.cz	Last month to register clean hydrogen projects	https://pro-energy.cz/news/detail/764745	30 700
21	23/03/2023	online	CZ	solarninovinky.cz 78	Last month to register clean hydrogen projects	https://www.solarninovinky.cz/nove-dota ce -na -vod	5 000
22	24/03/2023	online	CZ	scienceweek.cz	Last month to register clean hydrogen projects	https://www.scienceweek.cz/posledni-mesic-na-pri	5 000
23	21/03/2023	online	SK	euractiv.sk	Union wants to double the number of hydrogen valleys by 2025	Únia chce do roku 2025 zdvojnásobiť počet vodíkových údolí – euractiv.sk	104 300
24	19/04/2023	online	GR	newmoney.gr	Mirela Atanasiu (Clean Hydrogen JU): two Hydrogen Valleys coming to Corinth and Crete	https://www.newmoney.gr/roh/palmos-oikonomia	4 100 000
25	28/04/2023	online	UK	portstratgey.com	Ports H2 supply and demand study	https://www.portstrategy.com/environment-and-sustail	34 700
26	28/04/2023	online	ES	h2businessnews.com	Study on green hydrogen in ports and industrial coastal areas published	https://h2businessnews.com/publican-estudio-sobre-el	20 700
27	28/04/2023	online	IT	hydronews.it	Deloitte Belgium publishes the first study on H2 in ports commissioned by the Clean Hydrogen Partner	https://hydronews.it/deloitte-belgium-pubblica-il-p	49 300
28	May/June	print	CZ	Hospodarske noviny	Interview with Mirela Atanasiu	N/A	N/A

NB: N/A, not applicable.

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2.2. Legal and financial framework

In 2023, the following new rules have been adopted:

- Decision of the Governing Board of the Clean Hydrogen JU on working time and hybrid working – Governing Board Decision number CleanHydrogen-GB-2023-17 (Ares(2023)7767215);
- Decision of the Governing Board of the Clean Hydrogen JU on deputising rules to ensure the continuity of service – Governing Board Decision number CleanHydrogen-GB-2023-15 (Ares(2023)7767555).

Furthermore, regarding **Data Protection,** as an EU body applying Regulation (EU) 2018/1725, the Clean Hydrogen JU continued its data protection activities in 2023. The legal framework was updated in light of the European Data Protection Supervisor's (EDPS) supervisory opinion on the status of the Paymaster Office (PMO) of the European Commission in the service level agreements signed with EU Institutions, Offices and Agencies, where the PMO's role is identified as a separate controller.

In addition, in consideration of the EDPS's Prior-checking opinions on the management of experts and Grants Award and Management in the Participant Portal, the roles of Regulatory Agencies, Executive Agencies and Joint Undertakings have been identified as co-controllers together with DG RTD of the European Commission. These changes have entailed a revision of the specific data-sharing agreements, with the PMO and DG RTD respectively, aiming to clarifying the roles and responsibilities of each controller.

2.3. Budgetary and financial management

2.3.1. Budget

The Clean Hydrogen JU budget comprises revenue and expenditure.

On the expenditure side, the budget is divided into three titles:

- Title 1 covers staff expenditure, such as salaries, allowances and benefits, contributions, and taxes. In addition, it includes expenses for training, missions and medical services, and the costs associated with the recruitment procedure and representation costs;
- Title 2 covers the costs associated with the functioning of the Programme Office, such as the rent of premises, IT needs, expenses related to external communication, the cost of ex-post audits and the running costs in connection with operating activities, other service contracts and various office supplies;
- Title 3 covers expenditure related to operational activities of Clean Hydrogen JU for the FP7, H2020 and HE programmes, JRC collaboration, procurement activities and experts' fees.

Compared with 2022, the 2023 appropriations related to Titles 1 and 2 decreased by 7.42% in terms of commitments and by the same percentage in terms of payments in relation to the launch of the Clean Hydrogen JU. Appropriations related to Title 3 included commitment and payment appropriations for the third call for proposals under Horizon Europe and other operational expenditure such as procurement activities and experts' fees.

There were two budget amendments, one budget revision and two budget transfers in 2023. The first amendment introduced the reactivation of administrative commitment appropriations (CA) and payment appropriations (PA) to cover administrative procurement activities and increased needs in service contracts; the budget revision introduced increased revenues to align JU's budget with the EU voted budget for the Clean Hydrogen JU for 2023; the first amendment to the revised budget introduced the reactivation of commitment appropriations to cover operational activities owing to a lack of commitment credits to cover an additional payment of a completed H2020 project and 3 specific contracts of HE procurement activities. An overview of the initial budget and amendments is presented in Table 19.

Table 19. Budget for year 2023 – statement of revenue with initial voted budget, amendments, and budget revision

STATEMENT OF REVENUE	VOTED BUDGET 2023		AMENDED BUDGET 1 2023		REVISED BUDGET 1 2023		AMENDED REVISED BUDGET 1 2023	
HEADING	COMMITMENT APPROPRIATIONS (IN EUR)	PAYMENT APPROPRIATIONS (IN EUR)	COMMITMENT APPROPRIATIONS (IN EUR)	PAYMENT APPROPRIATIONS (IN EUR)	COMMITMENT APPROPRIATIONS (IN EUR)	PAYMENT APPROPRIATIONS (IN EUR)	COMMITMENT APPROPRIATIONS (IN EUR)	PAYMENT APPROPRIATIONS (IN EUR)
EU contribution (excl. EFTA and third country contributions)	**198 709 380**	**279 666 110**	**198 709 380**	**279 666 110**	**198 709 380**	**279 535 646**	**198 709 380**	**279 535 646**
of which Administrative	3 530 303	3 266 235	3 530 303	3 266 235	3 530 303	3 324 084	3 530 303	3 324 084
of which Operational	195 179 077	276 399 875	195 179 077	276 399 875	195 179 077	276 211 562	195 179 077	276 211 562
EFTA and third countries contribution	**64 820 923**	**42 681 089**	**64 820 923**	**42 681 089**	**65 640 675**	**43 792 080**	**65 640 675**	**43 792 080**
of which Administrative		68 918		68 918		81 440		81 440
of which Operational	4 820 923	6 612,171	4 820 923	6 612 171	5 640 675	7 710 640	5 640 675	7 710 640
of which Operational third countries excluding EFTA	60 000 000	36 000 000	60 000 000	36 000 000	60 000 000	36 000 000	60 000 000	36 000 000
Financial Members other than the Union contribution	**3 530 303**	**3 335 153**	**3 530 303**	**3 335 153**	**3 530 303**	**3 405 524**	**3 530 303**	**3 405 524**
of which Administrative	3 530 303	3 335 153	3 530 303	3 335 153	3 530 303	3 405 524	3 530 303	3 405 524
Unused appropriations of previous years	**127 395**	**834,022**	**427 395**	**1 134 022**	**427 395**	**993 279**	**899 883**	**993 279**
Reactivation of unused appropriations from administrative expenditure	**127 395**	**517 694**	**427 395**	**817 694**	**427 395**	**676 951**	**427 395**	**676 951**
Of which from 2021	127 395	517 694	127 395	517 694	127 395	517 694	127 395	517 694
Of which from 2022			300 000	300 000	300 000	159 257	300 000	159 257
Reactivation of unused appropriations from operational expenditure	**0**	**316 328**	**0**	**316 328**	**0**	**316 328**	**472 488**	**316 328**
Of which from 2021		316 328		316 328		316 328		316 328
Of which from 2022							472 488	
TOTAL	**267 188 000**	**326 516 374**	**267 488 000**	**326 816 374**	**268 307 752**	**327 726 529**	**268 780 240**	**327 726 529**

NB: EFTA, European Free Trade Association.

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2.3.2. Budget execution

2.3.2.1. Administrative expenditure

The Clean Hydrogen JU's administrative budget execution increased to 80.33% (compared to 79% in 2022) in terms of commitment appropriations.

In terms of payments appropriations, the execution rate also increased to 74.90% (from 73% in 2022).

More specifically, Title 1 commitment and payment rates decreased compared to 2022 (commitment rates: 87.41% in 2023 and 97% in 2022, payment rates: 86.10% in 2023 and 96% in 2022). Staff in active employment comprises 52% of total administrative budget but there was a decrease in 2023 and showed a commitment rate of 87.46%, due to the process of recruiting for four positions (Budget Officer, Executive Director, seconded national expert (SNE) and Synergies Officer).

The mission budget execution rate decreased to 76.66% in 2023 (from 97% in 2022) mostly due to the departure of the Clean Hydrogen JU's Executive Director in May 2023.

Title 2, on the other hand, improved in terms of both commitment and payments rates compared with those of 2022 (committed: 71.21 % in 2023 and 62 % in 2022, paid: 60.60 % in 2023 and 51 % in 2022). All budget lines show an execution rate below 90 % apart from that of Information, communication technology and data processing. However, two of the budget lines are mainly responsible for the overall low execution rate in 2023 (see above):

- Meeting expenses, where some meetings were foreseen, but ultimately not carried out;
- Service contracts, where the Framework Contract for the Technical Assistance to the Programme Office was signed only at the end of December of 2022 with no possibility of signing the specific contract (and the corresponding commitment) before year-end, meaning the contract did not run for the entire year but only for 8 months.

2.3.2.2. Operational expenditure

The budget execution reached 97.09% of commitment appropriations in 2023, mostly due to the global commitment related to the 3rd call for proposals under Horizon Europe which launched in January 2023. For Horizon 2020, the budget execution in terms of commitment decreased from 84 % in 2022 to 61.39 %. This was due to the inscription as commitment appropriations of some amounts coming from ex-post audits or MIM (Mutual Insurance Mechanism) interventions. There were not new calls for the Programme H2020, so these amounts were never committed again. For payments, the execution reached 69.41 % in 2023 (81 % in 2022). This low implementation rate is due to several delays in grant implementation that were mitigated with amendments that shifted payment from 2023 to 2024. Other delays resulted in claims being much lower than initially estimated. For Horizon Europe, the budget execution decreased to 97.10 % in terms of commitments (from 99 % in 2022) due to a study planned for 2023 that had to be postponed to 2024. For payments, the execution rate reached 89.16 % in 2023 (59% in 2022), with the remaining amount paid at the beginning of 2024 following the signature of some grant agreements before the deadline of February 2024. The overall execution rate in payments reached 85.67% and increased 21 percentage points from 2022 (Table 20).

Table 20. Budget 2023 – statement of expenditure

STATEMENT OF REVENUE	COMMITMENTS				PAYMENTS			
HEADING	AMENDED BUDGET 2023 (AWP)	AMENDED BUDGET 2023 AFTER TRANSFERS	EXECUTED BUDGET 2023	%	AMENDED BUDGET 2023 (AWP)	AMENDED BUDGET 2023 AFTER TRANSFERS	EXECUTED BUDGET 2023	%
Title 1 – Staff expenditure	4 233 776.82	4 233 776.82	3 700 697.15	87.41%	4 233 776.82	4 233,776.82	3 644 352.11	86.08%
Salaries & allowances	3 952 526	3 937 526	3 443 867.39	87.46%	3 952 526	3 872 526	3 341 890.37	86.30%
Expenditure relating to Staff recruitment	5 000	5 000	982.97	19.66%	5 000	5 000	982.97	19.66%
Mission expenses	61 250.82	76 250.82	75 000.00	98.36%	61 250.82	76 250.82	58 450.63	76.66%
Socio-medical infrastructure (incl. training)	45 000	45 000	39 689.69	88.20%	45 000	45 000	19 884.86	44.19%
External services	166 000	166 000	140 157.10	84.43%	166 000	231 000	222 988.00	96.53%
Receptions, events and representation	4 000	4 000	1 000.00	25.00%	4 000	4 000	155.20	3.88%
Title 2 – Infrastructure and operating expenditure	**3 288 981.65**	**3 288 981.65**	**2 342 185.43**	**71.21%**	**3 288 981.65**	**3 288 981.65**	**1 992 930.92**	**60.60%**
Rental of buildings and associated costs	440 166.19	440 166.19	381 637.57	86.70%	440 166.19	440 166.19	380 528.84	86.45%
Information, communication technology and data processing	462 815.46	462 815.46	436 981.45	94.42%	462 815.46	462 815.46	443 221.90	95.77%
Movable property and associated costs	20 000	20 000	14 877.11	74.39%	20 000	20 000	14 877.11	74.39%
Current administrative expenditure	9,000	9 000	6 000.00	66.67%	9 000	9 000	5 526.76	61.41%
Postage / Telecommunications	11 000	11 000	10 000.00	90.91%	11 000	11 000	6 349.21	57.72%
Expenditure on formal meetings	50 000	50 000	44 701.25	89.40%	50 000	50 000	11 323.37	22.65%
External communication information and publishing	755 000	755 000	606 415.60	80.32%	755 000	755 000	640 314.43	84.81%
Service contracts	1 541 000	1 541 000	841 572.45	54.61%	1 541 000	1 541 000	490 789.30	31.85%
Title 3 – Operational expenditure	**261 338 349.17**	**261 338 349.17**	**253 726 711.11**	**97.09%**	**320 284 638.73**	**320 284 638.73**	**274 396 682.87**	**85.67%**
Previous years' Calls/other funded actions	518 597.17	518 597.17	196 362.64	37.86%	61 318 051.7561	61 318 051.75	43 490 954.31	70.93%
Current year's Calls/other funded actions	260 819 752	260 819 752	253 530 348.47	97.21%	258 966 587	258 966 587	230 905 728.56	89.16%
TOTAL	**268 861 107.64**	**268 861 107.64**	**259 769 593.69**	**96.62%**	**327 807 397.20**	**327 807 397.20**	**280 033 965.90**	**85.43%**

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2.4. Financial and in-kind contributions from Members other than the Union

This section builds on and provides more details to overall summary provided in the Section 1.2.4 'Information on quantitative and qualitative leverage effects'. JU Members other than the EU contribute to the JU in the following ways:

- Financial contributions of the Members to the running costs of the Clean Hydrogen JU;
- co-financing required to carry out R&I actions supported by the Clean Hydrogen JU (i.e. in-kind contributions in operational activities (IKOP) through co-funding Clean Hydrogen JU projects);
- contributions towards additional activities (IKAA) by members other than the EU or their constituent or affiliated entities, as specified in an additional activities plan, which should represent contributions to the broader FCH Joint Technology Initiative and the sector as a whole.

In 2023, contributions from JU Members other than the Union are presented in Table 21.

Table 21. Contributions from members other than the EU, 2023 (EUR)

CONTRIBUTIONS FROM JU MEMBERS OTHER THAN THE UNION IN 2023	
NATURE	AMOUNT (IN €)
Financial contributions (FC) reported	3 405 524
In-Kind to Operational Activities (IKOP) reported	20 174 200
In-Kind to Additional Activities (IKAA) reported 2022	240 429 088
In-Kind to Additional Activities (IKAA) provisional 2023	444 905 473
TOTAL all contributions reported	**708 914 285**
TOTAL all contributions reported, including certified IKAA	**708 914 285**

The certification of In-Kind Contributions to operational activities (IKOP) is still ongoing. Cumulated in-kind contributions to operational activities up to 2023 is presented in Table 22.

Table 22. Evolution of cumulated IKOP up to 2023 (EUR)

VALUES OF IKOP – EVOLUTION (IN EUR) (OR GRAPH-OPTIONAL)				
REFERENCE OF THE PROJECT-CALL	TOTAL AMOUNT OF IKOP PLANNED FOR THE PROJECT	AMOUNT OF IKOP REPORTED BEFORE 2023	AMOUNT OF IKOP REPORTED IN 2023	TOTAL AMOUNT OF IKOP CERTIFIED UNTIL 2023
Call 2014	33 080 357.24	32 186 436.82	893 920.42	33 080 357.24
Call 2015	80 922 857.37	31 967 884.86	-9 216 131.91	12 823 291.09
Call 2016	7 631,592.64	7 774 692.64	-143 100.00	7 631 592.64
Call 2017	20 330 266.40	17 852 207.14	6 074 138.15	10 740 145.96
Call 2018	21 500 849.56	4 094 714.62	7 482 148.88	4 032 917.97
Call 2019	26 804 663.61	5 652 030.36	4 734 620.10	521 302.15
Call 2020	21 729 062.54	6 481 384.30	8 319 695.59	–
Call 2022	82 776 093.62	–	2 028 909.07	–
Call 2023	18 158 778.24	–	–	–
TOTAL	**312 934 521.22**	**106 009 350.74**	**20 174 200.30**	**68 829 607.05**

Similarly, certification of In-Kind Contributions to additional activities (IKAA) for 2023 is still ongoing until end of December 2024; provisional certified 2023 IKAA figures are presented in Table 23.

Table 23. Evolution of certified IKAA in 2022 and 2023, and total since 2021 (million EUR)

VALUES OF CERTIFIED IKAA – EVOLUTION (IN MILLION EUR)	
YEAR	AMOUNT OF CERTIFIED IKAA
2022 closed at year-end 2023	240
2023 provisional as of 5 June 2024	445
TOTAL since 2021	**685**

2.5. Administrative Procurement and contracts

In 2023, as in past years, the tender and contract management has included interinstitutional procurement procedures launched by the European Commission or other EU bodies and the resulting multiannual framework contracts. The Clean Hydrogen JU also cooperates with other JUs on tendering needs in order to minimise the administrative effort in the context of the Back Office Arrangements (BOA – see also in Section 2.7.2 on efficiency gains and synergies) the establishment of which was formalized in 2023 through a Service Level Agreement, signed between the Clean Aviation JU and seven other Joint Undertakings.

Most of the Clean Hydrogen JU's contracting was carried out through existing multiannual framework contracts of the European Commission, with the remaining part being covered through the Clean Hydrogen JU's own contracts, namely a framework contract for operational support of communication activities (booth services) and the contract for the organization of the Clean Hydrogen JU's yearly forum, the Hydrogen Week.

The Table 24 provides an overview of the contracts awarded in 2023, including the procedure used in each case and the name(s) of the contractor(s); only those contracts with a value exceeding EUR 15 000 are listed. In cases of specific contracts implementing a framework contract, the information is aggregated for each contractor under the same framework contract.

Table 24. Contracts awarded in 2023

DESCRIPTION OF THE CONTRACT	CONTRACT NUMBER/TITLE	TYPE OF CONTRACT	TENDER PROCEDURE	CONTRACTOR	START DATE	AMOUNT (IN €)
Microsoft annual fee for software licenses scenario C2	ORDER FORM No. 07722-OF-5715 under FWC DI/07722 – CR04	Specific contract	N/A	Insight Technology Solutions Belgium Inc	01.06.2023	19 658.34
Media planning, buying and monitoring services for 2023/2024	Specific contract implementing FWC COMM-2019-OP-0029-Lot1	Specific contract	N/A	GOPA COM.	22.12.2023	100 713.30
Success stories	Specific contract implementing FWC COMM-2019-OP-0029-Lot2	Specific contract	N/A	Consortium E2COMMs formed by EUROPEAN SERVICE NETWORK (leader) and ECORYS EUROPE	22.06.2023	26 840.00
Ongoing Services Eurodomain as from 01.07.2023 to 31.03.2024	Specific contract implementing FWC DI-07820	Specific contract	N/A	Deutsche Telekom Business Solutions GmbH	01.07.2023	16 960.95
Specific contract No7 for Operation and Maintenance of the European HRS availability system (E-HRS-AS)	Specific contract implementing FWC FCH/Contract 282	Specific contract	N/A	Spilett New technologies GmbH	11.04.2023	66 305.00
EU Hydrogen Research Days	Specific contract implementing FWC COMM-2020-OP-0030	Specific contract	N/A	ICF Next	06.09.2023	54 877.20
Specific Contract no 1	Specific contract implementing FWC CleanHydrogen/OP/Contract/326	Specific contract	N/A	TH!NK E	03.04.2023	495 216.45

DESCRIPTION OF THE CONTRACT	CONTRACT NUMBER/TITLE	TYPE OF CONTRACT	TENDER PROCEDURE	CONTRACTOR	START DATE	AMOUNT (IN €)
Specific Contract no 2	Specific contract implementing FWC CleanHydrogen/OP/ Contract/326	Specific contract	N/A	TH!NK E	22.12.2023	1 356 538.00
Specific Contract no 3 – Provision Of Data And Services In Support of The European Hydrogen Observatory and Monitoring	Specific contract implementing FWC Clean Hydrogen / Contract 332	Specific contract	N/A	Hydrogen Europe AISBL	22.12.2023	123 062.50
FWC – All-encompassing booth services for event participation	Framework Contract CleanHydrogen/Contract 356	FWC	Open procedure	CREASET SA	08.11.2023	500 000.00
Organisation of Hydrogen Week 2023	Direct Contract CleanHydrogen/ Contract 357	Direct contract	Direct Contract with Member	Hydrogen Europe AISBL	08.11.2023	286 351.50
Specific Contract 1 Inetum-RealDolmen for Managed Infrastructure Services Package 2023 01/05/2023-31/12/2023	Specific contract implementing FWC CAJU.2022.OP.02	Specific contract	N/A	RealDolmen	01.05.2023	79 075.09
Specific Contract 2 with Inetum-Realdolmen- Clean Hydrogen hosting services for the drupal platforms FCHO / H2V & TRUST	Specific contract implementing FWC CAJU.2022.OP.02	Specific contract	N/A	RealDolmen	01.05.2023	21 804.24
Specific Contract 4 with Inetum-RealDolmen for Managed Infrastructure Services Package 2024 01/01/2024-31/12/2024	Specific contract implementing FWC CAJU.2022.OP.02	Specific contract	N/A	RealDolmen	01.01.2024	65 824.64
Specific Contract 8 with Inetum-Realdolmen- Clean Hydrogen hosting services for the drupal platforms FCHO / H2V / TRUST / CRM	Specific contract implementing FWC CAJU.2022.OP.02	Specific contract	N/A	RealDolmen	01.01.2024	27 869.28
Interim services for period 09/01/2023-07/07/2023 – Digital communications assistant	Specific contract implementing FWC HR/R1/PR/2019/023	Specific contract	N/A	Randstad Belgium NV	09.01.2023	34 773.22
Renewal contract PA to ED for period 23/01-21/07/2023	Specific contract implementing FWC HR/R1/PR/2019/023	Specific contract	N/A	Randstad Belgium NV	23.01.2023	34 524.82
Interim assistant to Unit F&A – for period 17/07/2023 – 16/01/2024	Specific contract implementing FWC HR/R1/PR/2019/023	Specific contract	N/A	Randstad Belgium NV	17.07.2023	32 893.72
Interim services for period 16/08/2023 – 15/02/2024	Specific contract implementing FWC HR/R1/PR/2019/023	Specific contract	N/A	Randstad Belgium NV	16.08.2023	33 831.19

NB: FWC, framework contract; H2V, Hydrogen Valley Platform; N/A, not applicable.

2.6. IT and logistics

Information and communications technology (ICT) provides the ICT infrastructure, tools and services that enable staff members to work and teams to collaborate.

The year 2023 was marked by the specific actions fulfilled in the following mentioned distinct areas: ICT governance, Information and document management, digital transformation, cybersecurity and logistics and facility management.

2.6.1.1. ICT Governance

The JU is involved in the preparation of the Back-Office arrangement for ICT services as foreseen in the SBA to improve synergies and efficiencies among the new JUs for their common digital infrastructure. Further to the agreement on the description of the model in the concept note adopted by the Executive Directors and the Governing Board of the Clean Hydrogen Joint Undertaking, service level agreements will be gradually implemented. Under the lead of the Clean Hydrogen JU, the coordination of the organisation of shared ICT services was replaced by a new ICT Governance model as a first step.

To further develop the ICT services, the JU joined each interinstitutional framework contracts or inter-agency joint procurement of added-value, and adopted the new delivery model of DIGIT composed of Dynamic Purchasing Systems (DPS) such as TELCO, Microsoft Services and IT supplies. Besides this, Service Level Agreements were either renewed, extended or created for the common digital infrastructure to improve synergies and efficiencies among the new Joint JUs but also other agencies such as the new DIGIT Cloud broker model grouping 12 EU institutions for common access to the secure pan-European networks for the Commission.

The common conference centre of the White Atrium building was in the process of being upscaled with the necessary audio-visual functions to hold hybrid meetings via the progressive execution of a specific study project. To this effect the decision was taken to equip a second meeting room with the same equipment and facilities as the one released in 2022. The installation will take place during 2024.

2.6.1.2 Information management

The Clean Hydrogen JU continued to use (and adopt, where needed) flagship digital solutions developed by the European Commission, such as SysPer and Systal for HR services, ARES for document management, the eProcurement suite, the eGrants suite and the Next-EUROPA platform.

- The JU is already using the following modules from the new corporate eProcurement suite: Tenders Electronic Daily (Ted) eNotices for publication in the Official Journal, eTendering for preparing the publication of calls for tender and eSubmission for the electronic submission of offers. As part of the roll out of the eProcurement Programme, in 2023 the JU adopted the Public Procurement Management Tool (PPMT): a web-based application to plan, schedule, track and monitor public procurement procedures from early planning up to contract signature. This includes the mandatory use of PPMT for open procedures as of 25 October 2023 and the use of eForms as a legislative standard (established by Commission Implementing Regulation (EU) 2019/1780) for publishing public procurement data. The eTendering platform will be phased out gradually and shut down in June 2024.
- SYSPER (Personnel file management) and SYStal (tool for recruitment) are now key assets applications used for Human Resource management. The additional module MIPS for Mission Processing System has been further delayed but will complete the landscape of HR applications soon. The NDP module for numérisation des dossiers personnels has been used this year making another step in the digital transformation.
- The JU's web presence is supported by a website compliant with the Europa Web Publishing Platform (EWPP) hosted under the Next-EUROPE platform. This ensured stability and continuity of this essential tool for the external communication and visibility of the Clean Hydrogen JU programme. This year, the website also supported the webstreaming of our key events, such as the Info Day or Hydrogen Week.
- The hostings of the different knowledge platforms delivered to the JUs, such as TRUST, Observatory, Hydrogen Valley or the new CRM suite is ensured by our IT managed services provider. This provides the technical support of the various applications but also developments by third parties contracted aside. The public access to those communication tools is also supported by the necessary maintenance and support contracts.
- The deployment of software-as-a-service solutions started in 2022, with the internal file repository as a dedicated SharePoint library. The JU exploited further the potential of the data, information, knowledge and content management of this asset to develop a dedicated collaboration platform using Microsoft Teams channels and SharePoint libraries developed to facilitate the interaction with external actors such as the State Representatives Group or the provision of extra-muros support to the Programme Office.

- After the deployment of Teams with unified communications and collaboration features – such as SharePoint, OneDrive and Exchange Online – the JU developed a new version of the intranet supported by SharePoint as an internal communication platform to be released by Q1 2024.

2.6.1.3. Document Management

The main activities on document management can be summarised as follows:

Following the end of mandate of the Executive Director in May 2023, we prepared a smooth transmission of files and processes to the Acting Director. To this effect, each e-signatory manager and/or initiator of a document or action in ARES took action to ensure business continuity in updating the assignments.

Also for business continuity and compliance with the archiving policy every file saved in ARES was analysed and stored properly in the filing plan or cleared.

The hand-over exercise between the Directors took place successfully with the Clean Hydrogen JU and Secretariat-General (SEC GEN) on the 15 May 2023.

Through a Service Level Agreement with DG DIGIT, the Clean Hydrogen JU obtained its own Qualified Seal. This enabled the sealing capability in ARES and made e-signing with the Qualified Electronic Signature (QES) process leaner, efficient and fully integrated in ARES.

"Job users" were created and linked with ARES interfaced IT tools – namely eGrants/Compass and PPMT – so that the registration and filling of documents is facilitated.

ARES was interfaced with RETO/COMREF services and therefore the users` information derives directly from SYSPER without any manual intervention.

Since December 2023, the IT Officer has taken over the role of Document Management Officer (DMO) after completing the mandatory training. This ensures the continuation of the correct implementation and monitoring of the European Commission electronic archiving and document management (e-Domec) policy within the entire JU.

2.6.1.4. Digital transformation

Similar to 2022, the replacement of in-person meetings with virtual meetings and hybrid conferences was supported by the live-transmission from the studio in the White Atrium building and online webstreaming via the Clean Hydrogen website.

The Digital Workplace was modernised by making sure that each staff member was provided with modern IT equipment allowing more flexibility under the new teleworking working scheme:

- The support services were oriented to have more self-service functionality to fit the remote working capabilities (reset password/account, remote deployment of applications, etc.);
- The use of cloud services and storage was encouraged (OneDrive, remote desktop);
- The meeting rooms and staff computers were equipped to support the ability to participate in calls, videoconferences, and other collaborative workgroups from anywhere at any time.

The roles of the Single Point of Contact for COMPASS or the IT accounting system ((Accrual Based Accounting, (ABAC)) were again useful to ensure the successful implementation of H2020's 2023 call but also the transition period of the Executive Director mandate.

2.6.1.5. Cybersecurity

Regarding the JU's resilience to ever-evolving digital security threats, the Cybersecurity was reinforced by focusing on the business continuity operations:

- a close follow-up of the infrastructure-as-a-service solution and managed IT service contracts available to the Clean Hydrogen JU;
- efficient remote support provided by the IT officer and the service desk;

- making sure that JU is not affected by security incidents arising from external cyberattacks.

The developments of the new information security (Infosec) regulation and the dedicated role of Cyber Security Officer were followed closely in each dedicated meeting and group. The implementation of those recommendations for improvement will be facilitated by the preparation of the cybersecurity service group under the ICT back-office arrangement (BOA).

Regarding resilience, regular phishing campaigns and redteaming exercises for the infrastructure were performed with the support of Cybersecurity Service for the Union Institutions, Bodies, Offices and Agencies (CERT-EU) as part of our development of resilience to cyberattacks. In 2023, the focus was on credential theft and multifactor authentication, which is the root of many attacks.

Security recommendations and assessments for Microsoft 365 were performed by CERT-EU and Microsoft. Suggested improvements were immediately taken on board and implemented with the help of the ICT managed services provider to the extent possible.

The JU Local Information Security Officer (LISO) continued participating in the dedicated DIGIT Interinstitutional Committee for Digital Transformation (ICDT) CyberSecurity sub-group and the CERT-EU stakeholders forum. The new roles of LCO and chief information security officer (CISO) will be assessed in the perspective from the new ICT back-office arrangement and mutualisation.

2.6.1.6. Logistics and facility management

In addition, logistical support continued to be provided in the context of general administration. This encompasses the management of the supply and maintenance of equipment, namely stationery, goods and services for administration, and includes the monitoring of services provided in particular through the Office for Infrastructure (Brussels), the Translation Centre and the Publications Office of the European Union.

In consideration of the end date of the current usufruct contract (31.12.2024), the Clean Hydrogen JU, – as lead contracting authority, and on behalf of the Innovative Health Initiative (IHI) JU, the Clean Aviation JU, the Chips JU, the Circular Bio-based Europe (CBE) JU, the Eu-Rail JU and the newly established Smart Networks and Services (SNS) JU and Global Health EDCTP3 JU, launched an exceptional negotiated procedure without prior publication of a contract notice (Founding Regulation, Article 164 and Point 11 of Annex 1) , after prospecting the local market, for a new usufruct contract for housing the premises of the JU mentioned above. The award decision was signed at the end of 2023, and the new contract will be signed in the course of 2024. This procedure is part of the back-office arrangements for procurement matters common to the JUs in application of Article 13 of the basic act establishing the JUs ([127]). The new contract will enter into effect on 01 January 2025.

Logistical management and facility management were adapted to the new ways of working, in line with the Commission decision on new ways of working and hybrid working.

The year 2023 continued seeing the delivery and implementation of:

- remote work as an integrated way of working;
- more dynamic approaches to the use of office space;
- the use of modern technologies (e.g. "more wireless, less cables", universal docking stations for laptops, uniform model of laptop with tablet functionality);
- the use of web/videoconferencing-based meetings as a valid sustainable alternative to staff missions and physical meetings, which represents a significant benefit in terms of environmental footprint, efficiency, and work-life balance.

The use of web-conferences as a communication method continued to increase, with events in hybrid or completely virtual mode. We observed again a shift in costs from business travel to telecommunications. The ability to produce a livestreamed event is reinforced by the support of Teams live events as a new asset from

([127]) 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, 30.11.2021, p. 17–119*

the Microsoft 365 software-as-a-Service (SaaS) adopted by the JU. Taking this into account, new equipment for videoconferencing in each meeting room must be materialised in 2024.

Given the increased use of teleworking, the JU kept a failover solution for when a corporate device is damaged or missing by offering to the staff to possibility to work with a virtual desktop solution on a private device. This modern mobile device management as a temporary environment was of great support in facilitating the *extra-muros* work without any additional material.

2.7. Human Resources

2.7.1. HR Management

Staff selection and recruitment

The staff establishment plan (SEP) allows for 27 Temporary agents, 2 contract agents and 3 SNEs. A new SNE position was granted to the Clean Hydrogen JU and approved through the first amendment of the Annual Work Programme and Budget for 2023.

On 31/12/2023, there were 25 positions occupied, for Temporary Agents, 1 for Contract Agents and 2 SNEs.

The Finance Unit completed the selection procedure for the Budget officer in February 2023. This was an external procedure. An additional SNE position was granted to our organization.

We hired one SNE in March, as a replacement for the SNE who left in June 2022. We have not yet recruited the third SNE. The vacancy was not filled after the first publication of the vacancy; it was re-opened with a deadline in 2024.

Two staff members resigned in October. The selection procedure for the Financial Officer was set up on 27 October via an inter-agency mobility procedure.

Selection procedures for a Financial Officer and Synergies officer started in December 2023.

As soon as we learned that our Internal Control and Audit manager was leaving, we asked the other JUs if we could make use of their reserve list, to streamline the procedure with other JUs and to speed up the recruitment process. However, we did not select a candidate from the reserve list, received from the Global Health EDCTP3 JU. The Clean Aviation JU have organised a selection procedure for an internal control and audit manager; once their reserve list is established, we will ask permission to interview the candidates on this list.

A teambuilding day was held in December, which included a communication workshop in the morning and a teambuilding activity in the afternoon.

Learning and professional development

Most trainings followed by Clean Hydrogen JU staff members in 2023 were on lump sum funding in Horizon Europe and anti-fraud training.

In order to create more synergies between the JUs, especially in the HR area, several training sessions have been organised by one JU and were available to staff of all the JUs, (Table 25).

Table 25. Training overview

NAME OF TRAINING	ORGANIZED BY	GIVEN BY
Anti-fraud training	EuroHPC	Olaf
Ethics and whistleblowing	CAJU	BDO
Info session on pension	CBE	PMO

NAME OF TRAINING	ORGANIZED BY	GIVEN BY
Info session on joint sickness insurance scheme (JSIS)	CBE	PMO
Respect and dignity at the workplace (for managers)	IHI	E&Y
Respect and dignity at the workplace (for all staff)	IHI	E&Y

Staff statistics

Figure 33. Staff statistics: (a) gender balance and (b) nationalities

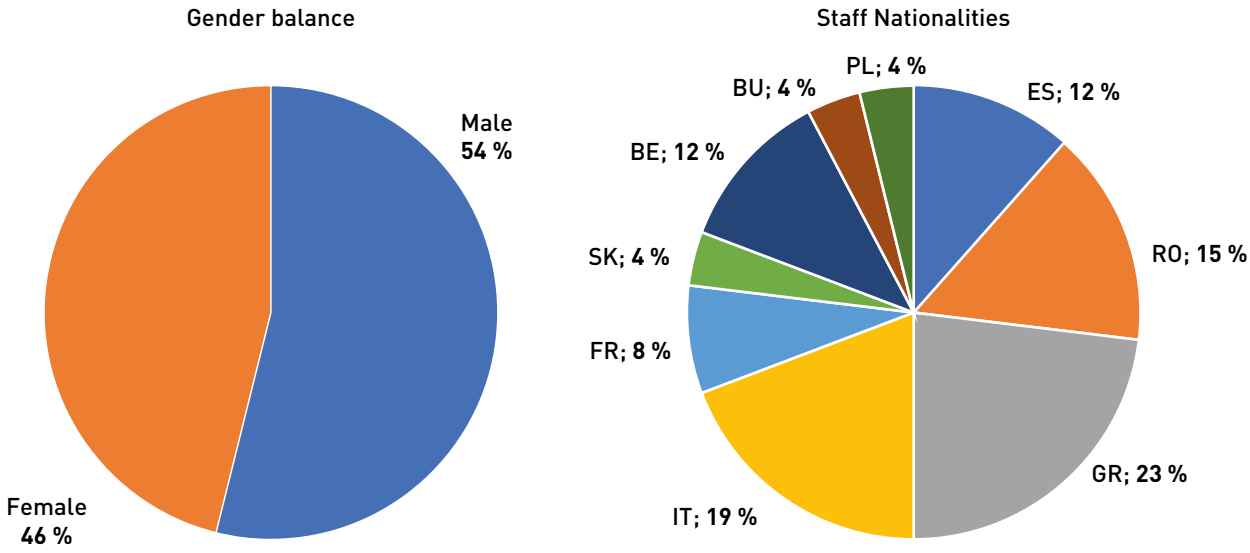


Table 26. Staff implementing rules (SIR) adopted in 2023

TITLE OF THE SIR	REFERENCE AND DATE OF THE GOVERNING BOARD DECISION (IF RELEVANT)
Decision on working time and hybrid working	CleanHydrogen-GB-2023-17 adopted on 15/11/2023
Decision on deputising rules	CleanHydrogen-GB-2023-15 adopted on 15/11/2023

2.7.2. Efficiency gains and synergies

The SBA establishes that the Clean Hydrogen JUs shall achieve synergies and provide horizontal support functions via the establishment of back-office arrangements, operating in identified areas. The SBA also underlines that these synergies should be implemented where the screening of resources has proved to be efficient and cost effective, while taking into account as much as possible compliance with the requirement of the accountability of each individual authorising officer.

In continuation of the study carried out in 2022, and in accordance with the guidance of the Governing Boards, the JUs further implemented the back-office arrangements (BOA) in four areas:

- accounting;
- procurement;
- Human Resources;
- ICT.

BOA Accounting

Taking into consideration this approach, in 2023, back-office arrangements were concluded in the following sectors:

- accounting (lead: EU-Rail JU);
- procurement (lead: Clean Aviation JU)

Further to the above, the Clean Hydrogen JUs are currently working on establishing back-office arrangements in the area of Human Resources Support and IT.

Scope of the back-office arrangements for Accounting Services and activities carried out in 2023

The JUs took over the accounting services that until 30 November 2022 had been provided by DG BUDG and succeeded in implementing the BOA for Accounting Services in 2022, and immediately for the accounting closure 2022.

EU-Rail is the lead JU of this BOA and Accounting services are provided by 3 Accounting Officers coming from the following JUs: CA JU, SESAR JU and EU-Rail JU.

Organisation:

- The Executive Director of the lead JU is responsible for the organisation, oversight and coordination of the accounting services provided to the other JUs on the basis of an annexe of the BOA SLA.
- The Head of Corporate Services (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 of and coordination with the lead JU.

In order to ensure the provision of these services, it was agreed between the EC and the JUs to make use of the support of the three additional Contractual Agents and of an external Accounting Services provider.

The BOA for Accounting services is fully operational and is delivering the intended services, including the preparation of the Annual Accounts for 10 Joint Undertakings. As of January 2024, the BOA team is composed of 3 Accounting Officers supported by 3 Accounting Assistants.

BOA Procurement

This BOA was established with the objective of centralising the administrative procurement capability and processes to maximise open tenders for the award of inter-JU FWCs and middle value negotiated procedures. The focus is on critical joint administrative procurement, such as ICT, building management/corporate services, and common support services that will be identified and agreed via joint Public Procurement Planning (PPP).

To agree on the concept for the BOA Procurement, the CAJU held a 'BOA co-design Workshop' on 7 October 2022 to address all JUs that expressed their interests in the BOA Procurement. During the workshop, the CAJU presented the concept and the principles of the joint cooperation.

The concept was supported by the bi-annual Joint Public Procurement Planning that reflects the common needs identified by the parties. On this basis, a Service Level Agreement was drafted by the BOA Procurement Coordinator (CAJU) and, following its approval, was signed by 10 JUs in November 2023.

During its first year of operations, the BOA Procurement has proven that through joint initiatives in public procurement and contract management, the JUs complement each other and work in synergy towards an economically efficient way of using the available resources and the establishment of a higher negotiation power.

Sharing knowledge and best practices and providing legal/procurement support through entities possessing specific expertise and practical experience in managing call for tenders, leads to time and cost savings among participating JUs. At the same time, a system among the members of the BOA Procurement wherein they

interchangeably perform the role of a leading contracting authority (LCA) allows for the optimisation of the use of resources.

There is a higher volume of services to be purchased and growing interest among bigger economic operators. An increase in the volume of services minimises the risk of the cancellation of procedures, since a contracting authority draws the attention of companies that are more familiar with EU institution procurement process and procedures. In addition, economies of scale of the JUs' purchases play a vital role by creating significant operational efficiencies in business production and cost advantages both for the contracting authority and for the contractor.

By shaping increased service/supply demand, negotiation with service providers/suppliers can be done more effectively. Finally, inter-institutional calls for tenders help eliminate a *''saucissonnage''* effect by replacing the number of individual low value contracts with a solid 4-year framework contract and thus contributing to the compliance with the applicable procurement and financial rules.

BOA Human Resources

Article 13 of the SBA identifies Human Resources Support among the areas where common back-office arrangements can be set up. In that respect, the CBE JU took the lead with IHI JU for the establishment of the BOA HR.

The BOA HR will implement actions in three main areas of HR Support:

1. recruitment;
2. HR legal framework and
3. HR digitalization.

Its objectives are to maximise synergies among the JUs, harmonise procedures by valorising best practices, ensure coherent HR support services, achieve efficiencies and economies of scale and increase the negotiation power of JUs operating under the SBA towards contractors and service providers.

Scope of the HR Back-Office arrangements and activities carried out in 2023

In line with the proposal of the enhanced coordination of the Network of JUs' HR officers, the conclusion of a Service Level Agreement (SLA) among the JUs was deemed necessary to ensure commitment to the execution of the HR BOA annual work plans.

In 2023, the CBE JU and IHI JU led the discussions regarding the drafting of the SLA and organised several meetings with the participating JUs with a view to providing clarity regarding all possible questions and coming to an agreement. The SLA is expected to be signed in Q1 2024 and HR activities set out in the annual work plan are to start in 2024 focusing on the three predefined areas of HR support.

In parallel, the CBE JU launched the HR BOA collaborative platform (on Teams) to allow the exchange of information and documents – such as the template library and minutes of the network meetings – among the HR officers' inter-JU network.

In 2023, the CBE JU, along with other JUs, also optimised efficiency gains and synergies by:

- sharing reserve lists to shorten the time to recruit;
- providing expertise and resources, allowing staff members to be panel members in several selection procedures of other JUs;
- supporting new JUs during their on-boarding/start-up phase by providing guidance, advice and templates;
- organising training courses of general interest to all JUs (e.g. ethics and integrity, anti-fraud, respect and dignity at the work place for JU managers);
- contributing to the development of a common HR legal framework among JUs by sharing Executive Director and Governing Board decisions on diverse HR regulatory topics;
- supporting the communication campaign on the role of confidential counsellors and the presentation of the newly appointed confidential counsellors to all JU staff members.

In 2023, the JUs, as interinstitutional partners, also attended meetings organized by the European Commission regarding the HR transformation programme that provides for the setting up of a new IT platform that will replace SYSPER.

In 2023, two new JUs started to use/implemented the e-recruitment tool 'SYSTAL', which use was granted to other two JUs (the Chips JU and the Global Health EDCTP3 JU), resulting in a total of 7 JUs using the same e-recruitment platform; SYSPER, etc; sharing information and best practices with the different JUs through meetings and working groups (e.g. with the Executive Directors, Heads of Administration, HR officers, legal officers) and adopting a common approach to implementing the rules of the EU staff regulations.

BOA ICT

The ICT area covers 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 to each JU.

The Clean Hydrogen JU co-leads the definition and implementation of the BOA ICT with the IHI JU.

A concept note, drafted by both leads and approved by all JUs, was endorsed by all Executive Directors at the end of 2022. Receiving further guidance from the European Commission services in early 2023, the leads complemented and redrafted the note, a second version of which was submitted to the Executive Directors and endorsed in December 2023. In accordance with the process defined by the European Commission, the endorsed concept note of the BOA ICT was ready for submission to the Governing Boards of all JUs for their approval. This was a pre-requisite to the discussion and signature of related SLAs.

However, in 2023, the common approach to ICT services, referred to as a "pre-BOA" for ICT, continued with the implementation of the common ICT annual work plan for 2023 (see Section 2.6.1.1 ICT Governance) and the adoption of the common ICT annual work plan for 2024, following the common practices implemented since 2011.

3. GOVERNANCE

3.1. Major developments

In 2023, governance was marked by the end of the mandate of the Executive Director (see the following section for related and subsequent activities).

3.2. Phasing-out plan monitoring

In 2023, in accordance with the provisions of Article 17(2)(1a) of the SBA and Article 10(2) (c) of the Horizon Europe Regulation, the Clean Hydrogen JU developed an initial version of its phasing-out plan, which was adopted by the Governing Board on 21 December 2023. Following the instructions received from the European Commission, this initial phasing-out plan focused on the administrative and operational adaptations needed for a 'winding-up procedure', while the other elements of the plan related to short and long-term targets, strategic alignment with the SRIA and future financial stability will be completed during 2024.

3.3. Governing Board

The Governing Board of the Clean Hydrogen JU comprises three representatives from the European Commission (representing the EU), six from Hydrogen Europe and one from Hydrogen Europe Research.

The Governing Board chair is Ms Melissa Verykios, representative of the Industry Grouping (Hydrogen Europe). The Vice-Chair is Ms Rosalinde van der Vlies, Director of Clean Planet at DG Research and Innovation and representative of the Commission.

During 2023, the Governing Board held two meetings, one on 17 March and one on 26 October.

Both meetings focused on strategic issues and discussions of the progress of the programme and included updates from the members on policy developments and Horizon Europe.

The first meeting, in March, was mainly dedicated to discussions regarding the Clean Hydrogen JU Interim Director decision, the EU Hydrogen Week, the AWP 2024 status (including grant agreement preparation (GAP) analysis, review of the SRIA and priorities for 2024), and the Report on national and regional policies on Hydrogen (2022).

In the October meeting, the main topics included the SRIA update and timeline, the AWP 2024 status (including the topics/budget of the call, procurements and lump-sum proposal), the contribution to the administrative costs of the Clean Hydrogen JU, an update on the Stakeholders Group's composition (including selection criteria), an update on the Hydrogen Week, the presentation of the Communication strategy, an update on synergies, the status of the BOA, the Clean Hydrogen JU interim evaluation and phasing-out strategy and the status of the selection of the new ED.

The GB also adopted the following major decisions by written procedure:

- CleanHydrogen-GB-2023-01 – Approval of 06 April 2023 of the Minutes of the Clean Hydrogen JU GB meeting of 25 October 2022;
- CleanHydrogen-GB-2023-02 – Adoption of 30 January 2023 of the first amendment to the Clean Hydrogen Joint Undertaking 2023 Annual Work Programme and Budget;
- CleanHydrogen-GB-2023-03 – Adoption of 20 February 2023 of the appointments of the representative of the Members other than the Union and of the observer in the pre-selection panel for the future ED's position;

- CleanHydrogen-GB-2023-04 – Adoption of 29 March 2023 of the revised budget of the Clean Hydrogen Joint Undertaking for 2023;
- CleanHydrogen-GB-2023-05 – Decision of the 15 May 2023 for the appointment of the Executive Director ad interim;
- CleanHydrogen-GB-2023-06 – Approval of 19 June 2023 of the Minutes of the Clean Hydrogen JU GB meeting of 17 March 2023;
- CleanHydrogen-GB-2023-07 – Approval of the 29 June 2023 of the Consolidated Annual Activity Report for 2022 including the corresponding expenditure and its assessment;
- CleanHydrogen-GB-2023-08 – Initial assessment of the 15 June 2023 of occupational activities of the former Executive Director of the Clean Hydrogen Joint Undertaking after leaving the service;
- CleanHydrogen-GB-2023-09 – Assessment of 26 July 2023 of the first request for occupational activities of the former Executive Director of the Clean Hydrogen Joint Undertaking after leaving the Services;
- CleanHydrogen-GB-2023-10 – Opinion of 30 June 2023 of the Governing Board on the 2022 annual accounts of the Clean Hydrogen JU;
- CleanHydrogen-GB-2023-11 – Approval of the 28 July 2023 of the list of actions selected for funding, the reserve lists and the list of rejected proposals under the Clean Hydrogen Joint Undertaking call for proposals with reference HORIZON-JTI-CLEANH2-2023;
- CleanHydrogen-GB-2023-12 – Initial assessment of the 6 July 2023 of the second request to authorise occupational activities of the former Executive Director of the Clean Hydrogen Joint Undertaking after leaving the Services;
- CleanHydrogen-GB-2023-13 – Assessment of the 2 August 2023 of the second request to authorise occupational activities of the former Executive Director of the Clean Hydrogen Joint Undertaking after leaving the Services;
- CleanHydrogen-GB-2023-14 – Assessment of the 24 August 2023 of the third request to authorise occupational activities of the former Executive Director of the Clean Hydrogen Joint Undertaking after leaving the Services;
- CleanHydrogen-GB-2023-15 – Decision of the 13 November 2023 on deputising rules to ensure the continuity of service;
- CleanHydrogen-GB-2023-16 – Decision of the 20 September 2023 approving additional lists of actions selected for funding under the Clean Hydrogen Joint Undertaking call for proposals with reference HORIZON-JTI-CLEANH2-2023-1;
- CleanHydrogen-GB-2023-17 – Decision of the 13 November 2023 on working time and hybrid working;
- CleanHydrogen-GB-2023-18 – Adoption of the 18 December 2023 of the Clean Hydrogen JU communication strategy;
- CleanHydrogen-GB-2023-19 – Adoption of the 21 December 2023 of the first amendment to the revised budget for 2023 of the Clean Hydrogen JU;
- CleanHydrogen-GB-2023-20 – Adoption of the 20 December 2023 of the Annual Work Programme and Budget for 2024 of the Clean Hydrogen JU;
- CleanHydrogen-GB-2023-21 – Adoption of the 21 December 2023 of the initial phasing-out plan of the Clean Hydrogen JU.

More information on the role and composition of the Clean Hydrogen JU Governing Board is available on the Clean Hydrogen JU's website (https://www.clean-hydrogen.europa.eu/about-us/organisation/governing-board_en).

Over the year 2023, the Governing Board has followed up and addressed various issues to secure the full compliance of the JU's practices with its legislative corpus, including matters related to the staff regulation (assessment of the occupational activities of former staff members after leaving the service), to the JU's Financial Rules (contribution of members only to the administrative expenditure of the JU) etc. The Governing Board addressed these issues during its plenary meetings and through written procedures, facilitated by the Programme Office in its role of secretariat.

3.4. Executive Director

In 2023, the mandate of the Executive Director (ED) came to its end. The Governing Board appointed Ms Mirela Atanasiu, Head of Unit of Operations and Communication, as Executive Director *ad interim* and the selection of the future ED was carried out under the steering of the European Commission. At the end of 2023, the Executive Director *ad interim* was still in place.

3.5. States Representatives Group

Established in 2022, the States Representatives Group (SRG) has 75 members, of which 64 representatives (main and alternate) are from the 27 Member States and 11 representatives are from 5 Associated Countries (4 Associated Countries have not nominated a representative).

In 2023, the SRG met on 6 June and 3 October. Its activities focused on following up the JU's work and results and advising the Governing Board accordingly, including the following:

- During the June meeting, the SRG members were updated on the European Commission initiatives on Hydrogen, on the status of the call for proposals in 2023 and on the progress of the discussion on topics of the call for proposals in 2024. The Chair presented the opinions on the AAR 2022 and discussions were held on the process and expected content of the Report on national and regional policies related to Hydrogen due by the end of 2023;
- At the September meeting, the Programme Office presented the status of the call for proposals in 2023, sharing the call results, and updated the SRG members on the AWP for 2024, on the Hydrogen Week and on the Cooperation with Member States. The Chair presented the template and process of the "Report describing the national or regional policies and identifying specific ways of cooperation" (SBA Article 20(9) and (10)). In 2023, the Programme Office set up a collaboration platform to facilitate the process of receiving contributions to this report from the 75 members of the SRG.

The formal consultation of the SRG took place in April 2023 regarding the Annual Activity Report for 2022 and in November regarding the Annual Work Programme for 2024. Both consultations concluded with positive opinions provided to the Governing Board, with some comments taken into account by the Programme Office.

The report on national and regional policies on Hydrogen was ready for submission to the Governing Board at the end of 2023. It includes the contributions of 19 countries and covers, for each country, the following content:

1. Policy initiatives and programmes on Hydrogen;
2. Hydrogen research and innovation update;
3. Demonstrations, deployment and uptake;
4. Dissemination events, dedicated technical workshops and communication activities;
5. National or regional policies and initiatives for complementarity with SRIA and AWP;
6. Government and collaborative Hydrogen funding;
7. Specific ways of cooperation of MS and Countries with the actions funded by the Clean Hydrogen JU.

3.6. Scientific Committee

In accordance with the founding regulation, this section is not applicable to the Clean Hydrogen JU.

3.7. Stakeholders Group

The Stakeholders Group is an advisory body to the Governing Board that is to be consulted on various horizontal issues or specific questions in areas related to the work of the Clean Hydrogen JU. The Stakeholders Group members were appointed by the GB on 2 February 2022 for a 4-year term.

In 2023, the Stakeholders Group met twice (June and October) and formally adopted the Rules of Procedure, following discussions in 2022. The vice-chair was also elected during the 5th meeting, in October 2023.

During the meetings of the Stakeholders Group, the Programme Office presented the status of the Annual Work Programme/call 2023 and other JU's activities, in particular synergies with other programmes and initiatives. Moreover, the SG members were asked to provide input on the Annual Work Programme/Call 2024, including synergies. In relation to this, the SG members were invited to propose new synergies within the Clean Hydrogen JU's annual work programme 2024 and to report on relevant ongoing activities in their sectors where synergies may be expected.

Considering the need to ensure full sector coverage and geographical and gender balance, the Governing Board had decided that the composition of the Stakeholders Group would be reassessed in 2023 for the remainder of the 4-year period. Thus, the Clean Hydrogen JU launched a new Call for Expression of Interest (CEI) for new Members open to all candidate groups or sector representatives, on 18 December 2023. This CEI will expand the composition of the Stakeholders Group for the remainder of the 4-year mandate (2024-2026).

4. FINANCIAL MANAGEMENT AND INTERNAL CONTROL

4.1. Control results

This section focuses on the results generated by the whole internal control system and presents other related information that supports management assurance of the achievement of the financial management and internal control objectives.

The Governing Board adopted the revised internal control framework on 16 August 2018. The Clean Hydrogen JU applies mutatis mutandis the components, principles and characteristics laid down in the internationally acknowledged Committee of Sponsoring Organizations of the Treadway Commission model of internal control, in line with the European Commission's internal control framework. Internal control systems and procedures are applicable at all levels of management and are designed to provide reasonable assurance of achieving the following objectives:

- effectiveness, efficiency and economy of operations;
- reliability of reporting;
- safeguarding of assets and information;
- prevention, detection, correction and follow-up of fraud and irregularities.

4.1.1. Effectiveness of controls (ex ante and ex post controls)

Control results regarding the legality and regularity of operations, fraud prevention and other control objectives – in particular the safeguarding of assets – are detailed in the subsequent sections.

4.1.2. Legality and regularity of the financial transactions

The control objective is to ensure that the Clean Hydrogen JU has reasonable assurance that the **total amount of any financial operation** authorised during the reporting year, which would **not** be **in conformity** with the applicable contractual or regulatory provisions, **does not exceed 2 % of the authorised payments** or revenue concerned. To reach this conclusion, the Clean Hydrogen JU reviewed the results of the key controls in place. For each item, materiality is assessed in accordance with Annex 14.

Despite the large number and magnitude of transactions, the Clean Hydrogen JU's residual error rate has not only stayed below the target threshold of 2% but has decreased from 0.88% in 2022 to 0.59% in 2023. This is the first time, the Clean Hydrogen JU has obtained such a low error rate, which was detected by *ex post* audits covering operational expenditure (grants) and showed the effectiveness and efficiency of the Clean Hydrogen JU's *ex ante* controls at the programme level.

In order to get a low error rate, the JU must achieve the main objective of *ex ante* controls: to ascertain that the principles of sound financial management have been applied.

Table 27 outlines and compares the main principles of *ex ante* and *ex post* controls.

Table 27. Ex ante and *ex post* controls

	EX ANTE CONTROLS	EX POST CONTROLS
When?	**Before** the transaction is authorised	**After** the transaction is authorised
Frequency?	Mandatory on **all** transactions	Made on a **sample** basis
How?	Mainly **desk review** of supporting documents, requests for clarification (e.g. beneficiaries' proposals and reports) and available results of controls already carried out relating to the operational and financial aspects of the operation.	Mainly **on-the-spot** checks at the beneficiary's premises
Impact?	Errors detected should be corrected **before** the transaction is approved	Errors detected (e.g. ineligible expenditure) should be corrected through **recovery orders** or offsetting with future payments
Level of assurance?	**Primary** means of ensuring sound financial management and legality and regularity of transactions, but based on desk review of available evidence.	**Secondary** means of ensuring sound financial management and legality and regularity of transactions, but more robust as normally carried out 'on the spot'

The Clean Hydrogen JU has developed and continues to apply procedures defining the controls to be performed by project and finance officers for every financial claim, invoice, commitment, payment and recovery order, taking into account risk-based and cost-effectiveness considerations.

For operational expenditure, the processing and recording of transactions in ABAC are performed using the corporate IT tools (System for Grant Management (SyGMa) and COMPASS) for H2020 and Horizon Europe grants and experts, which ensures a high degree of automation, and the controls are embedded in each workflow.

4.1.2.1. Ex ante control activities in 2023

Ex ante control activities in 2023 included:

- assessment of 53 periodic reports based on the "*Guidance H2020 ex-ante controls on interim & final payments*" issued by the Commission;
- targeted webinars focused on the specificities of each project;
- reinforced monitoring and targeted checks during *ex ante* controls for interim and final payments, in accordance with the H2020 *ex ante* control strategy, as published by the Common Support Centre Steering Board on 18 December 2020;
- double funding and plagiarism checks.

The internal guidance for grant agreement preparation has been updated based on the Horizon Europe rules, allowing the first grants signed under Horizon Europe to be compliant with these new rules. The Horizon Europe *ex ante* controls guidance (version 01 September 2023), the first guidance ever published for the Horizon Europe programme, helps staff with ex ante control checks. It describes the common ex-ante control procedures to be implemented for Horizon Europe (HE) grants (at the grant agreement preparation (GAP), amendments (AMD) and payments (REPA) stages) and provides guidance on streamlining and standardising practices throughout Horizon Europe implementing services.

As regards the Horizon Europe programme, a new version of the **Control Strategy for Horizon Europe** was adopted in November 2023. The Horizon Europe 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 of HE projects will be a single aggregated risk-based error rate based on all JUs' error rates and not an error rate at each JU level. The first HE projects signed in early 2023 with a 12-month reporting period could be audited as part of this new risk-based audit strategy. In addition, a risk-based *ex ante* control methodology will be applied in all grant management cycles in order to prevent the error from (re-)appearing. The more significant the risk (detected), the higher the intensity of risk-based *ex ante* controls.

4.1.2.2 Value and share of the operational transactions

The overview of the administrative and operational expenditures in terms of amounts and percentage provides an idea of the size of the transactions. Table 28 provides the total payment execution.

Table 28. Total payment execution in 2023

TOTAL PAYMENTS EXECUTION IN 2023		
Operational budget	236 payments	274 396 683
Administrative expenditure	408 payments	5 637 283
Total	**644 payments**	**280 033 966**

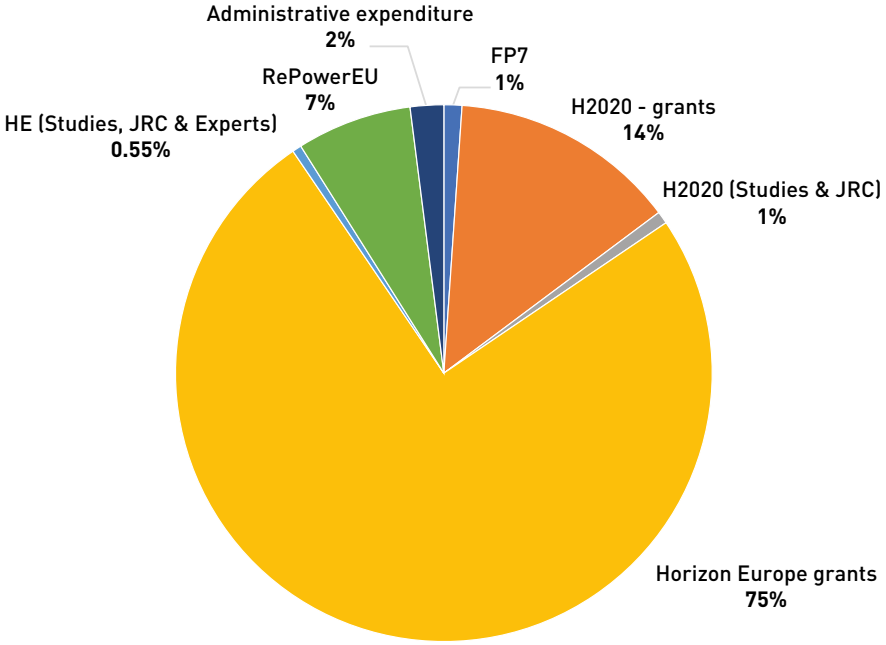
Table 29 and Figure 34 present the amounts and shares of operational and administrative expenditure.

Table 29. Amounts and shares of operational and administrative expenditure

PAYMENTS MADE	AMOUNTS (EUR)	%
Operational expenditure		
FP7	3 039 327.90	1.09%
H2020 – grants	38 371 362.76	13.70%
H2020 – studies	1 732 763.65	0.62%
H2020 – JRC	347 500.00	0.12%
Horizon Europe – grants	209 931 473.48	74.97%
HE – studies	724 897.28	0.26%
HE – JRC	407 500.00	0.15%
HE – Experts	411 094.39	0.15%
RePowerEU	19 430 763.41	6.94%
Administrative expenditure:	5 637 283.03	2.01%
Total:	**280 033 965.90**	**100%**

As for the share of expenditures, **grant management** represents more than **90 %** of the total 'payments made' while procurement accounts for 0.88% and expenditure payments for 2.01%.

Figure 34. Shares of operational and administrative expenditures



Since a large part of the budget is implemented via H2020 grants (existing grants running in 2022) and newly signed grants for Horizon Europe in 2023 (pre-financing paid), the main control activities focused on *ex ante* and *ex post* controls in this area.

The breakdown of the costs accepted and paid in 2023 is presented in the Table 30. In 2023, the value of payments reached the value of EUR 321 730 922.44 of which EUR 270 559 023.62 was paid to beneficiaries as interim/final payments, while EUR 51 171 898.82 was the result of full and partial clearing made against pre-financing paid at the beginning of the projects.

Table 30. Value of operational transactions with regard to budget execution

		N° OF TRANSACTIONS	VALUE OF PAYMENTS IN EUR	VALUE OF CLEARINGS IN EUR	VALUE OF ALL TRANSACTIONS IN EUR
FP7	Final payment	1	3 039 327.90	0.00	3 039 327.90
	Total	**1**	**3 039,327.90**	**0.00**	**3 039 327.90**
H2020	Interim payments (1)	18			89 329, 57.65
	Final payments (2)	22	38 157 458.83	51 171 898.82	
	Full Clearing (3)	13			
	Total (1) + (2) + (3)	**53**	**38 157 458.83**	**51 171 898.82**	**89 329 357.65**
Horizon Europe	Prefin				229 362 236.89
	Call 2022	39	229 362 236.89	N/A	
	Call 2023	27			
	Total	**66**	**229 362 236.89**	**N/A**	**229 362 236.89**
GRAND TOTAL		**120**	**270 559 023.62**	**51 171 898.82**	**321 730 922.44**

Annual approved budget 2023 – Title 3		319 328 374
Amended annual budget after request for increase, recoveries, etc.		320 284 639
Budget execution rate (%) – Title 3	**(project payment execution)**	**85.67 %**

The **budget execution** rate increased from **64.90** % in 2022 to **85.67**% in 2023. The reasons of this **steep increase in budget** execution rate were an excellent estimated budget in 2022 together with an excellent project payment execution rate, complemented by additional requests for higher prefinancing from the projects, which contributed to the increase of 20.77 percentage points (= 85.67 – 64.90) from the 2022 payment execution rate. This payment execution rate is actually higher than **85.67**% if the Brexit factor is taken into account, since that situation was outside the Clean Hydrogen JU's remit. Because the UK beneficiaries were ineligible for funding from the 2022 and 2023 calls, the UK-shares of the grants and consequently payments were not processed, and this prevented a better payment execution rate.

As part of the H2020 programme with its harmonised legal framework, cost claims used for the calculation of **interim and final payments** are included in the **audit programme level sampling**, notably the H2020 common representative sample (CRS). Accordingly, the Clean Hydrogen JU reports on the error rates drawn from these programme-level controls. The extension of findings across the programme also provides an additional element of assurance regarding the discharge procedure.

Regarding the Horizon Europe programme, the cost claims will be submitted in 2024 and may be selected for future *ex post* audits.

4.1.2.3. Ex post control of operational expenditure and error rates identified

Ex post controls are the final stage of the Clean Hydrogen JU's control strategy in the project lifecycle. This stage includes the *ex post* audits and necessary correction and recovery of unduly paid amounts.

In 2023, the following main results were achieved:

- The Clean Hydrogen JU and the Common Audit Service (CAS) cooperated on selecting **12 new corrective and representative H2020 ex post** audits for execution in 2024 with results expected by 31 December 2024, focusing primarily on the top 100 beneficiaries ([128]);
- Through continuous application of the Clean Hydrogen JU's sampling methodology (endorsed by the CIC Executive Committee on 19 July 2019), the Clean Hydrogen JU reached **a significant cumulative audit coverage** level (see Figure 4.6) of the overall H2020 expenditure, forming a strong basis for the declaration of assurance in 2023;
- The Clean Hydrogen JU participated in the extension of the audit findings exercise, common to all H2020 stakeholders, enabling further cleaning of the representative error rate **down to – 0.59 % of the residual error rate.**

For classification, reporting and error rate calculation purposes, the Clean Hydrogen JU distinguishes between representative and corrective audits (Figure 35).

Corrective audits are defined as all audits that were not selected using statistically representative sampling**.**

Overall targets of the H2020 ex-post audits

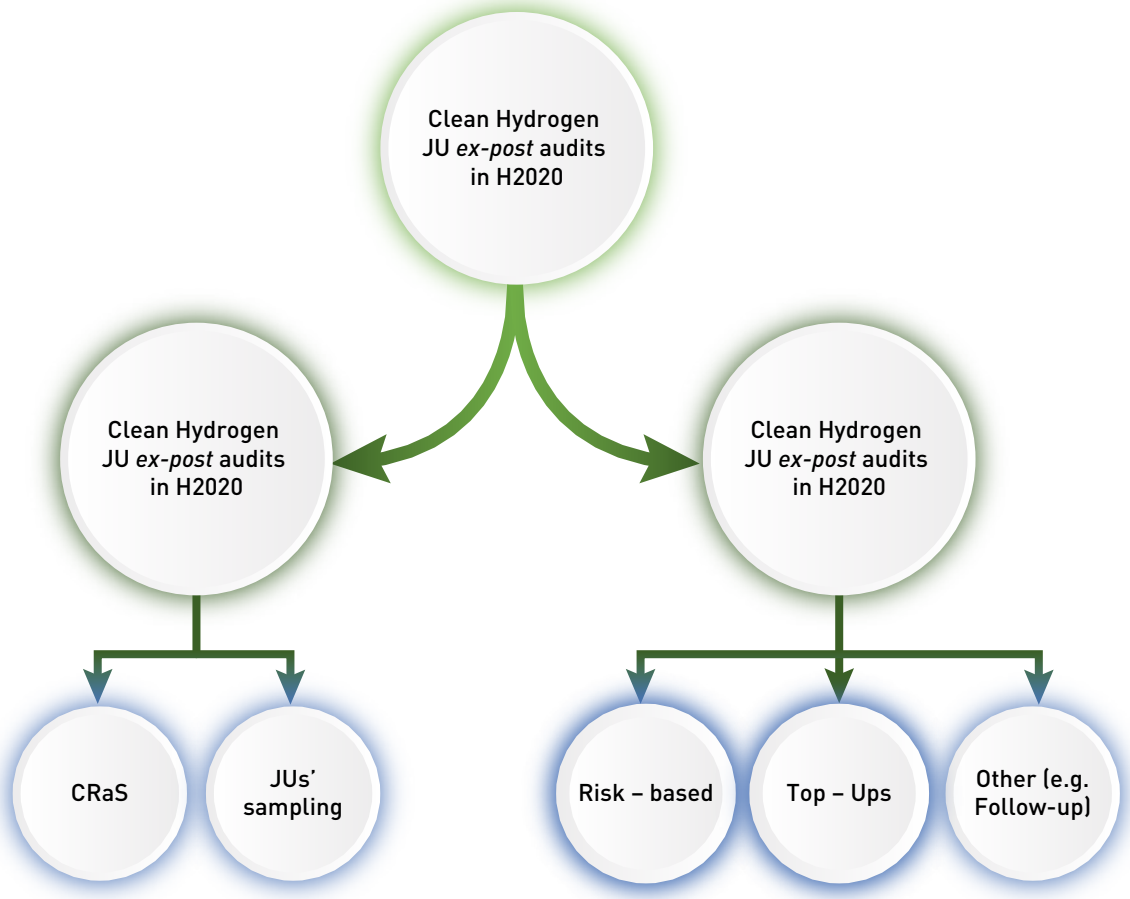
For the Clean Hydrogen JU, an initial target of 295 participations ([129]) was defined, following an anticipated payment profile of H2020 interim and final payments.

By 31 December 2023, the Clean Hydrogen JU had selected **185** participations in *ex post* audits (Table 31). Thanks to positive audit results (residual error rate of EC contribution of **–0.59**% as of 31 December 2023, attributed mainly to reinforced *ex ante* controls) and thanks to the significant *ex post* audit coverage achieved, the Clean Hydrogen JU was in the position to reduce the 295 participations to a revised number of 250 participations.

([128]) The top 100 beneficiaries of the Clean Hydrogen JU are those 100 beneficiaries that have the highest cumulative amounts of budgeted EC contributions in euros (for all their signed grants in the H2020 programme with the Clean Hydrogen JU)

([129]) Participation is defined as a combination of a beneficiary and a grant. For example, audits are launched at the beneficiary level and can include up to three different grants. For the achievement of the CAS targets, an audit with one grant agreement is counted as one participation, whereas an audit with three grant agreements is counted as three participations. For the initial Clean Hydrogen JU targets, an average of two participations was envisaged to be included in each *ex post* audit (based on the FP7 statistics).

Figure 35. Distinction between representative and corrective audits



NB: CRAS, common representative sample.

The remaining **65** participations (**250-185**, corresponding to approximately 28 audits) are assessed to be fully sufficient to cover ex-post control needs for the H2020 programme in the next 2-4 years.

The reduction of the ex-post audit targets should also contribute to further reduction of the audit burden of the beneficiaries and should contribute to efficient use of resources which can be allocated to preventive ex ante controls.

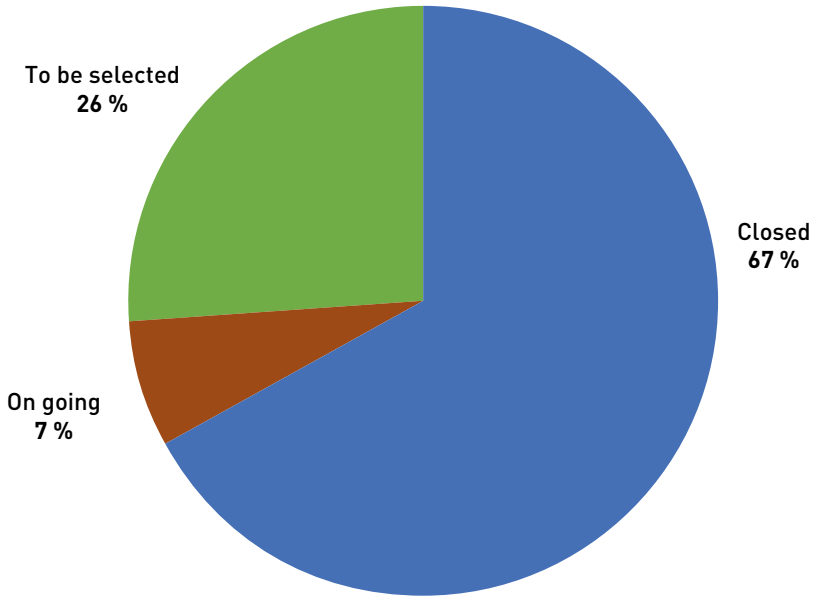
Starting from 2024, when the first Horizon Europe interim payments are expected, the Clean Hydrogen JU will gradually start phasing out the H2020 audits, which to be replaced by Horizon Europe audits.

As observed in Figure 36, with regard the number of participations, the Clean Hydrogen JU is **at 67%** (167/250) of the H2020 *ex post* audit campaign in terms of closed audits and is already at **74%** (185/250) in terms of selected and ongoing audits.

Table 31. H2020 ex post audits up to 31 December 2023 – completeness status

H2020 AUDITS WITH CLEAN HYDROGEN JU PARTICIPATIONS	NUMBER OF PARTICIPATIONS					
	CLOSED	ONGOING	TO BE SELECTED	H2020 INITIAL TARGET	H2020 REVISED TARGET	COMPLETION STATUS
Total up to 31 December 2023	167	18	65	295	250	67%

Figure 36. H2020 *ex post* audits up to 31 December 2023 – completeness status



H2020 overall direct audit coverage on the validated EC contribution

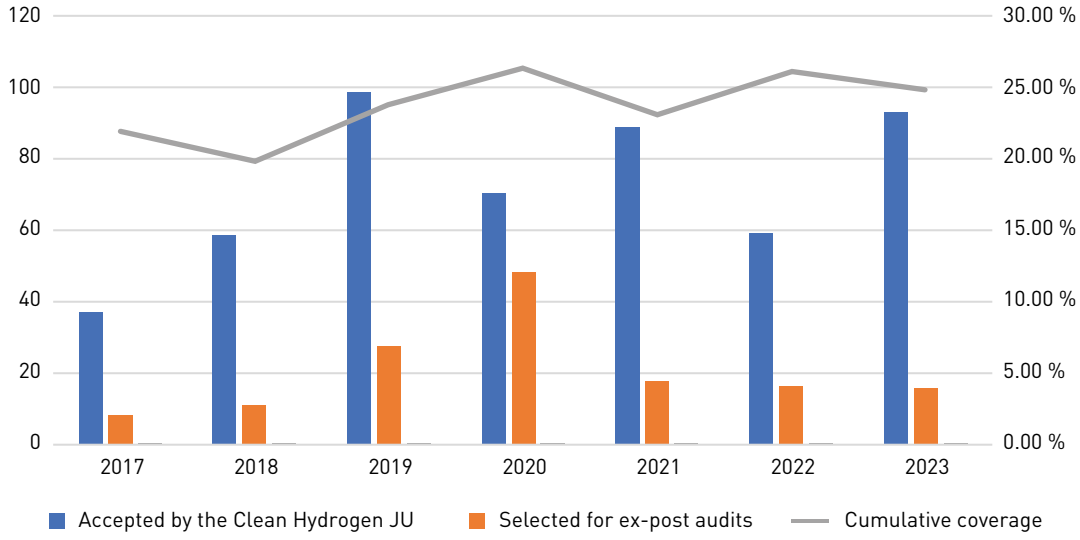
In 2023, the Clean Hydrogen JU validated EUR **93.07 million** of the EC contribution (EUR 59.12 million in 2022).

Throughout the year, the Clean Hydrogen JU selected corrective and representative audits to target overall audit coverage of around 25 % of H2020 expenditure (to be reached by the end of the framework programme) in order to ensure sufficient and timely audit results to support the annual declaration of assurance (Table 32 and Figure 37).

Table 32. Ex post audits: direct audit coverage up to 31 December 2023 (H2020 EC contribution)

YEAR	EC CONTRIBUTION IN MILLION EUR				
	ACCEPTED BY THE CLEAN HYDROGEN JU (MILLION EUR)	SELECTED FOR EX POST AUDITS (MILLION EUR)	CUMULATIVE COVERAGE	AUDITS CLOSED (MILLION EUR)	CUMULATIVE COVERAGE
2017	37.09	8.14	21.96%	1.47	3.95%
2018	58.65	10.80	19.79%	4.71	6.45%
2019	98.53	27.27	23.79%	11.39	9.04%
2020	70.03	48.48	35.83%	23.84	15.67%
2021	88.62	17.38	31.76%	13.89	15.67%
2022	59.12	15.71	31.01%	26.02	19.74%
2023	93.07	15.52	28.37%	44.22	24.86%
Total up to 31 December 2023	**505.11**	**143.30**	**28.37%**	**125.55**	**24.86%**

Figure 37. Direct audit coverage (%) of the selected audits of the EC contribution in comparison with validated EC contributions to the interim and final payments of the H2020 grants (in million EUR)



Thanks to the achievement of the targeted audit coverage set in the beginning of the H2020 *ex post* audit strategy and thanks to timely selection and closure of fresh audits on an annual basis, we can conclude that, by the end of 2023, overall audit targets had been achieved (and surpassed) and provide sufficient and timely basis for the assurance of achievement.

This allows the Clean Hydrogen JU, in 2024 and 2025, to decrease the intensity of the *ex post* audits for the H2020 programme, shift its focus to preventive measures (capitalising on the lessons learnt from the ex-post audits) for the ongoing H2020 grants and start focusing on the Horizon Europe *ex post* audit campaign.

H2020 representative audits

Representative audits in 2023 were selected following the Clean Hydrogen JUs' common sampling methodology. This methodology was built on the principles of stratified random sampling (which is similar to the method used by the FCH JU in FP7 and to a monetary unit sampling method) with the following objectives:

- efficient use of resources;
- focusing on large-value cost claims;
- providing an overview of the full range of projects and beneficiaries of the Clean Hydrogen JU programme;
- ensuring representativeness of the results, as per the International Standards on Auditing.

H2020 risk-based audits

In 2023, risk-based audits were selected by first applying an analytical approach of reviewing the inherent risk and exposure profiles of JU beneficiaries. In the second step, the beneficiaries selected were assessed internally by the project and financial officers and approved by management to validate a rationale for and specific risks involved in the projects signed with those beneficiaries.

As a result of this approach, six beneficiaries were selected for the risk-based audits, following a discussion with the operational services.

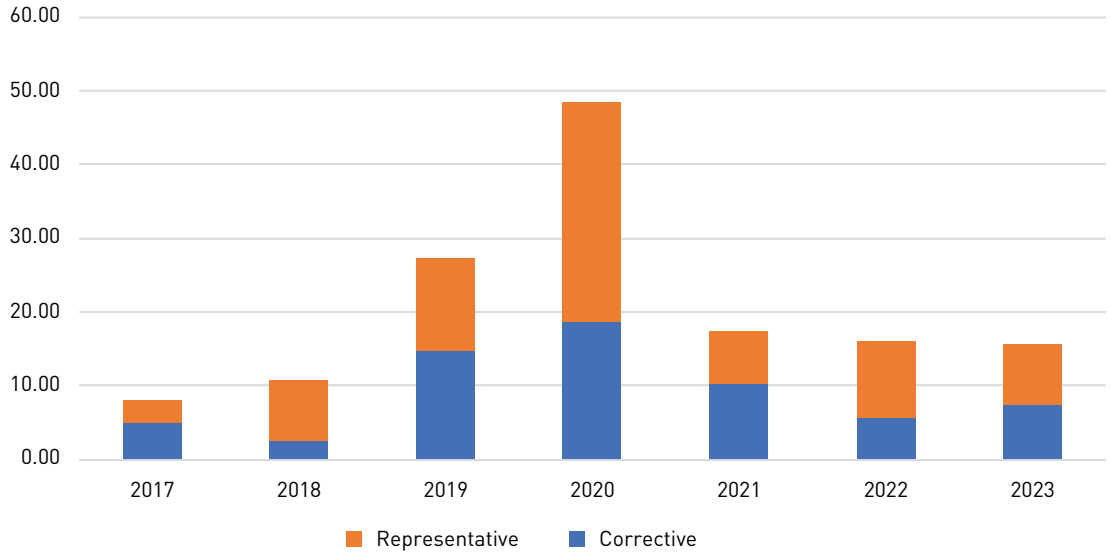
For efficiency purposes, all available cost claims validated by the Clean Hydrogen JU until the audit was launched, if available, were added to the selection.

The distribution of the coverage of the two main audit streams is captured in the Table and Figure 38.

Table 33. Classification of participations selected for ex post audits up to 31 December 2023

	CLEAN HYDROGEN JU CONTRIBUTION IN MIL. EUR		
YEAR	CORRECTIVE	REPRESENTATIVE	TOTAL
2017	4.98	3.16	8.14
2018	2.59	8.22	10.80
2019	14.66	12.61	27.27
2020	18.73	29.75	48.48
2021	10.29	7.10	17.38
2022	5.42	10.29	15.71
2023	7.39	8.13	15.52
Total up to 31 December 2023	**64.05**	**79.25**	**143.30**

Figure 38. JU contribution selected for ex post audits up to 31 December 2023



Results of the Clean Hydrogen JU-specific error rates for H2020

As part of its control strategy, to determine whether there had been material losses (e.g. due to errors) and whether financial rules and procedures were respected, the Clean Hydrogen JU periodically carries out checks of the accuracy and regularity of its *ex ante* controls by performing *ex post* controls on a sample of financial transactions.

As the majority of relevant expenditure for 2023 (excluding Horizon Europe pre-financing) is still related to the H2020 programme, this is the focus of the reporting in this AAR. Error rates for the Horizon Europe programme should become available progressively from AAR 2025 onwards.

Results of **78 representative items** were used to calculate an indicative cumulative **representative error rate for H2020 expenditure specific to the Clean Hydrogen JU, as of 31 December 2023:**

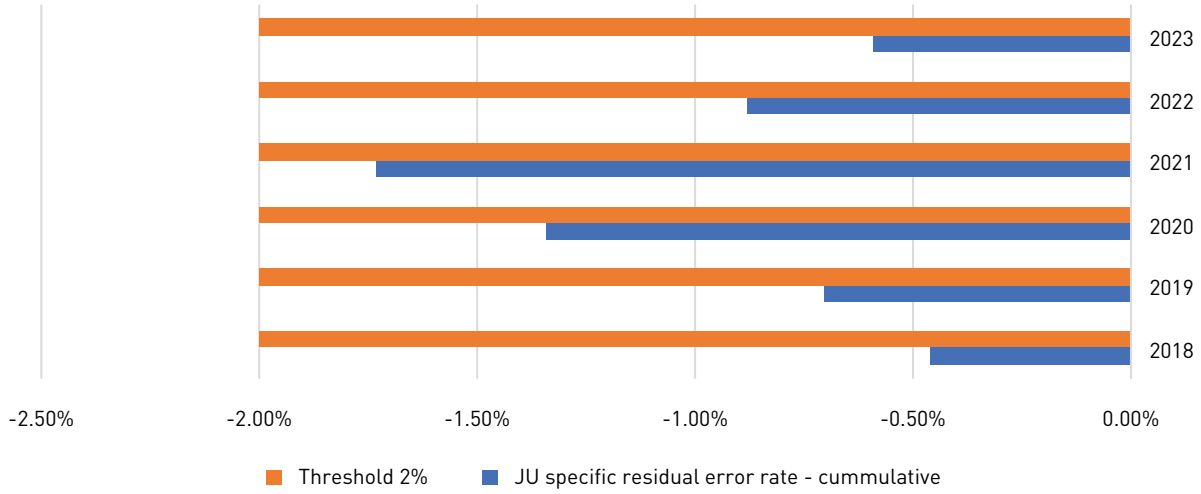
- representative detected error rate of **-2.77%;**
- residual error rate for Clean Hydrogen JU contribution of **-0.59%;**
- residual error rate for the Research and Innovation Family overall**: -1.55%**.

Table 34 and Figure 39 provide the annual evolution of the H2020 JU-specific residual error rate.

Table 34. Evolution of the H2020 JU-specific residual error rate for European Commission contribution (%)

YEAR	JU SPECIFIC RESIDUAL ERROR RATE – CUMULATIVE	THRESHOLD 2%
2018	-0.46%	-2.00%
2019	-0.70%	-2.00%
2020	-1.34%	-2.00%
2021	-1.73%	-2.00%
2022	-0.88%	-2.00%
2023	-0.59%	-2.00%

Figure 39. Evolution of the H2020 JU-specific residual error rate on Commission contribution



In line with the Financial Statement accompanying the Commission's proposal for the Horizon 2020 regulation, a reservation is not necessary for the related expenditure if the cumulative residual error rate for the programme falls within the target range of 2-5%. In 2023, and despite the above-mentioned caveats, the Clean Hydrogen JU cumulative residual error rate for Horizon 2020, calculated at 0.59%, more than fulfils this condition and is below the materiality threshold. The outstanding result of **a very low (0.59%) and decreasing error rate was achieved through the senior financial officers' expertise in explaining the financial rules, detecting errors and asking beneficiaries to correct them at the reporting stage** before the audits were conducted; this exceptional result was obtained thanks to the effort of the Clean Hydrogen JU's project and financial offers. Despite the absence of a reservation, the root causes of errors have been identified and targeted actions taken to address any identified weaknesses in order to remain below the materiality threshold of 2% of the total expense recognised until the end of the programme.

Since Horizon 2020 is a multi-annual programme, the error rates, and the residual error rate in particular, should be considered from a time perspective. The cleaning effect of audits will tend to increase the difference between the representative error rate detected and the cumulative values of the residual error rate, with the latter finishing at a lower value.

European Court of Auditors audits

Since 2020, the European Court of Auditors (ECA) has been performing additional system testing within each JU. This additional testing, based on a monetary unit sample of transactions, should provide the additional assurance required to assess the implementation of ongoing projects, and ensure the quality of the audit opinion, in line with auditing standards.

In respect of the individual discharge for each of the Clean Hydrogen JUs, the ECA will continue to provide each JU with a separate audit opinion. The opinion on the legality and regularity of underlying transactions will be assessed separately taking into account the following elements:

- the Clean Hydrogen JU's individual error rate from the ex post audits;
- the common error rate based on the results of the ECA's substantive testing;
- the error rate related to the transactions of a specific JU within the ECA's substantive testing;
- the correctness of the calculation of the residual error rate reported by the Clean Hydrogen JUs, based on the ex post audit results for their grant payments.

For 2023, the ECA selected and reviewed two transactions from JU participations validated in 2023.

Horizon Europe Framework Programme

The year 2023 was the third year of implementation of the Horizon Europe framework programme (2021-2027) and **60 Clean Hydrogen JU grants** were **signed in 2023**, resulting from the calls for proposals in 2022 and in 2023. No representative error rate calculation for Horizon Europe is available in 2023 as the Clean Hydrogen JU's ex post audit campaign for the Horizon Europe Programme is planned to be launched in 2024 at the earliest, once the first interim payments are validated.

H2020 programme – Implementation of audit results

The Clean Hydrogen JU has implemented the necessary controls and monitoring mechanisms to ensure that all errors detected in favour of the Clean Hydrogen JU are corrected in due course (either through a recovery order or by offsetting a future payment).

Extension of audit findings

Extension of the audit findings (formerly known as extrapolation) is the process whereby systematic errors detected in audited cost claims are extrapolated to all other non-audited JU claims from the same audited beneficiary. This means that systematic errors identified in individual cost claims of H2020 projects will be corrected in all projects of the beneficiaries concerned, including those funded by other granting authorities. For efficiency reasons, the minimum threshold for the audit extension is an average systematic error of 2% identified in the individual audits.

All audit adjustments (positive, nil or negative), including extensions, are implemented via H2020 corporate tools in Sygma/Compass via an AURI ([130]) workflow.

Table 35 summarises the status of the implementation of audit results for the finalised audits on a cumulative basis, as of the reporting cut-off reporting date of 31 December 2023. Table 36 summarises the time taken to implement closed audit results in the 2023 financial year for closed and ongoing projects.

[130] AURI = AUdit Results Implementation

Table 35. H2020: implementation of audit results – status up to 31 December 2023

NUMBER OF IMPLEMENTED AURI (CUMULATIVE FROM THE START OF THE MFF)					
	AUDIT RESULTS PROCESSED	AUDIT RESULTS PROCESSED (%)	AUDIT RESULTS PENDING	% AUDIT RESULTS PENDING (%)	TOTAL AUDITS
Audits	177	97.79 %	4	2.21 %	181
Extensions	52	100.00 %	0	0.00 %	52
Total	**229**	**98.28 %**	**4**	**1.72 %**	**233**

NUMBER OF IMPLEMENTED AUDIT RESULTS (CUMULATIVE FROM THE START OF THE MULTIANNUAL FINANCIAL FRAMEWORK)			
AUDIT RESULTS PROCESSED (%)	AUDIT RESULTS PENDING	AUDIT RESULTS PENDING (%)	TOTAL
97.79 %	4	2.21 %	181
100.00 %	0	0.00 %	52
98.28 %	4	1.72 %	233

Table 36. H2020: time to implement closed audit results in the 2023 financial year

	0-6 MONTHS	% TOTAL NUMBER (0-6 MONTHS)	ABOVE 6 MONTHS	% ABOVE SIX MONTHS	TOTAL
Closed projects. Negative adjustments with recovery	2	66.67%	1	33.33%	112
Closed projects. Positive or zero adjustment	25	80.65%	6	19.35%	67
On-going projects. Negative adjustments	11	100.00%	0	0.00%	69
On-going projects. Positive or zero adjustment	21	100.00%	0	0.00%	20
	59	**94.76%**	**7**	**5.24%**	**268**

Accounts

The main aim of accounting controls is to assure the quality and reliability of the accounts and underlying transactions through methodical checks of the accounting records (data) and timely communication and correction of errors. The controls carried out in 2023 followed the Annual Accounting Quality Plan. The controls performed are additional to the *ex ante* controls performed by the Financial Verifier and Authorising Officer on each transaction, in compliance with the Financial Regulation.

First, the controls were performed on the General Ledger (GL) account of invoices periodically according to the Accounting Quality plan. The vast majority of the invoices are subject to one of the following controls: operational/administrative coherence, Legal Entity default GL, greatest amounts checked, asset risk-based analysis or random sample. The errors detected are corrected either in ABAC or by means of an accounting adjustment at year end.

Second, Ernst & Young audited the final annual accounts of the Clean Hydrogen JU and stated in June 2023 that the Annual Accounts present a true and fair view of the financial position of the JU in all material respects for the year ending December 31, 2023.

Opinion on the reliability of the accounts

In the ECA's opinion, the accounts of the Clean Hydrogen JU for the year ending on 31 December 2023 present fairly, in all material respects, the financial position of the Clean Hydrogen JU, the results of its operations, its cash flows, and the changes in net assets for the year then ended, in accordance with its Financial Regulation and with accounting rules adopted by the Commission's accounting officer. These are based on internationally accepted accounting standards for the public sector. For the year ending 31 December 2022, the ECA issued a clean opinion on the reliability of the accounts ([131]).

([131]) ECA (2022), Annual report on EU joint undertakings for the financial year 2021, Publications Office of the European Union, Luxembourg

Opinion on the legality and the regularity of the transactions underlying the accounts

In the ECA's opinion, the transactions underlying the annual accounts for the year are legal and regular in all material respects.

4.1.2.4. Conclusion on the assessment as regards legality and regularity

The residual error rate (a prime indicator of the legality and regularity aspects of the underlying transactions), with its stable and positive results far below the 2% threshold for both the FP7 and H2020 programmes, confirms that both *ex ante* and *ex post* controls of the Clean Hydrogen JU are present and functioning effectively.

Over 2023, the Brexit crisis and the Russian war of aggression against Ukraine continued to overshadow all other contributing factors towards meeting the targets. However, most of the negative effects continued to be mitigated by flexible working techniques, increasing the digitalisation of finance and procurement processes, helping UK beneficiaries having funding through the UK Research Innovation agency and finding alternatives to the soaring price of electricity affecting the ongoing projects.

In conclusion, based on the analysis of the results of the above-mentioned control sources, no significant weakness was unveiled that could have had a material impact as regards the legality and regularity of the procurement and revenue operations. Therefore, it is possible to conclude that the internal controls systems implemented by the Clean Hydrogen JU provide sufficient assurance to adequately manage the risks relating to the legality and regularity of the underlying transactions.

4.1.3. Fraud prevention, detection, and correction

The Clean Hydrogen JU implements the common research anti-fraud strategy. In March 2019, the CIC adopted the revised strategy and the associated action plan. The implementation of the action plan is monitored through regular meetings of the Fraud and Irregularity Committee, in which the Clean Hydrogen JU participates. Furthermore, for areas of expenditure other than grants, the Clean Hydrogen JU applies mutatis mutandis, by analogy, the anti-fraud strategy of DG Research and Innovation. For Horizon Europe, the new "Guidance – Horizon Europe – Ex-ante Checks to Detect Potential Fraud (version 07/22)" helps alert staff members about additional checks. This is relevant in particular to expert management, procurement and internal fraud. The risk analysis leads to the conclusion that the residual risks (after mitigating actions) are low.

Awareness raising remains the main preventive measure. In this regard, OLAF anti-fraud training courses for the Clean Hydrogen JUs took place on 21 June 2023 and 28 November 2023 (for the whole JU staff), covering for *ex ante* checks to detect potential fraud in Horizon Europe programme. They delivered an updated version of the common antifraud training material for the R&I family and these training courses were addressed to all staff dealing with research grants in cooperation with OLAF, Fraud and Irregularity in Research (FAIR) committee and the Common Audit Service (CAS) of the DG R&I.

4.1.4. Assets and information, reliability of reporting

The safeguarding of assets "provides reasonable assurance regarding prevention or timely detection of unauthorized acquisition, use or disposition of the company's assets that could have a material effect on the financial statements" [132]. In the Clean Hydrogen JU, this has been ensured since 2011 by following the inventory procedure, which covers not only assets over EUR 420 but also any items below this level kept in the inventory. We keep the control effective by using our own inventory tags and perform annual physical inventory counts in relation to the assets report, which is provided to the accountant for the preparation of the annual accounts. Phaseout and impairment are also kept in a timely way in the database to support the disposal exercises performed on an ad hoc basis.

In the event of a disaster, the JU ensures the complete restoration of the system. In the common IT Security procedure for the JUs, the following pre-defined principles were kept:

[132] *Source:* The Committee of Sponsoring Organizations (COSO) of the Treadway Commission's Addendum, Reporting to External Parties

- Those using personal computers are responsible for backing up the information stored on their local machines. This can be automatized by the user using the OneDrive backup feature, which is included in the adopted Microsoft 365 solution.
- We use industry-standard media, techniques, and timelines when executing all backups. For servers, whenever system software permits, backups are performed without end-user involvement, over an internal network and during off hours. Media are stored in a secured cloud data center at a separate location and provider from the system being backed up. All Confidential information stored on backup media are encrypted using approved encrypting methods. Back up communication and streaming are also encrypted.
- With the increased use of cloud storage for the information management system, the JU is relying on the security measures and backup provided by the Microsoft 365 solution. Nevertheless, a cloud backup solution has been deployed as a safeguard of the retention policy of documents.
- Other general controls – such as antivirus software, firewalls and change management processes – are ensured by our ICT managed service providers. Regarding cybersecurity vigilance, we use the active solution of Microsoft Defender to safeguard our storage and communication, together with the passive support and monitoring of CERT-EU for intrusion detection and weaknesses. Phishing campaigns and redteaming exercises are performed on an annual basis with the support of European Union Agency for Cybersecurity (ENISA) and CERT-EU.

4.1.5. Efficiency of controls ("Time to")

TIME-TO-PAY ([133])

Operational payments

FP7

In 2023, the last FP7 report was assessed and paid.

H2020

In 2023, 53 (31 interim and 22 final) H2020 reports were assessed (57 in 2022). The overall time to pay (TTP) remained stable and in line with that of prior years (64 days in 2023 compared with 66 in 2022).

The gross TTP (including any suspensions due to requests for clarifications and amendments) reached 112 days.

Horizon Europe

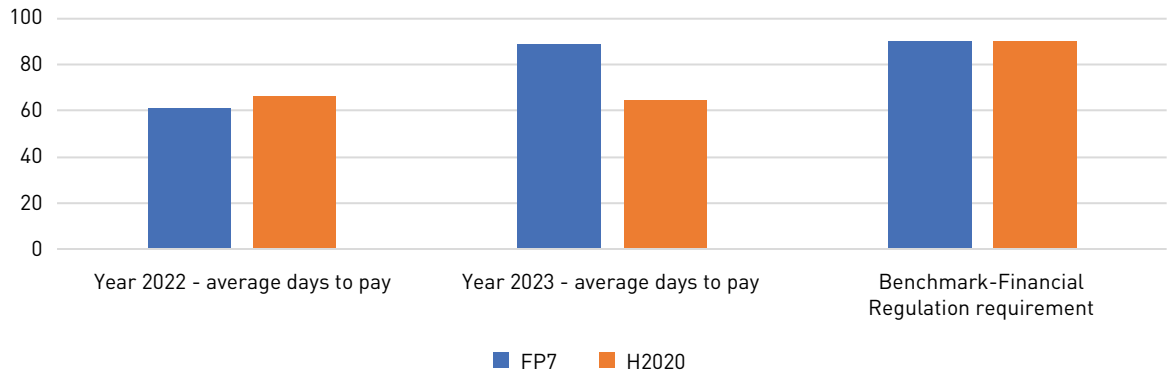
In total, 66 prefinancing payments were processed by 31 December 2023, with a few grants starting to incur costs in 2023. First interim reports are due and will be assessed in 2024.

Table 37. Efficiency of controls – TTP: operational expenditure

FRAMEWORK PROGRAMME – INTERIM AND FINAL PAYMENTS	YEAR 2022 – AVERAGE DAYS TO PAY	YEAR 2023 – AVERAGE DAYS TO PAY	BENCHMARK – FINANCIAL REGULATION REQUIREMENT
FP7	61	89	90
H2020	66	64	90
Horizon Europe	N/A	N/A	90

[133] Art 116.1 FR: 90 calendar days for contribution agreements, contracts and grant agreements involving technical services or actions which are particularly complex to evaluate and for which payment depends on the approval of a report or a certificate.

Figure 40. Efficiency of controls – TTP: operational expenditure



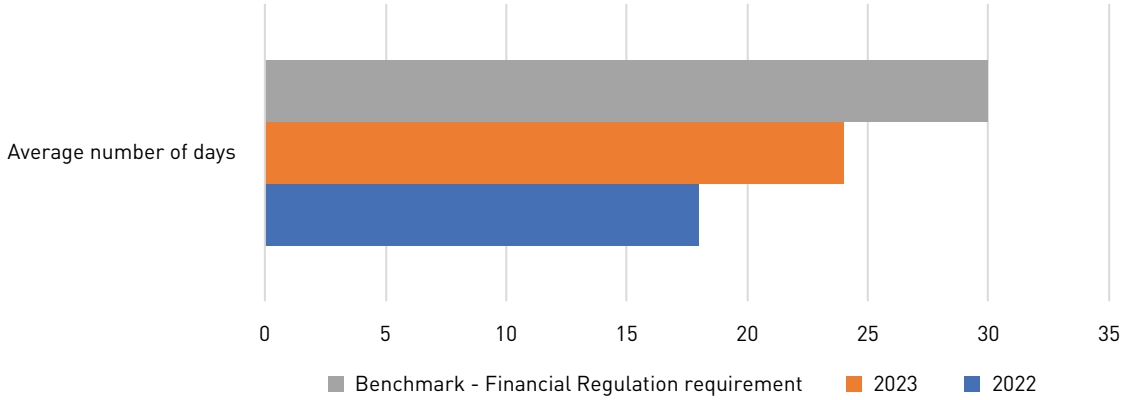
The number of days to assess and pay the H2020 cost claims decreased from 66 days in 2022 to 64 days in 2023.

Table 38. Efficiency of controls – TTP: administrative expenditure

ADMINISTRATIVE PAYMENTS	2022	2023	BENCHMARK – FINANCIAL REGULATION REQUIREMENT
Average number of days	18	24	30

The number of days to assess and pay the administrative expenditure increased from 18 days in 2022 to 24 days in 2023 (Table 38 and Figure 41).

Figure 41. Efficiency of controls – TTP: administrative expenditure



As shown by comparative analysis of an average TTP indicator over the past 2 years against required benchmarks, the Clean Hydrogen JU performed well below the limits of each of the required indicators.

This was achieved through effective monitoring and prioritising system that assesses various aspects, such as the timeliness of responses, priorities and the complexity of transactions. For complex transactions, such as final payments (based on a risk assessment), the Clean Hydrogen JU put preventive measures in place to anticipate and address any potential delays (e.g. missing certificates on financial statements)

Thanks to all these preventive and monitoring measures, the average TTP for both operational and administrative expenditure in 2022 and 2023 demonstrated high levels of efficiency.

4.1.6. Economy of controls

The **principle of economy** "requires that the resources used by the institution in the pursuit of its activities are made available in due time, in appropriate quantity and quality and at the best price."

The analysis of the economy of controls can be estimated based on their costs. Therefore, we have reported on the cost of the controls put in place in the Clean Hydrogen JU. Based on the calculation and assessment of the amount and percentage of the budget managed, we have assessed the economy aspect of our controls (Table 39).

Table 39. Cost of controls up to 31 December 2023

EFFICIENCY AND EFFECTIVENESS OF CONTROLS UP TO 31 DECEMBER 2023	OPERATIONAL EXPENDITURE / RUNNING GRANTS (FP7, H2020) AND NEWLY SIGNED GRANTS (HORIZON EUROPE)	RESOURCES USED ON EX ANTE AND EX POST CONTROLS (ESTIMATED)	AVERAGE PROPORTION
Operational expenditure for 2023	EUR 588 489 021.64	EUR 1 691 000.00	0.29 %
Number of running grants	117	9.5	12.32

As regards grant management, the Clean Hydrogen JU's total cost of controls, measured by the ratio of costs/ to payments, is 0.29% (0.96% in 2022). This means **that the cost of controls represented 0.29% of the Clean Hydrogen JU's operational expenditure** in 2023 and can be quantified as **EUR 14 453** per running grant agreement.

In 2023, the costs of controls increased compared with 2022, as based on the results of the first 2022 Horizon Europe call, 60 new grants were assessed before their signature in 2023 during the grant agreement preparation phase.

As an additional measure of effectiveness, we consider that the residual error rate shows a stable trend over the years, well below 2 %. In 2023, in particular, we demonstrated a significant reduction in the error rate, mainly thanks to targeted risk-based *ex ante* webinars, first introduced in 2020.

Table 39 demonstrates the measurable benefits of the efficient and effective use of resources in the Clean Hydrogen JU to reduce error rates and ensure that principles of sound financial management are well understood and followed by the Clean Hydrogen JU beneficiaries throughout the lifetime of the projects, as well as the monitoring of their scientific progress. From a long-term perspective, we believe that other benefits of a preventive nature that are not directly measurable will be materialised in the future.

4.1.7. Conclusion on the cost-effectiveness of controls

Based on the most relevant key indicators and control results, the Clean Hydrogen JU has assessed the effectiveness, efficiency and economy of its control system and reached a positive conclusion on the cost-effectiveness of the controls for which it is responsible.

Nevertheless, with the introduction of the new Horizon Europe programme, accompanied by significant increases in the budget and the number of grants to be assessed, the pressure on the JU team has increased dramatically compared with 2022 and is expected to increase further in the upcoming years. In order to ensure an adequate level of *ex ante* controls, especially for interim and final payments, the staffing issue shall also be addressed adequately ([134]).

([134]) We refer to the top staff issue risk identified in the Risk Assessment, Section 1 of the AAR

4.2. Audit observations and recommendations

4.2.1. Internal Audit

Internal audits are carried out by the Internal Audit Service (IAS) of the European Commission in liaison with the Internal Control and Audit Manager. In 2023, following the risk assessment performed by the IAS covering all processes (administrative, financial, operational and IT) and the subsequent delivery of the Strategic Internal Audit Plan (SIAP) covering 2023-2025, the Clean Hydrogen JU collaborated with the IAS for the first of the two audits set out in the strategic internal audit plan (SIAP), namely the audit on 'Operational synergies and stakeholder relations'. Interviews were conducted and the audit methodology was agreed with the IAS. The audit activities will continue in 2024.

The second audit, on back-office arrangements, will start at the end of 2024.

4.2.2. Audit by the European Court of Auditors

As regards European Court of Auditors (ECA) audits, in 2023 the Clean Hydrogen JU:

- liaised with the independent auditor (contracted in 2020 and in 2022 based on the results of the reopening of competition under EC (DG BUDG) FWC) to audit Clean Hydrogen JU accounts for 2021 and 2022 as required by the Financial Rules of the Clean Hydrogen JU;
- followed up and implemented recommendations made in the previous ECA reports on the 2021 and 2022 annual accounts;
- provided the necessary information and support to ECA audit of the 2022 accounts;
- supported the ECA team in their field and remote missions for the 2 Clean Hydrogen projects selected (on a sample basis) for an *ex post* financial reviews (see above), including follow-up with Clean Hydrogen JU beneficiaries and with the CAS;
- assisted the ECA in their preliminary review of the 2023 annual accounts and legality and regularity checks conducted in connection with these accounts.

In 2023, the Clean Hydrogen JU received, in the scope of their *Annual report on EU Joint Undertakings for the financial year 2022*, an unqualified (clean) opinion from the Court of Auditors on reliability of the accounts and on legality and regularity of the transactions underlying the accounts. In its report, the ECA confirmed that all previous applicable recommendations were fully completed by the Clean Hydrogen JU in 2023.

4.2.3. Overall Conclusions

In 2023, the Clean Hydrogen JU received positive feedback from both the Internal Audit Service (IAS) of the European Commission and the European Court of Auditors (ECA) on its performance and the legality and regularity of the operations.

These results, jointly with the other key performance indicators, confirmed the continuous improvement and maturity of the internal control environment and the efficiency and effectiveness of the preventive controls put in place by the JU and the follow-up actions it performed in relation to all previous audit recommendations.

All previous recommendations from the IAS and the ECA were adequately and effectively implemented.

4.3. Assessment of the effectiveness of internal control (IC) systems

The Clean Hydrogen JU internal control framework (ICF) is designed to provide reasonable assurance regarding the achievement of the following five objectives:

- effectiveness, efficiency and economy of operations;
- reliability of reporting;
- safeguarding of assets and information;
- prevention, detection, correction and follow-up of fraud and irregularities;
- adequate management of the risks relating to the legality and regularity of the underlying transactions.

4.3.1. Continuous monitoring

In line with the Commission's internal control framework and in line with the objectives and priorities described in the 2022 AWP, the Clean Hydrogen JU assesses annually all internal control components and 17 related principles to ensure that all internal control principles are present and functioning.

In order to conduct the assessment, internal control strengths and deficiencies are identified by using all available information sources such as self-assessment, weaknesses spontaneously reported by staff, exceptions and non-compliance events, ongoing monitoring of the implementation of control and anti-fraud strategies and audit conclusions, findings and recommendations.

The assessment results are evaluated and any potential weaknesses are addressed in the form of actions for improvement, communicated and corrected in a timely manner, with any serious matters reported as appropriate.

4.3.2. Risk assessment and management

On 16 August 2018, the Governing Board adopted a new internal control framework (ICF) stemming from the most up-to-date internationally acknowledged Committee of Sponsoring Organizations of the Treadway Commission model of internal control, in line with the European Commission's ICF. Risk assessment is one of the five key ICF components and consists of four principles:

ICF components and principles – risk assessment

Principle 6. The organisation specifies objectives with sufficient clarity to enable the identification and assessment of risks relating to objectives.

Principle 7. The organisation identifies risks to the achievement of objectives across the entity and analyses the risks as a basis for determining how the risks should be managed.

Principle 8. The organisation considers the potential for fraud in assessing risks to the achievement of objectives.

Principle 9. The organisation identifies and assesses changes that could significantly impact the system of internal control.

For the risk assessment and its conclusions, we refer to Section 1 of the AAR.

4.3.3. Prevention of Conflict of Interest

The Programme Office has developed a comprehensive set of rules and procedures that are effectively implemented across its entire governance structure, as follows:

- when joining the Programme Office team, each staff member agrees to the application of the staff regulation and signs a declaration of honour on the management of conflicts of interest;
- with the Executive Director's decision of 27 September 2019, the Clean Hydrogen JU applies by analogy, *mutatis mutandis*, the 'Code of good administrative behaviour for staff of the European Commission in their relations with the public;

- conflict of interest procedures was in place for the members of both the FCH 2 JU GB and the advisory bodies, and were renewed in December 2021 within the scope of the newly adopted rules of procedure of the GB for the Clean Hydrogen JU;
- specific measures were implemented for the prevention and management of conflicts of interest of experts in charge of the evaluation of grant applications and of the review of projects and tenders;
- for each recruitment procedure to select the best candidate, both Selection Committee members and candidates are required to declare any possible conflicts of interest by signing a declaration so that these conflicts of interests can be considered and potential adjustments made accordingly.

In addition, the Clean Hydrogen JU implements the common research anti-fraud strategy. In March 2019, the CIC adopted the revised strategy and the associated action plan. The implementation of the action plan is monitored through regular meetings of the Fraud and Irregularity Committee, in which the Clean Hydrogen JU participates.

Furthermore, for areas of expenditure other than grants, the Clean Hydrogen JU applies mutatis mutandis, by analogy, the anti-fraud strategy of DG Research and Innovation. This is relevant in particular to expert management, procurement and internal fraud. The risk analysis leads to the conclusion that the residual risks (after mitigating actions) are low.

The Clean Hydrogen JU has ensured the enforcement of Article 61 of the Financial Regulation (conflict of interests) and raises awareness both within its organisation and with external stakeholders.

The conflicts of interest and a lack of objectivity were identified as risks with a low probability. This is due to the ethical awareness and the stance of the Clean Hydrogen JU staff. As a result, the Clean Hydrogen JU has reasonable assurance that the measures in place to prevent conflicts of interest are effective.

4.4. Conclusion on the assurance

This section provides an overall conclusion on the declaration of assurance. It is important to note that only material weaknesses/ risks lead to any reservation concerning the assurances. The concept of materiality provides the Executive Director with the basis for assessing the importance of the weaknesses/risks identified. Deciding whether something is material involves making a judgement in both qualitative and quantitative terms (see details of the materiality criteria in Annex 5.8).

Based on the information provided in the previous sections, the following conclusions can be drawn:

- Concerning the Clean Hydrogen JU's policy activities, no qualification needs to be made. Likewise, there is no reservation in the procedures relating to the selection of contractors and beneficiaries for JU grant agreements and their underlying financial operations (legal and financial commitments). This is also the case for the JU's payments relating to administrative expenditure and procurement and for pre-financing payments in the case of grants.
- The amounts with a greater risk of being affected by errors are the expenditures incurred against cost statements. Based on the analysis of error rates and the effectiveness of the preventive, detective and corrective actions presented in Section 4.1., no reservation is necessary in this area either.
- At the time of developing the annual activity report, the certification process for the IKAA 2023 was still ongoing. The value of the certified IKAA 2022 stands at EUR 283.43 million (out of EUR 520.77 million in the IKAA Plan) and provisional IKAA 2023 of 445 million as of 5 June 2024 (out of EUR 995 million planned), will be updated with 2023 final data to be available end of December 2024, further and will be reported to the Clean Hydrogen JU Governing Board later in the years 2024 and beyond. Therefore, no reservation in this area is necessary either.

In conclusion, the Clean Hydrogen JU's management has reasonable assurance that, overall, suitable controls are in place and are working as intended, risks are being properly monitored and mitigated, and necessary improvements noted by the auditors (i.e. the IAS and the ECA) are being implemented. Therefore, the Executive Director ad interim, in her capacity as authorising officer, has signed the declaration of assurance presented in the following section.

4.5. Statement of Assurance

4.5.1. Assessment of the Annual Activity Report by the Governing Board

The declaration of the Executive Director ad interim and the Clean Hydrogen JU's AAR for 2023 give a fair assessment of the operational and financial management needed for achieving the objectives.

Based on the information provided, the Clean Hydrogen JU key objectives set up for 2023 were all achieved in compliance with the principles of legality and regularity of operations.

The Governing Board notes that the management of the Clean Hydrogen JU has reasonable assurance that, overall, suitable controls are in place and working as intended and that risks are being properly monitored and mitigated.

Therefore, the Executive Director *ad interim*, in her capacity as Authorising Officer, has signed the Declaration of assurance without any reservation.

The Governing Board thanks Ms Mirela Atanasiu, Executive Director ad interim of the Clean Hydrogen JU since May 2023, for her continuous effort to deliver the Clean Hydrogen JU's work programme in 2023.

4.5.2. Declaration of assurance

I, the undersigned, Valérie Bouillon-Delporte
Executive Director of the Clean Hydrogen JU,
In my capacity as authorising officer by delegation,

Declare that the information contained in this report gives a true and fair view.

State that I have reasonable assurance that the resources assigned to the activities described in this report have been used for their intended purpose and in accordance with the principles of sound financial management, and that the control procedures put in place give the necessary guarantees concerning the legality and regularity of the underlying transactions.

This reasonable assurance is based on my own judgement and on the information at my disposal, such as the results of the self-assessment, ex-post controls, the work of the internal audit capability, the observations of the Internal Audit Service and the lessons learnt from the reports of the Court of Auditors for years prior to the year of this declaration.

Confirm that I am not aware of anything not reported here which could harm the interests of the Joint Undertaking.

Brussels, date 28/06/2024

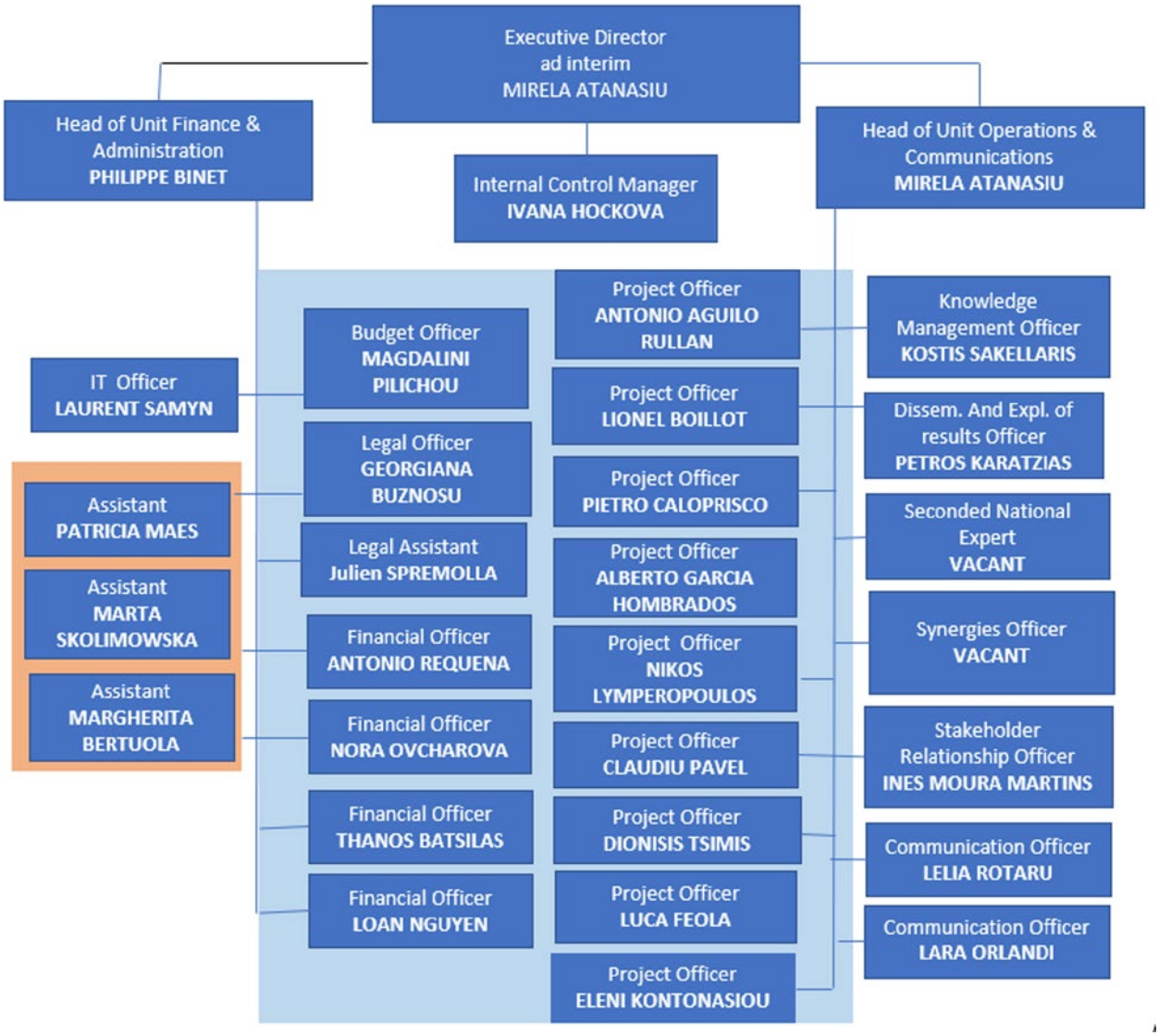
Valérie Bouillon-Delporte
Executive Director

5. ANNEXES

5.1. Organisational chart

The organisational chart valid at the end of 2023 is as follows:

Figure 42. Organisational chart



5.2. Establishment plan and additional information on HR management

Table 40. Human resources by function group/grade and type of post, 2022 and 2023

FUNCTION GROUP AND GRADE	2022				2023	
	AUTHORISED BUDGET		ACTUALLY FILLED AS OF 31/12		AUTHORISED BUDGET	
	PERMANENT POSTS	TEMPORARY POSTS	PERMANENT POSTS	TEMPORARY POSTS	PERMANENT POSTS	TEMPORARY POSTS
AD 16						
AD 15						
AD 14		1		1		1
AD 13						
AD 12		2		2		2
AD 11						
AD 10						2
AD 9		5		5		3
AD 8		4		4		2
AD 7		2		2		5
AD 6		3		3		2
AD 5						
TOTAL AD		**17**		**17**		**17**
AST 11						
AST10						
AST 9		1		1		2
AST 8		1		1		1
AST 7		1		1		1
AST 6		1		1		
AST 5		2		2		5
AST 4		3		3		
AST 3		1		1		1
AST 2						
AST 1						
TOTAL AST		**10**		**10**		**10**
AST/SC 6						
AST/SC 5						
AST/SC 4						
AST/SC 3						
AST/SC 2						
AST/SC 1						
TOTAL AST/SC		**10**		**10**		**10**
TOTAL AD+AST+AST/SC		**27**		**27**		**27**
GRAND TOTAL	**27**				**27**	

NB: AD, administrator; AST, assistant; SC, secretary.

Table 41. Contract staff by function group

CONTRACT AGENTS	AUTHORIZED	ACTUALLY FILLED AS OF 31/12/2023
Function Group IV	1	0
Function Group III	1	1
Function Group III		
Function Group I		
TOTAL	**2**	**1**

Table 42. SNEs

SECONDED NATIONAL EXPERTS	AUTHORIZED	ACTUALLY FILLED AS OF 31/12/2023
SNE	3	2
TOTAL	**3**	**2**

5.3. Publications from projects

This section provides a list of publications in 2023 related to H2020 and Horizon Europe projects, based on the information extracted from the following sources:

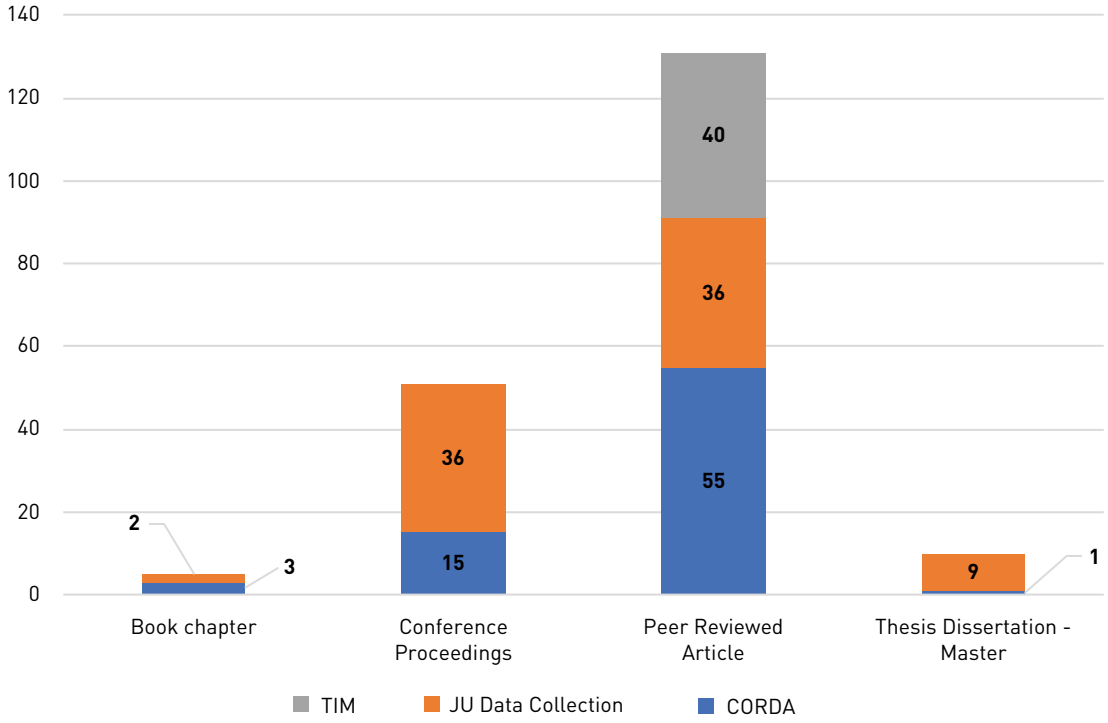
- CORDA;
- Clean Hydrogen JU Data Collection 2024;
- JRC's TIM tool

The list also includes additional publications from 2022 that were not reported in due time by the projects for the Annual Activity Report of 2024. As regards publications of (H2020) projects of previous years, please refer to our past Annual Activity Report publications.

In total we identified 206 new publications, 107 in 2022 and 99 in 2023. About one third of them was extracted from CORDA (79 in total), 85 additional ones came from the Clean Hydrogen JU Data Collection and 42 more were identified using TIM. These include the first publications (in total 18) from Horizon Europe projects, all in 2023.

Focusing on 2023 publications, in the figure below you can find their split per type and source collected:

Figure 43. Project publications by type and source in 2023



5.3.1. Additional Publications of 2022 (complementing AAR22)

Table 43. Additional publications of 2022

SOURCE	ACRONYM	PUBLICATION TYPE	TITLE	AUTHORS	PUBLISHED IN / PRESENTED AT	YEAR
JU data collection	AD ASTRA	Peer-reviewed article	'A physically-based modelling to predict the cyclic voltammetry response of LSCF-type electrodes: Impact of the ohmic losses and microstructure'	Effori, E., Laurencin, J., Tezyk, V., Montella, C., Dessemond, L. and Siebert, E.	*Solid State Ionics*	2022
JU data collection	Best4hy	Peer-reviewed article	'Hydrothermally-assisted recovery of yttria-stabilized zirconia (YSZ) from end-of-life solid oxide cells'	Saffirio, S., Pylypko, S., Fiorot, S., Schiavi, I., Fiore, S., Santarelli, M., Ferrero, D., Smeacetto, F. and Fiorilli, S.	*Sustainable Materials and Technologies*	2022
CORDA	Channel	Peer-reviewed article	'Composition-dependent morphology, structure, and catalytical performance of nickel–iron layered double hydroxide as highly-efficient and stable anode catalyst in anion exchange membrane water electrolysis'	Jiang, W., Faid, A. Y., Gomes, B. F., Galkina, I., Xia, L., Lobo, C. M. S., Desmau, M., Borowski, P., Hartmann, H., Maljusch, A., Besmehn, A., Roth, C., Sunde, S., Lehnert, W. and Shviro, M.	*Advanced Functional Materials*	2022
CORDA	Channel	Peer-reviewed article	'Ternary NiCoFe nanosheets for oxygen evolution in anion exchange membrane water electrolysis'	Faid, A. Y., Barnett, A. O., Seland, F. and Sunde, S.	*International Journal of Hydrogen Energy*	2022
CORDA	Channel	Peer-reviewed article	'Unveiling hydrogen evolution dependence on KOH concentration for polycrystalline and nanostructured nickel-based catalysts'	Faid, A. Y., Foroughi, F., Sunde, S. and Pollet, B.	*Journal of Applied Electrochemistry*	2022
CORDA	Comsos	Peer-reviewed article	'When SOFC-based cogeneration systems become convenient? A cost-optimal analysis'	Marocco, P., Gandiglio, M. and Santarelli, M.	*Energy Reports*	2022
JU data collection	eghost	Conference proceedings	'Social life cycle assessment of a solid oxide electrolysis cell stack'	Campos-Carriedo, F., Puig-Samper, G., Bargiacchi, E., Iribarren, D. and Dufour, J.	23rd World Hydrogen Energy Conference	2022
JU data collection	eghost	Conference proceedings	'Sustainability assessment of a proton-exchange membrane fuel cell stack as a basis for the development of eco-design guidelines'	Mori, M., Iribarren, D., Cren, J., Monnier, E., Stropnik, R., Lotrič, A., Sekavčnik, M., Cortés, D., Giménez, L., Rey, L., Puig-Samper, G., Campos-Carriedo, F., Bargiacchi, E., Dufour, J. and Cor, E.	23rd World Hydrogen Energy Conference	2022
JU data collection	eghost	Conference proceedings	'The role of circularity and criticality indicators in the eco-design of fuel cells and hydrogen technologies'	Bargiacchi, E., Campos-Carriedo, F., Puig-Samper, G., Iribarren, D., Rey, L., Cor, E. and Dufour, J.	European Hydrogen Energy Conference 2022	2022
CORDA	FCH2rail	Conference proceedings	'Bi-mode hydrogen train requirements using geospatial line assessment'	Herwartz, S., Kühlkamp, F., Pagenkopf, J., Fernandez Del Rey, A., Valera, M., Carillo Dominguez, A. M. and Ganhao, F.	*Proceedings of the World Congress on Railway Research 2022*	2022
CORDA	FCH2rail	Peer-reviewed article	'Review and comparison of worldwide hydrogen activities in the rail sector with special focus on on-board storage and refueling technologies'	Mathias Böhm, M., Fernández Del Rey, A., Pagenkopf, J., Varela, M., Herwartz-Polster, S. and Nieto Calderón, B.	*International Journal of Hydrogen Energy*	2022
CORDA	FCH2rail	Conference proceedings	'The EU project FCH2rail – Fuel cell hybrid powerpack for rail applications'	Dittus, H., Terron, E., Landtmeters, T., Fernandez Del Rey, A., Martin-Carillo, A., De la Cruz, C., Ganhao, F. and Kück, S.	*Proceedings of the World Congress on Railway Research 2022*	2022

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SOURCE	ACRONYM	PUBLICATION TYPE	TITLE	AUTHORS	PUBLISHED IN / PRESENTED AT	YEAR
CORDA	FCH2rail	Conference proceedings	'The FCH2rail project: A demonstration of a modular fuel cell hybrid power pack'	Kühlkamp, F., Schenker, M., Pagenkopf, J., Dittus, H., Herwartz, S., Fernández Del Rey, A. and Varela, M.	*Proceedings of the TRA 2022*	2022
CORDA	FCH2rail	Conference proceedings	'Using absorption refrigerator and metal hydrides in hydrogen fuel cell trains: Draft design process and feasibility'	Kordel, M., Heckert, F., Knetsch, K. and Boeck, L.	*European Hydrogen Energy Conference 2022 Proceeding Book*	2022
CORDA	Flhysafe	Conference proceedings	'Comparing distributed and integrated hazard analysis environments'	Berres, A., Lubbe, S., Schäfer, M. and Voth, V.	*Proceedings of the 32nd European Safety and Reliability Conference (ESREL 2022)*	2022
CORDA	Further-FC	Peer-reviewed article	'Exploring critical parameters of electrode fabrication in polymer electrolyte membrane fuel cells'	Talukdar, K., Morawietz, T., Sarkezi-Selsky, P., Yezerska, K., Sergeev, O., Heger, J.-F., Jahnke, T., Gazdzicki, P. and Friedrich, K. A.	*Journal of Power Sources*	2022
CORDA	Further-FC	Peer-reviewed article	'In die Tiefen der Brennstoffzelle'	Morawietz, T., Heger, J.-F., Friedrich, K. A. and Käß, H.	*GIT Labor-Fachzeitschrift*	2022
CORDA	Further-FC	Peer-reviewed article	'Into the depths of hydrogen fuel cells'	Morawietz, T., Heger, J.-F., Friedrich, K. A. and Käß, H.	*Imaging & Microscopy*	2022
CORDA	Further-FC	Peer-reviewed article	'The challenges in reliable determination of degradation rates and lifetime in polymer electrolyte membrane fuel cells'	Zhang, Q., Harms, C., Mitzel, L., Gazdzicki, P. and Friedrich, K. A.	*Current Opinion in Electrochemistry*	2022
CORDA	Haeolus	Book chapter	'Electrolysers towards EU MAWP 2023 targets and beyond'	Andrenacci, S., Choi, Y., Raka, Y., Talic, B. and Colmenares-Rausseo, L.		2022
CORDA	Haeolus	Conference proceedings	'Green hydrogen from intermittent renewables'	Zenith, F.		2022
CORDA	Haeolus	Peer-reviewed article	'Operating hydrogen-based energy storage systems in wind farms for smooth power injection: A penalty fees aware model predictive control'	Mariani, V., Zenith, F. and Glielmo, L.	*MDPI Energies*	2022
CORDA	Haeolus	Conference proceedings	'The Haeolus project in Berlevåg'	Zenith, F.	*Hydrogen Production in the Arctic seminar*	2022
CORDA	Haeolus	Peer-reviewed article	'Two-stage model predictive control for a hydrogen-based storage system paired to a wind farm towards green hydrogen production for fuel cell electric vehicles'	Abdelghany, M. B., Shehzad, M. F., Mariani, V. Liuzza, D. and Glielmo, L.	*International Journal of Hydrogen Energy*	2022
CORDA	Haeolus	Peer-reviewed article	'Value of green hydrogen when curtailed to provide grid balancing services'	Zenith, F., Nord Flote, M., Santos-Mugica, M., Scott Duncan, C., Mariani, V. and Marcantonini, C.	*International Journal of Hydrogen Energy*	2022
CORDA	Hycare	Peer-reviewed article	'An effective activation method for industrially produced TiFeMn powder for hydrogen storage'	Dreistadt, D. M., Le, T.-T., Capurso, G., Bellosta von Colbe, J. M., Santhosh, A., Pistidda, C., Scharnagl, N., Ovri, H., Milanese, C., Jerabek, P., Klassen, T. and Jepsen, J.	*Journal of Alloys and Compounds*	2022

SOURCE	ACRONYM	PUBLICATION TYPE	TITLE	AUTHORS	PUBLISHED IN / PRESENTED AT	YEAR
CORDA	Hycare	Peer-reviewed article	'In-situ neutron diffraction during reversible deuterium loading in Ti-rich and Mn-substituted $Ti(Fe,Mn)_{0.90}$ alloys'	Dematteis, E. M., Barale, J., Capurso, G., Deledda, S., Sørby, M. H., Cuevas, F., Latroche, M. and Baricco, M.	*Journal of Alloys and Compounds*	2022
CORDA	Hycare	Peer-reviewed article	'$TiFe_{0.85}Mn_{0.05}$ alloy produced at industrial level for a hydrogen storage plant'	Barale, J., Dematteis, E. M., Capurso, G., Neuman, B., Deledda, S., Rizzi, P., Cuevas, F. and Baricco, M.	*International Journal of Hydrogen Energy*	2022
CORDA	Hydrosol-Beyond	Peer-reviewed article	'Conceptual design of an innovative gas–gas ceramic compact heat exchanger suitable for high temperature applications'	Zavattoni, S., Cornolti, L., Puragliesi, R., Arrivabeni, E., Ortona, A. and Barbato, M.	*Heat Mass Transfer*	2022
JU data collection	Hypster	Conference proceedings	'Blowout from a hydrogen storage cavern?'	Polytechnique, Brouard Consulting, Ineris and Storengy	SMRI Spring Meeting, Rapid City, South Dakota	2022
JU data collection	Hypster	Conference proceedings	'Characteristic features of salt cavern behavior'	Armines and Polytechniques	SaltechMech Conference, Utrech	2022
JU data collection	Hypster	Peer-reviewed article	'Computational fluid dynamics applied to hydrogen safety?'	Ineris	*Journal Energies*	2022
JU data collection	Hypster	Conference proceedings	'Haze, rain and inversion temperature in gas storage salt caverns?'	Armines and Polytechniques	American Rock Mechanics Association 2022, Santa Fe, New Mexico	2022
JU data collection	Hypster	Conference proceedings	'Modélisation de l'éruption d'une cavité saline de stockage souterrain d'hydrogène?'	Armines, Polytechniques, Brouard Consulting, Ineris and Storengy	11ème journées nationales de géotechnique et de géologie de l'ingénieur, Lyon	2022
JU data collection	Hypster	Conference proceedings	'Risk identification for a hydrogen storage in salt cavern?'	Ineris	Submitted for the Gastech Conference 2022	2022
CORDA	Hystories	Peer-reviewed article	'Assessment of the potential for underground hydrogen storage in salt domes'	Lankof, L., Urbańczyk, K. and Tarkowski, R.	*Renewable and Sustainable Energy Reviews*	2022
CORDA	Hystories	Conference proceedings	'Enabling large-scale hydrogen storage in salt caverns: Recent developments'	Réveillère, A., Fournier, C., Karimi-Jafari, M. and Courault, C.		2022
CORDA	Hystories	Peer-reviewed article	'Modeling hydrogen – rock – brine interactions for the Jurassic reservoir and cap rocks from Polish lowlands'	Labus, K. and Tarkowski, R.	*International Journal of Hydrogen Energy*	2022
CORDA	Hyuspre	Thesis dissertation – master's	'Analyzing the transition of electricity generation in the European electricity system until 2030'	Perez Villanueva, C. M.		2022
CORDA	Hyuspre	Peer-reviewed article	'Geological hydrogen storage: Geochemical reactivity of hydrogen with sandstone reservoirs'	Aliakbar Hassanpouryouzband, A., Adie, K., Cowen, T., Thaysen, E. M., Heinemann, N., Butler, I. B., Wilkinson, M. and Edlmann, K.	*ACS Energy Letters*	2022
CORDA	Hyuspre	Peer-reviewed article	'Relative permeability of hydrogen and aqueous brines in sandstones and carbonates at reservoir conditions'	Rezaei, A., Hassanpouryouzband, A., Molnar, I., Derikvand, Z., Haszeldine, R. S. and Edlmann, K.	*Geophysical Research Letters*	2022

SOURCE	ACRONYM	PUBLICATION TYPE	TITLE	AUTHORS	PUBLISHED IN / PRESENTED AT	YEAR
JU data collection	Newely	Conference proceedings	'High-performance alkaline water electrolysis using anion-exchange membrane-electrode assembly with catalyst coated membrane and platinum free catalysts'	Naah, M., Tsoy, E., Khalid, H., Chen, Y., Li, Q., Bae, C., ¼ and Henjibkensmeier, D.	*ECS Meeting Abstracts*	2022
CORDA	Newely	Peer-reviewed article	'Optimization of the membrane electrode assembly for an alkaline water electrolyser based on the catalyst-coated membrane'	Plevová, M., Hnát, J., Žitka, J., Pavlovec, L., Otmar, M. and Bouzek, K.	*Journal of Power Sources*	2022
CORDA	Newely	Peer-reviewed article	'Properties of anion exchange membranes with a focus on water electrolysis'	Khalid, H., Najibah, M., Park, H. S., Bae, C. and Henkensmeier, D.	*Membranes (Basel)*	2022
CORDA	Newsoc	Peer-reviewed article	'Novel SrO-containing glass-ceramic sealants for solid oxide electrolysis cells (SOEC): Their design and characterization under relevant conditions'	Javed, H., Zanchi, E., D'Isanto, F., Bert, C., Ferrero, D., Santarelli, M. and Smeacetto, F.	*Materials*	2022
CORDA	Newsoc	Peer-reviewed article	'Printability of carboxymethyl cellulose / glass-containing inks for robocasting deposition in reversible solid oxide cell applications'	Lamnini, S., Baino, F., Montalbano, G., Javed;, H. and Smeacetto, F.	*Materials Letters*	2022
CORDA	Newsoc	Peer-reviewed article	'Torsional behaviour of glass-joined, laser-processed Crofer 22 APU interconnect: Unravelling the effect of surface roughness on the shear strength'	Smeacetto, F., Zanchi, E., Menon, D. M. N., Janner, D., Lamnini, S., Salvo, M., De La Pierre, S., Javed, H. and Ferraris, M.	*Ceramics International*	2022
CORDA	Reflex	Conference proceedings	'SOC development at Elcogen'	Noponen, M., Granö-Fabritius, H., Pylypko, S. and Õunpuu, E.	European Fuel Cell Forum 2022: 15th European SOFC & SOE Forum, 5–8 July 2022	2022
CORDA	Reflex	Conference proceedings	'Solid oxide electrolysis stack development and upscaling'	Di Iorio, S., Monnet, T., Palcoux, G., Ceruti, L. and Mougin, J.	European Fuel Cell Forum 2022: 15th European SOFC & SOE Forum, 5–8 July 2022	2022
CORDA	Remote	Peer-reviewed article	'Life cycle assessment of a renewable energy system with hydrogen-battery storage for a remote off-grid community'	Gandiglio, M., Marocco, P., Bianco, I., Lovera, D., Blengini, G. A. and Santarelli, M.	*International Journal of Hydrogen Energy*	2022
CORDA	Remote	Peer-reviewed article	'Life cycle environmental analysis of a hydrogen-based energy storage system for remote applications'	Bionaz, D., Marocco, P., Ferrero, D., Sundseth, K. and Santarelli, M.	*Energy Reports*	2022
JU data collection	RUBY	Conference proceedings	'A dynamic multi-scale model for solid oxide cells validated on local current measurements: Impact of global cell operation on the electrodes reaction mechanisms'	Da Rosa Silva, E., Hubert, M., Morel, B., Moussaoui, H., Debayle J. and Laurencin, J.	*ECS Transactions*	2022
CORDA	RUBY	Conference proceedings	'Voltage prognosis of PEMFC estimated using multi-reservoir bidirectional echo state network'	Chanal, D., Steiner, N. Y., Chamagne, D. and Pera, M.-C.	2022 10th International Conference on Systems and Control (ICSC)	2022
JU data collection	SH2E	Peer-reviewed article	'Assessing the prospective environmental performance of hydrogen from high-temperature electrolysis coupled with concentrated solar power'	Puig-Samper, G., Bargiacchi, E., Iribarren, D. and Dufour, J.	*Renewable Energy*	2022
CORDA	SH2E	Conference proceedings	'Life cycle costing approaches of fuel cell and hydrogen systems: A literature review'	Ishimoto, Y., Wulf, C. and Kuckshinrichs, W.	*Proceedings of 23rd World Hydrogen Energy Conference*	2022

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JU data collection	SH2E	Conference proceedings	'Prospective life cycle assessment of hydrogen production in a solid oxide electrolyser integrated into a parabolic trough concentrated solar power plant'	Puig-Samper, G., Bargiacchi, E., Iribarren, D. and Dufour, J.	*Proceedings of Hypothesis XVI*	2022
JU data collection	Shipfc	Conference proceedings	'Comparison of decarbonisation solutions for shipping: Hydrogen, ammonia and batteries'	Wang, H., Trivyza, N., Boulougouris, E. and Mylonopoulos, F.	Society of Naval Architects and Marine Engineers 14th International Marine Design Conference	2022
JU data collection	Shipfc	Conference proceedings	'Fuel cell, ammonia powered container ship: A case study'	Louvros, P., Trivyza, N. L., Komianos, A. and Boulougouris, E.	Transport Research Arena Conference 2022	2022
JU data collection	Shipfc	Peer-reviewed article	'Intercomparison between LH_2, LNG and pressurized NH_3 dispersion using an adiabatic mixing approach'	Venetsanos, A. G., Boulougouris, G. C., Giannissi, S., Krassa, Th., Andronopoulos, S. and Bartzis, J.G.	*International Journal of Hydrogen Energy*	2022
JU data collection	SO-FREE	Conference proceedings	'Solid oxide fuel cell systems for decentralized, hydrogen-based power generation'	Neubauer, R., Reiter, B. and Hauth, M.		2022
JU Data Collection	Stashh	Conference proceedings	'Stashh: Standard sized FC module for heavy duty applications'	Theisen, P.	2022 European Automotive Research Partners Association Autumn Meeting	2022
CORDA	Stashh	Conference proceedings	'The Stashh fuel-cell module standard'	Zenith, F., Bouwman, R. and Lundkvist, H.	Vehicle Power and Propulsion Conference	2022
CORDA	Switch	Peer-reviewed article	'Fast online diagnosis for solid oxide fuel cells: Optimisation of total harmonic distortion tool for real-system application and reactants starvation identification'	Moussaoui, H., Hammerschmid, G., Van herle, J. and Subotić, V.	*Journal of Power Sources*	2022
CORDA	Switch	Peer-reviewed article	'Operation analysis of a flexible solid oxide cell module for power to hydrogen and polygeneration'	Salas Ventura, S., Metten, M., Tomberg, M., Ullmer, D., Heddrich, M. P. and Ansar, S. A.	*Chemie Ingenieur Technik – Special Issue: (Bio)Process Engineering*	2022
CORDA	THOR	Conference proceedings	'Classification of compromised DOFS data with LSTM neural networks'	Usenco, V. and Lasn, K.	*Proceedings of 8th European Congress on Computational Methods in Applied Sciences and Engineering (Eccomas 2022)*	2022
CORDA	THOR	Peer-reviewed article	'Integration of optical fibre sensors by material extrusion 3-D printing – The effect of bottom interlayer thickness'	Wang, S. and Lasn, K.	*Materials & Design*	2022
CORDA	THYGA	Peer-reviewed article	'The impact of hydrogen admixture into natural gas on residential and commercial gas appliances'	Leicher, J., Schaffert, J., Cigarida, H., Tali, E., Burmeister, F., Giese, A., Albus, R., Görner, K., Carpentier, S., Milin, P. and Schweitzer, J.	*Energies*, Vol. 15, No 3, 777	2022
JU data collection	Waste2watts	Peer-reviewed article	'Biogas composition from agricultural sources and organic fraction of municipal solid waste'	Calbry-Muzyka, A., Madi, H., Rüsch-Pfund, F., Gandiglio, M. and Biollaz, S.	*Renewable Energy*	2022

SOURCE	ACRONYM	PUBLICATION TYPE	TITLE	AUTHORS	PUBLISHED IN / PRESENTED AT	YEAR
JU data collection	Waste2watts	Thesis dissertation – master's	'Experimental analysis about the performances of commercial materials for biogas purification'	Giacalone, L.	Master's thesis report	2022
JU data collection	Waste2watts	Conference proceedings	'Operating SOFC on reformed biogas with sulfide poisoning'	Frantz, C., Schucan, L. and Van herle, J.	European Fuel Cell Forum 2022: 15th European SOFC & SOE Forum, Lucerne, Switzerland, 5–8 July 2022	2022
JU data collection	Waste2watts	Thesis dissertation – master's	'Performance losses of anode-supported SOFC exposed to dulphide contaminants'	Schucan, L.	Semester project	2022
JU data collection	Waste2watts	Thesis dissertation – master's	'Performance losses of electrolyte-supported SOFC exposed to sulphide contaminants'	Savioz, L.	Semester project	2022
JU data collection	Waste2watts	Thesis dissertation – master's	'Purification of biogas from sulphur compounds: Experimental investigation and techno-economic assessment'	Cappai, F.	Master's thesis report	2022
JU data collection	Waste2watts	Thesis dissertation – master's	'Solid oxide fuel cells: Performance analysis for integrated cogeneration with bio-syngas'	Tamburrano, G.	Master's thesis	2022
JU data collection	Waste2watts	Thesis dissertation – master's	'Stability of methane reforming catalysts towards dimethyl sulfide'	Hanria, Y.	Master's thesis	2022
JU data collection	Waste2watts	Conference proceedings	'Techno-economic evaluation of biogas-fed SOFC power system integrated with CCS and CCU'	Yu, H., Wang, L. and Van herle, J.	European Fuel Cell Forum 2022: 15th European SOFC & SOE Forum, Lucerne, Switzerland	2022
TIM	PRESLHY	Peer Reviewed Article	'A CFD analysis of liquefied gas vessel explosions'	Ustolin F.; Tolias I.C.; Giannissi S.G.; Venetsanos A.G.; Paltrinieri N.	Process Safety and Environmental Protection	2022
TIM	HEAVENN	Peer Reviewed Article	'A green hydrogen energy system: Optimal control strategies for integrated hydrogen storage and power generation with wind energy'	Schrotenboer A.H.; Veenstra A.A.T.; uit het Broek M.A.J.; Ursavas E.	Renewable and Sustainable Energy Reviews	2022
TIM	PRETZEL	Peer Reviewed Article	'A high-performance, durable and low-cost proton exchange membrane electrolyser with stainless steel components'	Stiber S.; Sata N.; Morawietz T.; Ansar S.A.; Jahnke T.; Lee J.K.; Bazylak A.; Fallisch A.; Gago A.S.; Friedrich K.A.	Energy and Environmental Science	2022

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TIM	HyCARE	Peer Reviewed Article	'A novel emergency gas-to-power system based on an efficient and long-lasting solid-state hydride storage system: Modeling and experimental validation'	Dreistadt D.M.; Puszkiel J.; von Colbe J.M.B.; Capurso G.; Steinebach G.; Meilinger S.; Le T.-T.; Guarneros M.C.; Klassen T.; Jepsen J.	Energies	2022
TIM	AD ASTRA	Peer Reviewed Article	'Addressing planar solid oxide cell degradation mechanisms: A critical review of selected components'	Vladikova D.; Burdin B.; Bianchi F.R.; Bosio B.; Piccardo P.; Spotorno R.; Uchida H.; Polverino P.; Adinolfi E.A.; Postiglione F.; Lee J.-H.; Moussaoui H.; Van herle J.	Electrochemical Science Advances	2022
TIM	LOWCOST-IC	Peer Reviewed Article	'Ag–SiO_2 – An optimized braze for robust joining of commercial coated stainless steel to ceramic solid oxide cells'	Wang Z.; Li C.; Cao J.; Ritucci I.; Khajavi P.; Kiebach R.	Ceramics International	2022
TIM	AD ASTRA	Peer Reviewed Article	'Characterization of a metallic interconnect operated in stack during 40,000 hours in SOFC mode'	Piccardo P.; Spotorno R.; Bongiorno V.; Paravidino D.; Geipel C.; Patrone G.; Valente F.	E3S Web of Conferences	2022
TIM	PECDEMO	Peer Reviewed Article	'Chemical treatment of Sn-containing transparent conducting oxides for the enhanced adhesion and thermal stability of electroplated metals'	Ahmet I.Y.; Abdi F.F.; van de Krol R.	Advanced Materials Interfaces	2022
TIM	qSOFC	Peer Reviewed Article	'Developing an automated tool for quantitative analysis of the deconvoluted electrochemical impedance response of a solid oxide fuel cell'	Alboghobeish M.; Ferrario A.M.; Pumiglia D.; Della Pietra M.; McPhail S.J.; Pylypko S.; Borello D.	Energies	2022
TIM	PECSYS	Peer Reviewed Article	'Development of various photovoltaic-driven water electrolysis technologies for green solar hydrogen generation'	S. Calnan; R. Bagacki; F. Bao; I. Dorbandt		2022
TIM	ShipFC	Peer Reviewed Article	'Effect of the active metal on the NOx formation during catalytic combustion of ammonia SOFC off-gas'	Weissenberger T.; Zapf R.; Pennemann H.; Kolb G.	Catalysts	2022
TIM	SCORED 2:0	Peer Reviewed Article	'Evaluation of inkjet-printed spinel coatings on standard and surface nitrided ferritic stainless steels for interconnect application in solid oxide fuel cell devices'	S. Pandiyan; M. Bianco; A. El-kharouf; R. Tomov		2022
TIM	FLHYSAFE	Peer Reviewed Article	'FPGA-based real-time simulation for LLC resonant converter prototyping'	Bhattacharya S.; Gregoire L.-A.; Kallo J.; Stevic M.; Garg M.; Willich C.	Distributed Generation Systems, PEDG 2022	2022
TIM	VIRTUAL-FCS	Peer Reviewed Article	'Fuel cell prognosis using particle filter: application to the automotive sector'	Julie A.; Nadia Y.S.; Simon M.; Noureddine Z.; Fabian V.D.L.; Daniel H.	IEEE International Symposium on Industrial Electronics	2022
TIM	HYDRAITE	Peer Reviewed Article	'Impact of hydrogen liquefaction on hydrogen fuel quality for transport applications (ISO-14687:2019)'	Hookham M.J.F.; Le Gendre E.; Coulpier C.; Carré M.; Morris A.S.O.; Moore N.; Hristova Y.; Bacquart T.	Processes	2022
TIM	CRESCENDO	Peer Reviewed Article	'Kinetic diagnostics and synthetic design of platinum group metal-free electrocatalysts for the oxygen reduction reaction using reactivity maps and site utilization descriptors'	Luo F.; Wagner S.; Ju W.; Primbs M.; Li S.; Wang H.; Kramm U.I.; Strasser P.	Journal of the American Chemical Society	2022
TIM	ID-FAST	Peer Reviewed Article	'Lattice Boltzmann simulation of liquid water transport in gas diffusion layers of proton exchange membrane fuel cells: Parametric studies on capillary hysteresis'	Sarkezi-Selsky P.; Schmies H.; Kube A.; Latz A.; Jahnke T.	Journal of Power Sources	2022
TIM	HYDRAITE	Peer Reviewed Article	'Measuring total sulphur amount fraction at picomol/mol in hydrogen fuel: New results from cryo-GC-SCD analytical method'	Bacquart T.; Morris A.S.O.; Bartlett S.; Kjos O.; Murugan A.; Storms W.	Processes	2022

SOURCE	ACRONYM	PUBLICATION TYPE	TITLE	AUTHORS	PUBLISHED IN / PRESENTED AT	YEAR
TIM	PECSYS	Peer Reviewed Article	'Nickel site modification by high-valence doping: Effect of tantalum impurities on the alkaline water electro-oxidation by NiO probed by operando raman spectroscopy'	Saguì N.A.; Ström P.; Edvinsson T.; Bayrak Pehlivan I.	ACS Catalysis	2022
TIM	Demo4Grid	Peer Reviewed Article	'Optimal dispatch model for PV-electrolysis plants in self-consumption regime to produce green hydrogen: A Spanish case study'	Matute G.; Yusta J.M.; Beyza J.; Monteiro C.	International Journal of Hydrogen Energy	2022
TIM	MARANDA	Peer Reviewed Article	'Parametrization, simulation and energy management evaluation of a fuel cell hybrid electric bus'	Olmos J.; Hajduk P.; Anttila J.; Pulkkinen V.; Aman R.; Saez-De-Ibarra A.	2022 IEEE Vehicle Power and Propulsion Conference, VPPC 2022 – Proceedings	2022
TIM	SElySOs	Peer Reviewed Article	'Performance and degradation of electrolyte-supported single cell composed of Mo-Au-Ni/GDC fuel electrode and LSCF oxygen electrode during high temperature steam electrolysis'	Vibhu V.; Vinke I.C.; Zaravelis F.; Neophytides S.G.; Niakolas D.K.; Eichel R.-A.; de Haart L.G.J.	Energies	2022
TIM	MultHyFuel	Peer Reviewed Article	'Preliminary risk assessment of hydrogen refuelling stations in a multifuel context'	Pique S.; Quesnel S.; Weinberger B.; Nouvelot Q.; Houssin D.; Vyazmina E.; Torrado D.; Saw J.L.	Chemical Engineering Transactions	2022
TIM	INSPIRE	Peer Reviewed Article	'Revealing the nature of active sites on Pt-Gd and Pt-Pr alloys during the oxygen reduction reaction'	Kluge R.M.; Psaltis E.; Haid R.W.; Hou S.; Schmidt T.O.; Schneider O.; Garlyyev B.; Calle-Vallejo F.; Bandarenka A.S.	ACS Applied Materials and Interfaces	2022
TIM	PECSYS	Peer Reviewed Article	'Scalable and thermally-integrated solar water-splitting modules using Ag-doped Cu(In,Ga)Se2 and NiFe layered double hydroxide nanocatalysts'	Bayrak Pehlivan İ.; Saguì N.A.; Oscarsson J.; Qiu Z.; Zwaygardt W.; Lee M.; Mueller M.; Haas S.; Stolt L.; Edoff M.; Edvinsson T.	Journal of Materials Chemistry	2022
TIM	PECSYS	Peer Reviewed Article	'Scalable photovoltaic-electrochemical cells for hydrogen production from water – Recent advances'	Lee M.; Haas S.; Smirnov V.; Merdzhanova T.; Rau U.	ChemElectroChem	2022
TIM	INSPIRE	Peer Reviewed Article	'Spatially resolved electrochemical impedance spectroscopy of automotive PEM fuel cells'	Haimerl F.; Sabawa J.P.; Dao T.A.; Bandarenka A.S.	ChemElectroChem	2022
TIM	PRESLHY	Peer Reviewed Article	'The evolution and structure of ignited high-pressure cryogenic hydrogen jets'	Ren Z.; Giannissi S.; Venetsanos A.G.; Friedrich A.; Kuznetsov M.; Jordan T.; Wen J.X.	International Journal of Hydrogen Energy	2022
TIM	PRETZEL	Peer Reviewed Article	'Towards replacing titanium with copper in the bipolar plates for proton exchange membrane water electrolysis'	Kellenberger A.; Vaszilcsin N.; Duca D.; Dan M.L.; Duteanu N.; Stiber S.; Morawietz T.; Biswas I.; Ansar S.A.; Gazdzicki P.; Wirkert F.J.; Roth J.; Rost U.; Brodmann M.; Gago A.S.; Friedrich K.A.	Materials	2022
TIM	ELYntegration	Peer Reviewed Article	'Understanding the effects of ultrasound (408 kHz) on the hydrogen evolution reaction (HER) and the oxygen evolution reaction (OER) on Raney-Ni in alkaline media'	Foroughi F.; Immanuel Bernäcker C.; Röntzsch L.; Pollet B.G.	Ultrasonics Sonochemistry	2022
TIM	AD ASTRA	Peer Reviewed Article	'Volatilization of chromium from AISI 441 stainless steel: Time and temperature dependence'	Spotorno R.; Paravidino D.; Delsante S.; Piccardo P.	Surface and Coatings Technology	2022

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NB: Ineris, Institut national de l'environnement industriel et des risques.

5.3.2. Publications of 2023

Table 44. Publications of 2023

SOURCE	ACRONYM	PUBLICATION TYPE	TITLE	AUTHORS
JU data collection	24_7 ZEN	Peer-reviewed article	'Enhancement of the intrinsic Ni/GDC activity under rSOC operation by means of Fe–Au doping: An electro-kinetic study'	Zaravelis, F. and Niakolas, D. K.
JU data collection	24_7 ZEN	Peer-reviewed article	'Thickness effect of thin-film barrier layers for enhanced long-term operation of solid oxide fuel cells'	Bernadet, L., Buzi, F., Baiutti, F., Segura-Ruiz, J., Dolado, J., Montinaro, D., Torrell, M., Morata, A. and Tarancón, A.
JU data collection	Advancepem	Peer-reviewed article	'Ce-radical scavenger-based perfluorosulfonic acid Aquivion® membrane for pressurised PEM electrolysers'	Siracusano, S., Giacobello, F., Tonella, S., Oldani, C. and Aricò, A. S.
TIM			'11–23 % Cr steels for solid oxide fuel cell interconnect applications at 800 °C – How the coating determines oxidation kinetics'	
CORDA	BRAVA	Peer-reviewed article	'A comparative study on the activity and stability of iridium-based co-catalysts for cell reversal tolerant PEMFC anodes'	Marić, R., Gebauer, C., Eweiner, F. and Strasser, P.
CORDA	Channel	Peer-reviewed article	'The influence of loadings and substrates on the performance of nickel-based catalysts for the oxygen evolution reaction'	Jiang, W., Lehnert, W. and Shviro, M.
CORDA	Comsos	Peer-reviewed article	'Evaluation of the environmental sustainability of SOFC-based cogeneration systems in commercial buildings'	Marocco, P., Gandiglio, M. and Santarelli, M.
JU data collection	eghost	Peer-reviewed article	'How can the European ecodesign directive guide the deployment of hydrogen-related products for mobility?'	Campos-Carriedo, F., Bargiacchi, E., Dufour, J. and Iribarren, D.
JU data collection	eghost	Peer-reviewed article	'Life cycle sustainability assessment of a proton exchange membrane fuel cell technology for ecodesign purposes'	Mori, M., Iribarren, D., Cren, J., Cor, E., Lotrič, A., Gramc, J., Drobnič, B., Rey, L., Campos-Carriedo, F., Puig-Samper, G., Bargiacchi, E., Dufour, J. and Stropnik, R.
JU data collection	Elvhys	Peer-reviewed article	'Fragments generated during liquid hydrogen tank explosions'	Collina, G., Ustolin, F., Tincani, G., Giannini, L., Salzano, E. and Cozzani, V.
JU data collection	Elvhys	Peer-reviewed article	'Modelling of fireballs generated after the catastrophic rupture of hydrogen tanks'	Giannini, L., Tincani, G., Collina, G., Salzano, E., Cozzani, V. and Ustolin, F.
JU data collection	Elvhys	Conference proceedings	'Numerical modelling of liquid hydrogen tanks performance during fire engulfment'	Schiaroli, A., Scarponi, G. E., Cozzani, V. and Ustolin, F.
JU data collection	Elvhys	Peer-reviewed article	'Physical model of non-adiabatic blowdown of cryo-compressed hydrogen storage tanks'	Cirrone, D., Makarov, D., Kashkarov, S., Friedrich, A. and Molkov, V.
JU data collection	Elvhys	Peer-reviewed article	'Safety of liquid and cryo-compressed hydrogen: Overview of physical and CFD models developed at Ulster University'	Cirrone, D., Makarov, D. and Molkov, V.

SOURCE	ACRONYM	PUBLICATION TYPE	TITLE	AUTHORS
CORDA	e-Shyips	Peer-reviewed article	'Challenges for zero-emission yacht design'	Ansaloni, G. M. M., Bionda, A. and Rossi, M.
CORDA	Flhysafe	Peer-reviewed article	'Immersed and integrated converter (30 kW) for fuel cell system in aircraft application'	Mercier, S., Beranger, B., Ecrabey, J. and Gaillard, F.
CORDA	Further-FC	Peer-reviewed article	'Computation of oxygen diffusion properties of the gas diffusion medium-microporous layer assembly from the combination of X-ray microtomography and focused ion beam three dimensional digital images'	Ahmed-Maloum, M., David, T., Guetaz, L., Duru, P., Pauchet, J., Quintard, M. and Prat, M.
CORDA	Further-FC	Peer-reviewed article	'Detailed catalyst layer structure of proton exchange membrane fuel cells from contrast variation small-angle neutron scattering'	Chabot, F., Lee, J., Vandenberghe, F., Guétaz, L., Gebel, G., Lyonnard, S., Porcar, L., Rosini, S. and Morin, A.
JU data collection	GAIA	Peer-reviewed article	'ORR activity and voltage-cycling stability of a carbon-supported PtxY alloy catalyst evaluated in a PEM fuel cell'	Loichet Torres, P. A., Li, Y.-S., Grön, C., Lazaridis, T., Watermeyer, P., Cheng, N., Liebscher, C. H. and Gasteiger, H. A.
CORDA	Haeolus	Conference proceedings	'Grid balancing with electrolysers and wind power'	Zenith, F., Nord Flote, M., Santos-Mugica, M., Scott Duncan, C., Mariani, V. and Marcantonini, C.
TIM			'Elucidating mechanistic background of the origin and rates of peroxide formation in low temperature proton exchange fuel cells'	
JU data collection	HIGGS	Peer-reviewed article	'Enabling the injection of hydrogen in high-pressure gas grids: Investigation of the impact on materials and equipment'	Sánchez-Laínez, J., Cerezo, A., de Gracia, M. D. S., Aragón, J., Fernandez, E., Madina, V. and Gil, V.
JU data collection	Highlander	Peer-reviewed article	'Stabilization of carbon-supported platinum–rare earth nanoalloys during electrochemical activation'	Campos-Roldán, C. A., Filhol, J.-S., Guesmi, H., Bigot, M., Chattot, R., Zitolo, A., Blanchard, P.-Y., Rozière, J., Jones, D. J. and Cavaliere, S.
TIM			'Experimental deconvolution of resistance contributions in commercial solid oxide cells with Ni-CGO electrode'	
JU data collection	Hylical	Peer-reviewed article	'Designing magnetocaloric materials for hydrogen liquefaction with light rare-earth Laves phases'	Liu, W., Gottschall, T., Scheibel, F., Bykov, E., Fortunato, N., Aubert, A., Zhang, H., Skokov K. and Gutfleisch, O.
JU data collection	Hylical	Peer-reviewed article	'Magnetocaloric materials for hydrogen liquefaction'	Romero-Muñiz, C., Law, J. Y., Revuelta-Losada, J., Moreno-Ramírez, L. M. and Franco, V>
JU data collection	Hylical	Peer-reviewed article	'On the high-field characterization of magnetocaloric materials using pulsed magnetic fields'	Salazar Mejía, C., Niehoff, T., Straßheim, M., Bykov, E., Skourski, Y., Wosnitza J. and Gottschall, T.
JU data collection	Hypster	Conference proceedings	'Hypster: 1st demonstrator for hydrogen storage in France'	Storengy, Ineris, Grange, M., Hevin, G. and Djizanne, H.
JU data collection	Hypster	Conference proceedings	'Mechanical stability of a salt cavern used for hydrogen storage'	Ineris, Brouard Consulting, Storengy, Djizanne, H., Brouard, B. and Hévin, G.
TIM			'GIS-based analysis of rock salt deposits' suitability for underground hydrogen storage'	
JU data collection	Hypster	Conference proceedings	'The regulatory framework of geological storage of hydrogen in salt caverns'	Ineris, Inovyn, ESK, Weinberger, B., Djizanne, H., Pique, S., Lahaie, F., Bannach, A., Wagler, T., Stevenson, R. and Applewhite, R.
JU data collection	Hyselect	Conference proceedings	'Allothermally heated reactors for solar-powered implementation of sulphur-based thermochemical cycles'	Krishna Thanda, V., Thomey, D., Wullenkord, M., Eßer, K.-P., Agrafiotis, C., Dimitrakis, D., Roeb, M. and Sattler, C.

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SOURCE	ACRONYM	PUBLICATION TYPE	TITLE	AUTHORS
JU data collection	Hyselect	Thesis dissertation – master's	'Construction and optimization of SO2 depolarized electrolyser'	Narayana Prasad, P.
JU data collection	Hyselect	Conference proceedings	'Enhanced system design to reduce the SO2 crossover to the cathode in SO2 depolarized electrolyser (SDE)'	Narayana Prasad, P., Garg, N. and Santasalo-Aarnio, A.
JU data collection	Hyselect	Conference proceedings	'Hyselect: Efficient water splitting via a flexible solar-powered hybrid thermochemical-sulphur dioxide depolarized electrolysis cycle'	Project Consortium
JU data collection	Hyselect	Conference proceedings	'Sulphur dioxide depolarized electrolysis for hydrogen production: Approaches and applications'	Queda, L., Dimitrakis, D., Thanda, V. K., Thomey, D. and Sattler, C.
CORDA	Hystories	Peer-reviewed article	'An insight into underground hydrogen storage in Italy'	Barison, E., Donda, F., Merson, B., Le Gallo, Y. and Réveillère, A.
CORDA	Hystories	Peer-reviewed article	'Assessing and modeling hydrogen reactivity in underground hydrogen storage: A review and models simulating the Lobodice town gas storage'	Tremosa, J., Jakobsen, R. and Le Gallo, Y.
CORDA	Hystories	Peer-reviewed article	'First assessment of an area potentially suitable for underground hydrogen storage in Italy'	Mattera, S., Donda, F., Tinivella, U., Barison, E., Le Gallo, Y. and Vincent, C.
JU data collection	Hyuspre	Peer-reviewed article	'Geochemical integrity of wellbore cements during geological hydrogen storage'	Aftab, A., Hassanpouryouzband, A., Martin, A., Kendrick, J. E., Thaysen, E. M., Heineman, N., Utley, J., Wilkinson, M., Haszeldine, R. S. and Edlmann, K.
TIM			'Investigation of coated FeCr steels for application as solid oxide fuel cell interconnects under dual-atmosphere conditions'	
CORDA	Hyuspre	Book chapter	'Mapping hydrogen storage capacities of UK offshore hydrocarbon fields and exploring potential synergies with offshore wind'	Peecock, A., Martinez-Felipe, A., Edlmann, K., Mouli-Castillo, J. and McKenna, R.
TIM			'Lattice Boltzmann simulation of liquid water transport in gas diffusion layers of proton exchange membrane fuel cells: Impact of gas diffusion layer and microporous layer degradation on effective transport properties'	
JU data collection	Hyuspre	Peer-reviewed article	'Microbial risk assessment for underground hydrogen storage in porous rocks'	Thaysen, E. M., Armitage, T., Slabon, L., Hassanpouryouzband, A. and Edlmann, K.
CORDA	Hyuspre	Book chapter	'Natural hydrogen seeps as analogues to inform monitoring of engineered hydrogen storage'	McMahon, C. J., Roberts, J. J., Johnson, G., Edlmann, K., Flude, S. and Shipton, Z. K.
JU data collection	Immortal	Peer-reviewed article	'Structure dynamics of carbon-supported platinum-neodymium nanoalloys during the oxygen reduction reaction'	Campos-Roldán, C. A., Chattot, R., Filhol, J.-S., Guesmi, H., Pailloux, F., Bacabe, R., Blanchard, P.-Y., Zitolo, A., Drnec, J., Jones, D. J. and Cavaliere, S.
JU data collection	JIVE	Conference proceedings	'State of play of performance of FCBs (fuel cell buses) and HRS (hydrogen refuelling infrastructures)'	Roderer, V. and Stolzernburg, K.
JU data collection	JIVE	Conference proceedings	'Status of testing fuel cell buses and their hydrogen filling stations'	Buss, K., Eckert, S., Roderer, V. and Stolzenburg, K.
JU data collection	JIVE 2	Conference proceedings	'Status of testing fuel cell buses and their hydrogen filling stations'	Buss, K., Eckert, S., Roderer, V. and Stolzenburg, K.
JU data collection	Multiphy	Peer-reviewed article	'Benchmark study of performances and durability between different stack technologies for high temperature electrolysis'	Aicart, J., Surrey, A., Champelovier, L., Henault, K., Geipel, C., Posdziech, O. and Mougin, J.

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SOURCE	ACRONYM	PUBLICATION TYPE	TITLE	AUTHORS
CORDA	Newely	Other	'MEA production'	Fouda-Onana, F., Mues, L., Goll, M., Razmjooei, F. and Reissner, R.
CORDA	Newely	Other	'MPL coating procedure'	Razmjooei, F. S., Reissner, R., Gago, A. S. and Ansar, S. A.
CORDA	Newely	Peer-reviewed article	'Pre-swelling of FAA3 membranes with water-based ethylene glycol solution to minimize dimensional changes after assembly into a water electrolyser: Effect on properties and performance'	Najibah, M., Kong, J., Khalid, H., Hnát, J., Park, H. S., Bouzek, K. and Henkensmeier, D.
CORDA	Newsoc	Peer-reviewed article	'A multiscale model validated on local current measurements for understanding the solid oxide cells performances'	Da Rosa Silva, E., Sassone, G., Prioux, M., Hubert, M., Morel, B. and Laurencin, J.
CORDA	Newsoc	Peer-reviewed article	'Effect of steam to carbon dioxide ratio on the performance of a solid oxide cell for H2O/CO2 co-electrolysis'	Bimpiri, N., Konstantinidou, A., Tsiplakides, D., Balomenou, S. and Papazisi, K. M.
TIM			'Multiscale analysis of Ni-YSZ and Ni-CGO anode based SOFC degradation: From local microstructural variation to cell electrochemical performance'	
CORDA	Newsoc	Peer-reviewed article	'Electrophoretic deposition of MnCo2O4 coating on solid oxide cell interconnects manufactured through powder metallurgy'	Zanchi, E., Sabato, A. G., Monterde, M. C., Bernadet, L., Torrell, M., Calero, J. A., Tarancón, A. and Smeacetto, F.
CORDA	Newsoc	Peer-reviewed article	'Enhancement of the intrinsic Ni/GDC activity under rSOC operation by means of Fe–Au doping: An electro-kinetic study'	Zaravelis, F. and Niakolas, D. K.
CORDA	Newsoc	Peer-reviewed article	'Hole polarons in LaFeO3 and La1−xSrxFeO3−δ: Stability, trapping, mobility, effect of Sr concentration, and oxygen vacancies'	Hartmann, C., Laurencin, J. and Geneste, G.
CORDA	Newsoc	Peer-reviewed article	'Large area solid oxide fuel cells with room temperature sputtered barrier layers: Role of the layer thickness and uniformity in the enhancement of the electrochemical performances and durability'	Coppola, N., Rehman, H. S. U., Carapella, G., Polverino, P., Montinaro, D., Martinelli, F., Granata, V., Galdi, A., Maritato, L. and Pianese, C.
CORDA	Newsoc	Peer-reviewed article	'Low temperature performance and durability of solid oxide fuel cells with titanate based fuel electrodes using reformate fuel'	Christensen, J. O., Sudireddy, B. R. and Hagen, A.
CORDA	Newsoc	Peer-reviewed article	'Transition metals in Ni/GDC for the reversible solid oxide cell operation: Optimization of the Mo-Au-Ni synergy and further enhancement via substitution of Mo with Fe'	Zaravelis, F., Sygellou, L., Soyvalioti, A. and Niakolas, D. K.
CORDA	Newsoc	Peer-reviewed article	'Understanding the Ni migration in solid oxide cell: A coupled experimental and modeling approach'	Rorato, L., Shang, Y., Yang, S., Hubert, M., Couturier, K., Zhang, L., Vulliet, J., Chen, M. and Laurencin, J.
TIM			'Oxygen reduction reaction activity in non-precious single-atom (M-N/C) catalysts – Contribution of metal and carbon/nitrogen framework-based sites'	
TIM			'PEMFC performance decay during real-world automotive operation: Evincing degradation mechanisms and heterogeneity of ageing'	
JU data collection	Prometeo	Conference proceedings	'Green hydrogen production by means of solar heat and power in high temperature solid oxide electrolyzers'	Giaconia, A., Della Pietra, M., Moreno, P., Testi, M., Diethelm, S., Romero Alvarez, M., Robino, M., van Herle, J., Morico, B. and Dobrée, J.
JU data collection	Prometeo	Peer-reviewed article	'Techno-economic analysis of solar hydrogen production via PV power / concentrated solar heat driven solid oxide electrolysis with electrical/thermal energy storage'	Zhang, Y., Wang, Z., Du, Z., Li, Y., Qian, M., Van herle, J. and Wang, L.

SOURCE	ACRONYM	PUBLICATION TYPE	TITLE	AUTHORS
JU data collection	Reactt	Peer-reviewed article	'A multiscale model validated on local current measurements for understanding the solid oxide cells performances'	Da Rosa Silva, E., Sassone, G., Prioux, M., Hubert, M., Morel, B. and Laurencin, J.
JU data collection	Reactt	Peer-reviewed article	'Fast online diagnosis for solid oxide fuel cells: Optimization of total harmonic distortion tool for real-system application and reactants starvation identification'	Moussaoui, H., Hammerschmid, G., Van herle, J. and Subotić, V.
JU data collection	Reactt	Peer-reviewed article	'Model-free VRFT-based tuning method for PID controllers'	Vrančić, D., Moura Oliveira, P., Bisták, P. and Huba, M.
TIM			'Pore-scale imaging of hydrogen displacement and trapping in porous media'	
JU data collection	Reactt	Peer-reviewed article	'Multiscale modelling of solid oxide cells validated on electrochemical impedance spectra and polarization curves'	Sassone, G., Da Rosa Silva, E., Prioux, M., Hubert, M., Morel, B., Léon, A. and Laurencin, J.
CORDA	Reflex	Conference proceedings	'Recent highlights on solid oxide cells, stacks and modules developments at CEA'	Mouginn, J., Laurencin, J., Vulliet, J., Petitjean, M., Grindler, E., Di Iorio, S., Couturier, K., Dejob, T., Gonzalez, B. and Cubizolles, G.
JU data collection	Rorepower	Peer-reviewed article	'Robust remote power supply (Rorepower)'	Kiviaho, J., Mikkola, J., Münch, M., Penchini, D., Boltze, M., Spirig, M. and Tuomaala, M.
CORDA	RUBY	Peer-reviewed article	'A multiscale model validated on local current measurements for understanding the solid oxide cells performances'	Da Rosa Silva, E., Sassone, G., Prioux, M., Hubert, M., Morel, B. and Laurencin, J.
CORDA	RUBY	Peer-reviewed article	'Fast online diagnosis for solid oxide fuel cells: Optimisation of total harmonic distortion tool for real-system application and reactants starvation identification'	Moussaoui, H., Hammerschmid, G., Van herle, J. and Subotić, V.
CORDA	RUBY	Peer-reviewed article	'LT-PEM fuel cells diagnosis based on EIS, clustering, and automatic parameter selection'	Chanal, D., Yousfi Steiner, N., Chamagne, D. and Pera, M.-C.
JU data collection	SH2E	Peer-reviewed article	'Life cycle costing approaches of fuel cell and hydrogen systems: A literature review'	Ishimoto, Y., Wulf, C., Schonhoff, A. and Kuckshinrichs, W.
JU data collection	Sherlohck	Peer-reviewed article	'Evaluation of acetophenone as a novel alcohol-cycloalkane bifunctional liquid organic hydrogen carrier (LOHC)'	D'Ambra, F., Levy, J., Hajiyev, P., Cantat, T., Gébel, G., Faucheux, V. and Nicolas, E.
CORDA	Sherlohck	Peer-reviewed article	'First principles-based approaches for catalytic activity on the dehydrogenation of liquid organic hydrogen carriers: A review'	Gemechu, D. N., Mohammed, A. M., Redi, M., Bessarabov, D., Mekonnen, Y. S. and Obodo, K. O.
JU data collection	SO-FREE	Conference proceedings	'Compositional analysis of SOFC short stacks operating under different feedstocks: Experimental analysis and model-based interpretation'	Santoni, F., Loreti, G., Monforti Ferrario, A., Marino, F. and Cigolotti, V.
JU data collection	SO-FREE	Conference proceedings	'Designing for flexible use of hydrogen and natural gas: The SO-FREE project'	McPhail, S., Cigolotti, V., Innerkofler, M., Noponen, M., Megel, S., Tregambe, C., Wierzbicki, M., Bubniak, L. and Del Zotto, L.
TIM			'Structural and reactivity effects of secondary metal doping into iron–nitrogen–carbon catalysts for oxygen electroreduction'	
JU data collection	SO-FREE	Peer-reviewed article	'Performance evaluation of an anode-supported solid oxide fuel cell short-stack operating with different hydrogen-natural gas blends as stationary combined heat and power system'	Monforti Ferrario, A., Santoni, F., Marino, F., Alfano, A., Stenius, J., Noponen, M., Neubauer, R. and Cigolotti, V.
JU data collection	SO-FREE	Conference proceedings	'Solid oxide stack development at Elcogen'	Noponen, M., Puranen, J., Alfano, A. and Granö-Fabritius, H.
JU data collection	SO-FREE	Conference proceedings	'Validation of solid oxide fuel cell short stack test bench in SO-FREE project'	Marinoa, F., Arcidiaconoa, L., Santonia, F., Monforti Ferrarioa, A., Simonettia, L., Scotinia, A. and Hatunoglud, A.
CORDA	Teachy	Conference proceedings	'Hydrogen readiness of European education systems? A gap analysis'	Steinberger-Wilckens, R.

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SOURCE	ACRONYM	PUBLICATION TYPE	TITLE	AUTHORS
CORDA	Teachy	Conference proceedings	'Training, re- and up-skilling for the hydrogen economy'	Steinberger-Wilckens, R.
JU data collection	Teachy	Conference proceedings	'Up-skilling the European fuel cell and hydrogen work force'	Steinberger-Wilckens, R. and Al-Sagheer, Y.
JU data collection	Waste2watts	Peer-reviewed article	'Analysis of the performances of a solid oxide fuel cell fed by biogas in different plant configurations: An integrated experimental and simulative approach'	Tamburrano, G., Pumiglia, D., Monforti Ferrario, A., Santoni, F. and Borello, D.
JU data collection	Waste2watts	Thesis dissertation – master's	'Carbon neutrality in Switzerland: Exploring the role of waste water treatment plants in carbon capture, storage, and utilization'	Stücker, L.
JU data collection	Waste2watts	Conference proceedings	'Deactivation mechanisms of Ni-Fe and Ru-exsolution reforming catalysts during prolonged exposure to H2S and DMS contaminants'	Frantz, C., Hanria, Y., Rumpf, L., Mensi, M., Janák, M., Müller, C. R. and Van herle, J.
JU data collection	Waste2watts	Peer-reviewed article	'Hydrogen sulphide and carbonyl sulphide removal from biogas for exploitation in high-temperature fuel cells'	Santoni, F., Gislon, P., Rozzi, E., Gandiglio, M., McPhail, S., Lanzini, A., Pagani, M. and Fiorilli, S.
JU data collection	Waste2watts	Thesis dissertation – master's	'Techno-economic assessment of different biogas purification and carbon capture technologies for multi-scale biogas-fed SOFC system'	Monticone, G.
JU data collection	Waste2watts	Conference proceedings	'Techno-economic evaluation of biogas-fed SOFC power system integrated with biogas cleaning unit'	Yu, H., Wang, L. and Van herle, J.
JU data collection	Waste2watts	Conference proceedings	'Techno-economic feasibility of biogas-fed SOFC power system integrated with biogas cleaning unit and carbon capture technologies'	Yu, H., Wang, L., Van herle, J. and Pina, E. A.
JU data collection	Waste2watts	Conference proceedings	'Testing of solid oxide fuel cells fed with dry and steam reformed biogas with hydrogen sulfide and dimethyl sulfide contaminants'	Frantz, C., Shucan, L., Savioz, L., Diethelm, S., Aubin, P., Montinaro, D., Mittmann, F. and Van herle, J.
JU data collection	Winner	Book chapter	'Interconnects and coatings'	Talic, B., Stefan, E. and Larring, Y.
JU data collection	Winner	Book chapter	'Tubular protonic ceramic electrolysis cells and direct hydrogen compression'	Vøllestad, E.

NB: Ineris, Institut national de l'environnement industriel et des risques.

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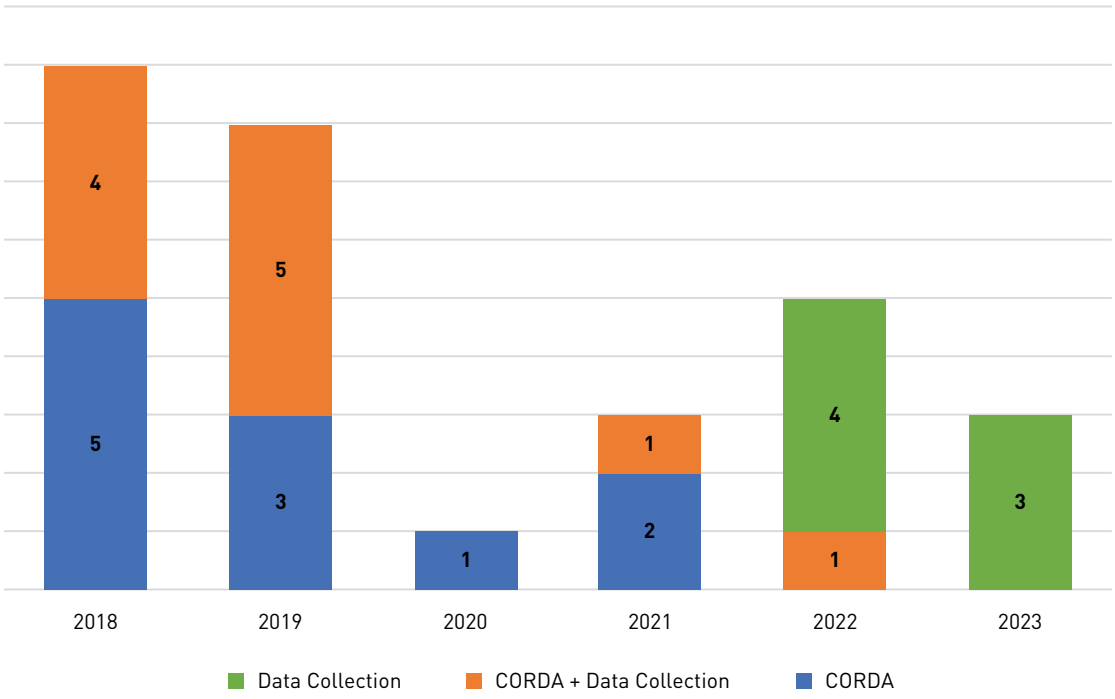
5.4. Patent from projects

The patents reported in this section concern H2020 projects for the whole duration of the Programme, not just for year 2022. The reason is the long time required for their processing and approval, which can take more than 5 years. Concerning the source of information, they have been mainly extracted from CORDA ([135]), complemented by the Clean Hydrogen JUs annual data collection of 2024. As expected, there are no patents related to Horizon Europe projects yet.

Differences compared to the Annual Activity Report 2022 are noted in green font. It is interesting to note that 8 additional patent applications or awards were identified through the Clean Hydrogen JU data collection in 2024, but only one of them reported in CORDA so far.

Figure 44. Project patents identified in 2023



([135]) Date of extraction: 21/02/2024.

5.4.1. Information extracted from CORDA

Table 45. Patent information taken from CORDA

PROJECT NUMBER	PROJECT ACRONYM	PATENT APPLICATION TITLE	PATENT APPL. NAME	PATENT APPL. DATE	PATENT AWARDED	PATENT NO	LINK
671403	INNO-SOFC	Protection arrangement and method of solid oxide cells	Elcogen Oy	14/03/2018	YES	US10535883B2	https://patents.google.com/patent/US10535883B2/en?q=TI%3d(Protection+arrangement+and+method+of+solid+oxide+cells)&patents=false&oq=TI%3d(Protection+arrangement+and+method+of+solid+oxide+cells)
671473	D2Service	Heat Exchanger and Method for Manufacturing a Heat Exchanger Core with Manifold	Bosal Emission Control Systems Nv	19/04/2018	YES	US1fin9873B2	https://patents.google.com/patent/US11359873B2/en?q=TI%3d(Heat+Exchanger+and+Method+for+Manufacturing+a+Heat+Exchanger+Core+with+Manifold)&patents=false&oq=TI%3d(Heat+Exchanger+and+Method+for+Manufacturing+a+Heat+Exchanger+Core+with+Manifold)
700101	Giantleap	Inrichting voor het koppelen van een trekkend voertuig met een te trekken voertuig	VDL Enabling Transport Solutions BV	06/02/2018	YES	NL2020382B1	https://patents.google.com/patent/NL2020382B1/nl?q=TI%3d(Inrichting+voor+het+koppelen+van+een+trekkend+voertuig+met+een+te+trekken+voertuig)&patents=false&oq=TI%3d(Inrichting+voor+het+koppelen+van+een+trekkend+voertuig+met+een+te+trekken+voertuig)
700667	SOSLeM	Recursive, Time-Series-Based Method for Determining the State of an Electrochemical Reactor	AVL List GmbH	27/11/2018	YES	US20200386818A1	https://patents.google.com/patent/US20200386818A1/en?q=TI%3d(Recursive%2c+Time-Series-Based+Method+for+Determining+the+State+of+an+Electrochemical+Reactor)&patents=false&oq=TI%3d(Recursive%2c+Time-Series-Based+Method+for+Determining+the+State+of+an+Electrochemical+Reactor)
700667	SOSLeM	Method for Determining an Operating State of an Electrochemical System	AVL List GmbH	07/12/2018	YES	AT520682B1	https://patents.google.com/patent/AT520682B1/en?q=TI%3d(Method+for+Determining+an+Operating+State+of+an+Electrochemical+System)&patents=false&oq=TI%3d(Method+for+Determining+an+Operating+State+of+an+Electrochemical+System)
779644	TAHYA	Composite Pressure Vessel with Reinforced Inner Liner and Process for the Production Thereof	Plastic Omnium New Energies France SAS	26/06/2019	YES	EP3814673B1	https://patents.google.com/patent/EP3814673B1/en?q=TI%3d(Composite+-Pressure+Vessel+with+Reinforced+Inner+Liner+and+Process+for+the+Production+Thereof)&patents=false&oq=TI%3d(Composite+Pressure+Vessel+with+Reinforced+Inner+Liner+and+Process+for+the+Production+Thereof)
779644	TAHYA	Composite Pressure Vessel with Boss Connector	Plastic Omnium Advanced Innovation and Research SA	26/06/2019	YES	US11015762B2	https://patents.google.com/patent/US11015762B2/en?q=TI%3d(Composite+Pressure+Vessel+with+Boss+Connector)&patents=false&oq=TI%3d(Composite+Pressure+Vessel+with+Boss+Connector)
779644	TAHYA	Tank Liner Having Two Cylindrical Sections	Plastic Omnium New Energies France SAS	26/06/2019	YES	US11506335B2	https://patents.google.com/patent/US11506335B2/en?q=TI%3d(Tank+Liner+Having+Two+Cylindrical+Sections)&patents=false&oq=TI%3d(Tank+Liner+Having+Two+Cylindrical+Sections)
101007182	SH2APED	End Fitting for a Pressurised Fluid Reservoir	Plastic Omnium New Energies France SAS	14/1/2021	NO	EP4090877A1	https://patents.google.com/patent/EP4090877A1/en?q=TI%3d(End+Fitting+for+a+-Pressurised+Fluid+Reservoir)&patents=false&oq=TI%3d(End+Fitting+for+a+Pressurised+Fluid+Reservoir)

PROJECT NUMBER	PROJECT ACRONYM	PATENT APPLICATION TITLE	PATENT APPL. NAME	PATENT APPL. DATE	PATENT AWARDED	PATENT NO	LINK
875118	NEWELY	Composite ion-exchange membrane, method for preparing the same, and use thereof	KIST	11/06/2020	YES	KR20210153842A	https://patents.google.com/patent/KR20210153842A/en?q=TI%3d(%E2%80%AFComposite+ion-exchange+membrane%2c+method+-for+preparing+++the+same%2c+and+use+thereof+)&patents=-false&oq=TI%3d(%E2%80%AFComposite+ion-exchange+membrane%2c+method+-for+preparing+++the+same%2c+and+use+thereof)
875118	NEWELY	Polymer grafted with cationic groups as side chain, preparation method thereof, and anion exchange membrane made of the same	KIST, Technion	27/01/2021	YES	KR20220108630A	https://patents.google.com/patent/KR20220108630A/en?q=TI%3d(%E2%80%AF-Polymer+grafted+with+cationic+groups+as+side+chain%2c+preparation+method+thereof%2c+and+anion+exchange++membrane+made+of+the+-same)&patents=false&oq=TI%3d(%E2%80%AFPolymer+grafted+with+cationic+groups+as+side+chain%2c+preparation+method+thereof%2c+and+anion+exchange++membrane+made+of+the+same)

5.4.2. Additional information on patents, complementing the partial information on CORDA from previous data collections of the Clean hydrogen JU

Table 46. Additional patent information from previous Clean Hydrogen JU data collections

PROJECT NUMBER	PROJECT ACRONYM	PATENT APPLICATION TITLE	PATENT APPLICANT NAME	PATENT APPLICATION DATE	PATENT AWARDED	PUBLICATION NO	LINK
700266	Cell3Ditor	Method and machine for producing parts made of ceramic or metallic material by additive manufacturing	3DCERAM	20/06/2018	YES	EP3444049B1	https://patents.google.com/patent/EP3444049B1/en?q=TI%3d(Method+and+machine+for+producing+parts+made+of+ceramic+or+metallic+material+by+additive+manufacturing)&patents=false&oq=TI%3d(Method+and+machine+for+producing+parts+made+of+ceramic+or+metallic+material+by+additive+manufacturing)
700266	Cell3Ditor	Method and machine for producing at least one part in at least one ceramic and/or metal material by additive manufacturing	3DCERAM	20/06/2018	YES	EP3444050B1	https://patents.google.com/patent/EP3444050B1/en?q=TI%3d(Method+and+machine+for+producing+at+least+one+part+in+at+least+one+ceramic+and%2for+metal+material+by+additive+manufacturing)&patents=false&oq=TI%3d(Method+and+machine+for+producing+at+least+one+part+in+at+least+one+ceramic+and%2for+metal+material+by+additive+manufacturing)

PROJECT NUMBER	PROJECT ACRONYM	PATENT APPLICATION TITLE	PATENT APPLICANT NAME	PATENT APPLICATION DATE	PATENT AWARDED	PUBLICATION NO	LINK
700266	Cell3Ditor	Method of manufacturing pieces by the technique of additive manufacturing by pasty process with an improved supply of paste and manufacturing machine for implementing the method	3DCERAM	15/02/2018	YES	KR102039061B1	https://patents.google.com/patent/KR102039061B1/en?q=TI%3d(Method+of+manufacturing+pieces+by+the+technique+of+additive+manufacturing+by+pasty+process+with+an+improved+supply+of+paste+and+manufacturing+machine+for+implementing+the+method)&patents=false&oq=TI%3d(Method+of+manufacturing+pieces+by+the+technique+of+additive+manufacturing+by+pasty+process+with+an+improved+supply+of+paste+and+manufacturing+machine+for+implementing+the+method)
700266	Cell3Ditor	Electrochemical cell device for use in a SOFC and/or a SOEC and methods for operating a SOFC or a SOEC by using thereof	ICREA, IREC	18/06/2019	YES	EP3754768A1	https://patents.google.com/patent/EP3754768A1/en?q=TI%3d(Electrochemical+cell+device+for+use+in+a+SOFC+and%2for+a+SOEC+and+methods+for+operating+a+SOFC+or+a+SOEC+by+using+thereof)&patents=false&oq=TI%3d(Electrochemical+cell+device+for+use+in+a+SOFC+and%2for+a+SOEC+and+methods+for+operating+a+SOFC+or+a+SOEC+by+using+thereof)
735918	INLINE	Calibration procedure for a projector	Profactor Gmbh	07/05/2019	YES	AT522320B1	https://patents.google.com/patent/AT522320B1/en?q=TI%3d(Kalibrierverfahren+f%C3%BCr+einen+Projektor)&patents=false
700355	HyGrid	Carbon molecular sieve membrane and its use in separation processes	TUE Tecnalia	19/10/2019	YES	EP4072715A	https://www.patentguru.com/EP4072715A
700355	HyGrid	Method for low hydrogen content separation from a natural gas mixture	TUE Tecnalia	09/12/2019	YES	US20210339190A1	https://www.patentguru.com/US20210339190A1
826204	DOLPHIN	Procédé de fabrication d'un guide d'écoulement pour réacteur électrochimique	CEA	20/12/2021	YES	EP4016677A1	https://patentimages.storage.googleapis.com/04/31/13/bb1f9368ef6a02/EP4016677A1.pdf
735918	INSIGHT	Fuel cell stack, indicator fuel cell, fuel cell system and method for determining degradation of a fuel cell stack	AVL	2019	YES	AT522869A1	https://patents.google.com/patent/AT522869A1/en?oq=AT522869+
735918	INSIGHT	Procedure for providing an indicator	AVL	25/10/2018	YES	AT521864A2	https://patents.google.com/patent/AT521864A2/en?oq=AT521864
875088	CHANNEL	Cathode catalyst (NiMo) for water electrolysis	Norwegian University of Science and Technology (NTNU)	9/11/2022	NO		Application No. 2216708.4 at UK Intellectual Property Office

5.4.3. Additional patents collected from the Clean Hydrogen JU data collection exercise for 2024, complementing the information on CORDA (information to become available in the coming years, when embargo ends)

Table 47. Information for additional patents, currently under embargo, from the 2024 Clean Hydrogen JU data collection

PROJECT NUMBER	PROJECT ACRONYM	PATENT APPLICATION TITLE	PATENT APPLICANT NAME	PATENT APPLICATION DATE	PATENT AWARDED	PUBLICATION NO	LINK
875025	FURTHER-FC	Under embargo	Arnaud MORIN, Joël PAUCHET and Thi Bich Hue TRAN	01/12/2023	NO		Under embargo
101007216	BEST4Hy	Under embargo	CEA	30/11/2023	NO		Under embargo
101007216	BEST4Hy	Under embargo	CEA	22/11/2022	NO		Under embargo
101007216	BEST4Hy	Under embargo	Hensel Recycling GmbH	29/06/2023	NO		Under embargo
101006667	SO-FREE	Fuel cell system	AVL	27/01/2022	YES	AT525946A1	https://seeip.patentamt.at/NPatentSuche/Details/c6eec59c-af02-484c-878e-308f4f09affb
101006667	SO-FREE	Fuel cell system to generate electrical power	AVL	09/08/2022	NO	A 50611/2022	https://seeip.patentamt.at/NPatentSuche/Details/dcf8eaee-cb04-42fb-bb29-10ac8665ddda
101006667	SO-FREE	Fuel cell system and method for a fuel cell system	AVL	13/06/2022	NO	A 50412/2022	https://seeip.patentamt.at/NPatentSuche/Details/a07ce7ac-8b5f-4ac7-ae27-2ffca64e73d0

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5.5. Scoreboard of Horizon 2020 legacy Key Performance Indicators (KPIs)

In the two subsections below one can find the Horizon 2020 legacy KPIs, that were reported for the FCH 2 JU in its Annual Activity Reports. When a row has a grey shade it means that either the reported value is the same as the one reported in the AAR 2021 and is not expected to change in the future or that it is not relevant any more as there are no more Calls for H2020 after 2020. A third table, concerning the KPIs specific to FCH 2 JU has been omitted as it is not relevant anymore. It's last reporting can be found in the AAR 2022.

5.5.1. Scoreboard of common KPIs

Table 48. Scoreboard of common KPIs

	H2020 KPI NUMBER	KPI	TYPE OF DATA REQUIRED	RESULTS H2020 (CALLS 2014-2020)
INDUSTRIAL LEADERSHIP	12	SME – Share of participating SMEs introducing innovations new to the company or the market (covering the period of the project plus three years)	Number of SMEs that have introduced innovations to the company or market	122
	13	SME – Growth and job creation in participating SMEs	Turnover of company, number of employees	Turnover of SMEs at most recent reporting: EUR 8,085.6 Mil No of employees at SMEs at most recent reporting: 79,731 employees
SOCIETAL CHALLENGES	14	Publications in peer-reviewed high-impact journals	Publications from relevant funded projects (as reported in CORDA)	549 publications in peer-reviewed journals
	15	Patent applications and patents awarded in the area of the JTI	Patent application number (combined sources, aligned with Section 5.4)	21 patents awarded and 8 patent pending applications
	16	Number of prototypes testing activities and clinical trials	Reports on prototypes, and testing activities, clinical trials	Nr of prototypes: 591 Nr of testing activities: 739 Nr of clinical trials: 1
	17	Number of joint public-private publications in projects	Properly flagged publications data (DOI) from relevant funded projects (as reported in CORDA)	131 Joint Public/Private (not reported in CORDA anymore)
	18 (136)	New products, processes and methods launched on the market	Project count and drop-down list enabling choice of the type of processes, products and methods	Nr of projects with: New products: 78 New processes: 41 New methods: 32
EVALUATION	NA	Time to inform (TTI) all applicants of the outcome of the evaluation of their application from the final date for submission of completed proposals	Number and % of information letters sent to applicants within target Average TTI (calendar days) Maximum TTI (calendar days)	–
	NA	Redress after evaluations	Number of redresses requested	–
GRANTS	N/A	Time to Grant (TTG) measured (average) from call deadline to signature of grants	Average TTG in calendar days Maximum TTG in calendar days	–
GRANTS	NA	Time to grant (TTG) measured (average) from call deadline to signature of grants	Number and % of grants signed within target	–

[136] This indicator is not legally compulsory but covers several additional specific indicators requested for more societal challenges by the services in charge.

	H2020 KPI NUMBER	KPI	TYPE OF DATA REQUIRED	RESULTS H2020 (CALLS 2014-2020)
PAYMENTS	N/A	Time to Pay (TTP) (% made on time) – pre-financing – interim payment – final payment	Average TTP in calendar days	Average TTP: 65 days
HR	N/A	Vacancy rate (%)	Vacancy rate (%)	Vacancy rate= 6.5 %
JU EFFICIENCY	NA	Time to sign (TTS) grant agreements from the date of informing successful applicants (information letters)	Average TTS in calendar days Maximum TTS in calendar days	Average TTS: 110 days Maximum TTS: 170 days (after approval of a request for GAP extension by the consortium)
	N/A	Administrative budget: Number and % of total of late payments	Number and % of total of late payments	% of late payments: 6% Number of late payments: 25

NB: N/A, not applicable; TTS, time to sign. Based on Annex II to Council Decision 2013/743/EU.
Source: CORDA, unless otherwise noted. Data were extracted from CORDA on 21 February 2024.

5.5.2. Indicators for monitoring cross-cutting issues ([137])

Table 49. Indicators for monitoring cross-cutting issues

NUMBER	DEFINITION/RESPONDING TO QUESTION	TYPE OF DATA REQUIRED	AAR 2022 (CALLS 2014-2020) ([138])
2.1	Total number of participations by EU-27 Member States + the UK	Nationality of H2020 applicants and beneficiaries (number)	EU-27 + UK Application Participations: 3 197 Grant Participations: 1 395 Application Participants: 1 329 Grant Participants: 727
2.2	Total amount of EU financial contribution by EU-27 Member State + the UK (EUR million)	Nationality of H2020 beneficiaries and corresponding EU financial contribution	In EUR million per country (total EUR 583.6 million):

AT	24.77	ES	39.21	LV	0.66
BE	23.01	FI	18.81	MT	0.03
BG	0.39	FR	88.44	NL	54.45
CY	0.17	HR	0.73	PL	1.06
CZ	1.46	HU	0.02	PT	0.76
DE	152.28	IE	0.28	RO	0.26
DK	27.66	IT	54.34	SE	9.66
EE	0.76	LT	0.13	SI	3.52
EL	6.15	LU	1.64	UK	72.92

([137]) Based on Annex III to Council Decision 2013/743/EU; source: CORDA, unless specified otherwise
([138]) The figures concern the maximum EU contribution for 133 projects, not including ELECTROU which was terminated very early. Data were extracted from CORDA on 21st February 2024

NUMBER	DEFINITION/RESPONDING TO QUESTION	TYPE OF DATA REQUIRED	AAR 2022 (CALLS 2014-2020) ([138])
N/A	Total number of participations by Associated Countries	Nationality of H2020 applicants and beneficiaries (number)	Associated Countries Application Participations: 353 Grant Participations: 153 Application Participants: 150 Grant Participants: 83
N/A	Total amount of EU financial contribution by Associated Country (EUR million)	Nationality of H2020 beneficiaries and corresponding EU financial contribution	In EUR million per country (total EUR 49.3 million): CH 14.76 IL 0.24 IS 1.07 NO 32.33 TR 0.85 UA 0.05
3.1	Share of EU financial contribution going to SMEs (Enabling and industrial tech and Part III of H2020)	Number of H2020 beneficiaries flagged as SMEs % of EU contribution going to beneficiaries flagged as SMEs	SME beneficiaries Grants participations 351 (22 %) Grant participants 170 (21 %) Funding EUR 175.5 mil. (28 %)
6.1	Percentage of women participants in H2020 projects	Gender of participants in H2020 projects	25.92 % (12.605 women)
6.2	Percentage of women project coordinators in H2020	Gender of MSC fellows, ERC principal investigators and scientific coordinators in other H2020 activities	50/133 (37.6 %)
6.3	Percentage of women in EC advisory groups, expert groups, evaluation panels, individual experts, etc.	Gender of members of advisory groups, panels, etc.	Scientific Com: 3/9 (33.3 %) SRG: 9/42 (21.4 %) Evaluators: N/A
7.1	Share of third-country participants in H2020	Nationality of H2020 beneficiaries	Third Countries Grants participations 14 Grant participants 13 EU Funding EUR 0.28 mil.
7.2	Percentage of EU financial contribution attributed to third-country participants	Nationality of H2020 beneficiaries and corresponding EU financial contribution	0.04 %
9.1	Share of projects and EU financial contribution allocated to IAs	Number of IA proposals and projects properly flagged in the WP; follow-up at grant level	Number: 36 / 133 (27%) Funding: EUR 366.73 mil / EUR 632.89 mil (57.95 %)
9.2	Within the IAs, share of EU financial contribution focused on demonstration and first-of-a-kind activities	Topics properly flagged in the WP; follow-up at grant level	EUR 366.732 mil / EUR 886.2 mil (40.7%)

<table>
<tr><th>NUMBER</th><th>DEFINITION/RESPONDING TO QUESTION</th><th>TYPE OF DATA REQUIRED</th><th>AAR 2022 (CALLS 2014-2020) [138]</th></tr>
<tr><td>N/A</td><td>Scale of impact of projects (high technology readiness level – TRL)</td><td>Number of projects addressing TRL between (2-3, 4-6, 5-7)</td><td>Based on TRL specified in the topic (project start)<table><tr><th>TRL</th><th># projects</th></tr><tr><td>2</td><td>14</td></tr><tr><td>3</td><td>30</td></tr><tr><td>4</td><td>28</td></tr><tr><td>5</td><td>15</td></tr><tr><td>6</td><td>11</td></tr><tr><td>7</td><td>10</td></tr><tr><td>8</td><td>1</td></tr><tr><td>unspecified</td><td>24</td></tr></table></td></tr>
<tr><td>11.1</td><td>Percentage of H2020 beneficiaries from the private-for-profit sector</td><td>Number of and % of the total H2020 beneficiaries classified by type of activity and legal status</td><td>Participations: 948 / 1562 (61 %)
Participants: 543/ 823 (66 %)</td></tr>
<tr><td>11.2</td><td>Share of EU financial contribution going to private-for-profit entities (Enabling and industrial tech and Part III of Horizon 2020)</td><td>H2020 beneficiaries classified by type of activity; corresponding EU contribution</td><td>EUR 444.61 mil (70 %)</td></tr>
<tr><td>12.1</td><td>EU financial contribution for public-private partnerships (PPP) (Art. 187)</td><td>EU contribution to PPP (Art. 187)</td><td>EUR 665,000,000, with additional
EUR 95,000,000 for administrative costs
(Article 3 of FCH 2 JU founding regulation)</td></tr>
<tr><td>12.2</td><td>PPPs leverage: total amount of funds leveraged through Art. 187 initiatives, including additional activities, divided by the EU contribution</td><td>Total funding made by private actors involved in PPPs
– in-kind contribution already committed by private members in projects selected for funding
– additional activities (i.e. research expenditure/investment of industry in the sector, compared to previous year)</td><td>See section 1.2.4</td></tr>
</table>

<table>
<tr><th>NUMBER</th><th>DEFINITION/RESPONDING TO QUESTION</th><th>TYPE OF DATA REQUIRED</th><th>AAR 2022 (CALLS 2014-2020) [138]</th></tr>
<tr><td>13.3</td><td>Dissemination and outreach activities other than peer-reviewed publications [conferences, workshops, press releases, publications, flyers, exhibitions, training, social media, websites, communication campaigns (e.g. radio, TV)]</td><td>A drop-down list allows for selection of the type of dissemination activity. Number of events, funding amount and number of persons reached thanks to the dissemination activities</td><td>Activities as reported by the projects during the Clean Hydrogen data collection exercise of 2023 for the reporting year of 2022 respectively:
<table><tr><th>Dissemination activities (excl. Scientific Publications)</th><th>2022</th></tr><tr><td>Total Activities</td><td>554</td></tr><tr><td>Conferences/Events (Presentations)</td><td>219</td></tr><tr><td>Meetings (with policy stakeholders/working groups, etc)</td><td>125</td></tr><tr><td>Education & Training Activities</td><td>106</td></tr><tr><td>Other</td><td>104</td></tr></table>
<table><tr><th>EU Research Days</th><th>2023 (81 projects)</th></tr><tr><td>Websites</td><td>80</td></tr><tr><td>Twitter accounts</td><td>27</td></tr><tr><td>LinkedIn accounts</td><td>19</td></tr></table></td></tr>
<tr><td>14.2</td><td>Proposal evaluators by country</td><td>Nationality of proposal evaluators (at pool level)</td><td>N/A
(no more H2020 evaluations)</td></tr>
<tr><td>14.3</td><td>Proposal evaluators by organisations' type of activity</td><td>Type of activity of evaluators' organisations</td><td>N/A
(no more H2020 evaluations)</td></tr>
<tr><td>N/A</td><td>Participation of RTOs and universities in PPPs (Art. 187 initiatives)</td><td>Number of RTOs participations in funded projects and % of the total
Number of universities participations in funded projects and % of the total
% of budget allocated to RTOs and to universities</td><td>301 / 1562 (19 %)
204 / 1562 (13 %)
RTO: EUR 99.4 million (16 %)
HES: EUR 49.4 million (8 %)</td></tr>
<tr><td>N/A</td><td>The aim is to ensure that research projects funded are efficiently compliant with provisions on ethics</td><td>% of proposals not granted because of non-compliance with ethical rules/proposals invited to grant (target 0 %); time to ethics clearance (target 45 days)</td><td>N/A</td></tr>
<tr><td>N/A</td><td>Error rate</td><td>% of representative error; % residual error</td><td>H2020:
Representative: -2.77%
Residual: -0.59%</td></tr>
<tr><td>N/A</td><td>Implementation of ex-post audit results</td><td>Number of cases implemented; of cases implemented/total cases</td><td>H2020: # closed participations : 92
Percentage of implementation: 85.31%</td></tr>
</table>

5.5.3. Scoreboard of Horizon Europe common Key Impact Pathway Indicators (KIPs)

The nine Key Impact Pathways, presented in the Table 50, are calculated and reported via the Horizon Europe Dashboard, based on the continuous reporting of the projects. Some difference may exist between this and our more detailed data collection, where for example we have already identified the first project publications.

For most of the KPI there are no results to report yet, as the first grants from Call 2022-1 were only signed in December 2022. Therefore, most indicators are zero, except for two short-term indicators which are presented below and are reported in the table in bold green format, below the description of the KIPs:

- Short-term KIP-2 – Number of researchers: 1142 researchers
- Short-term KIP-9 – Co-investment amount: Eur 852 million

These are reported in Table 50 in bold and green below the description of the KIPs.

Table 50. Scoreboard of Horizon Europe common KIP indicators

KEY IMPACT PATHWAY (139)	SHORT-TERM	MEDIUM-TERM	LONGER-TERM	DETAIL PER ACTION OR GLOBALLY FOR [YEAR N]
Towards scientific impact				
1-Creating high-quality new knowledge	Publications -Number of peer-reviewed scientific publications resulting from the Programme	Citations -Field-Weighted Citation Index of peer-reviewed Publications resulting from the Programme	World-class science -Number and share of peer-reviewed publications resulting from the projects funded by the Programme that are core contribution to scientific fields	-
2-Strengthening human capital in R&I	Skills -Number of researchers involved in upskilling (training, mentoring/coaching, mobility and access to R&I infrastructures) activities in projects funded by the Programme 1 142 Researchers	Careers -Number and share of upskilled researchers involved in the Programme with increased individual impact in their R&I field	Working conditions -Number and share of upskilled researchers involved in the Programme with improved working conditions, including researchers' salaries	-
3-Fostering diffusion of knowledge and open science	Shared knowledge Share of research outputs (open data/ publication/software etc.) resulting from the Programme shared through open knowledge infrastructures	Knowledge diffusion -Share of open access research outputs resulting from the Programme actively used/cited	New collaborations -Share of Programme beneficiaries which have developed new transdisciplinary/transsectoral collaborations with users of their open access research outputs resulting from the Programme	-
Towards societal impact				
4-Addressing Union policy priorities and global challenges through R&I	Results -Number and share of results aimed at addressing identified Union policy priorities and global challenges (including SDGs) (multidimensional: for each identified priority) Including: Number and share of climate-relevant results aimed at delivering on the Union's commitment under the Paris Agreement	Solutions -Number and share of innovations and research outcomes addressing identified Union policy priorities and global challenges (including SDGs) (multidimensional: for each identified priority)Including: Number and share of climate-relevant innovations and research outcomes delivering on Union's commitment under the Paris Agreement	Benefits -Aggregated estimated effects from use/exploitation of results funded by the Programme on tackling identified Union policy priorities and global challenges (including SDGs), including contribution to the policy and law-making cycle (such as norms and standards) (multidimensional: for each identified priority) Including: Aggregated estimated effects from use/exploitation of climate-relevant results funded by the Programme on delivering on the Union's commitment under the Paris Agreement including contribution to the policy and law-making cycle (such as norms and standards)	-
5-Delivering benefits and impact through R&I missions	R&I mission results -Results in specific R&I missions (multidimensional: for each identified mission)	R&I mission outcomes Outcomes in specific R&I missions (multidimensional: for each identified mission)	R&I mission targets met -Targets achieved in specific R&I missions (multidimensional: for each identified mission)	Not applicable for the JUs

[139] NB: For some of those KIPs the data will not be available in the short or even medium term.

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KEY IMPACT PATHWAY (139)	SHORT-TERM	MEDIUM-TERM	LONGER-TERM	DETAIL PER ACTION OR GLOBALLY FOR [YEAR N]
6-Strengthening the uptake of R&I in society	Co-creation -Number and share of projects funded by the Programme where Union citizens and end-users contribute to the co-creation of R&I content	Engagement -Number and share of participating legal entities which have citizen and end-users engagement mechanisms in place after the end of projects funded by the Programme	Societal R&I uptake -Uptake and outreach of co-created scientific results and innovative solutions generated under the Programme	-
Towards technological / economic impact				
7-Generating innovation-based growth	Innovative results -Number of innovative products, processes or methods resulting from the Programme (by type of innovation) & Intellectual Property Rights (IPR) applications	Innovations -Number of innovations resulting from the projects funded by the Programme (by type of innovation) including from awarded IPRs	Economic growth -Creation, growth & market shares of companies having developed innovations in the Programme	-
8-Creating more and better jobs	Supported employment -Number of full time equivalent (FTE) jobs created, and jobs maintained in participating legal entities for the project funded by the Programme (by type of job)	Sustained employment -Increase of FTE jobs in participating legal entities following the project funded by the Programme (by type of job)	Total employment -Number of direct & indirect jobs created or maintained due to diffusion of results from the Programme (by type of job)	-
9- Leveraging investments in R&I	Co-investment -Amount of public & private investment mobilised with the initial investment from the Programme Eur 852 million	Scaling-up -Amount of public & private investment mobilised to exploit or scale-up results from the Programme (including foreign direct investments)	Contribution to '3 % target' – Union progress towards 3 % GDP target due to the Programme	-

NB: For some of those KIPs, the data will not be available in the short or even medium term. Based on Annex V to Regulation (EU) 2021/695.

Clean Hydrogen Partnership
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5.5.4. Horizon Europe Partnership common Key Performance Indicators

This section is based on a Commission's experts' interim report published on 21 June 2021 ([140]). For some of the indicators there are no results to report yet, as the first grants from Call 2022 were only signed in December 2022 (Table 51). In 2023 DG R&I provided clarifications on the common indicators below, including their definitions and what is expected from the JUs to report. The reporting was therefore aligned to the instructions given at that time. Note also that the Clean Hydrogen JU has no targets for most of these KPIs, thus the targets were reported as not applicable.

Table 51. Common KPI baseline values, results for 2023 and targets for 2027

N°	CRITERION ADDRESSED	PROPOSED COMMON INDICATORS	BASELINE	RESULTS FOR 2023	TARGET 2027
1	**Additionality**	Progress towards (financial and in-kind) contributions from partners other than the Union – i.e. committed vs. actual	€ 1.1 B ([141])	EUR 685 million ([142])	€ 1.0 B ([143])
2	**Additionality/ Synergies**	Additional investments triggered by the EU contribution, including qualitative impacts related to additional activities ([144])	N/A ([145])	3	N/A
3	**Directionality**	Overall (public and private, in-kind and cash) investments mobilized towards EU priorities ([146])	100% towards Green Deal € 2.56 B ([147]) 40% towards Resilience € 1 B	100% towards Grean Deal 300.5 + IKOP + IKAA for 2023 (single value) 20% towards Resilience	100% towards Grean Deal € 2.0 B 40% towards Resilience € 0.8 B
4	**International visibility and positioning**	International actors involved ([148])	68	70	N/A

([140]) Commission Experts' report, Section 5 and Appendix 1 https://op.europa.eu/en/publication-detail/-/publication/6b63295f-d305-11eb-ac72-01aa75ed71a1/language-en/format-PDF/source-215872593)

([141]) Amount of 1.7 billion is expected to be reached by the end of the Horizon Europe (HE) programme, and € 566 million have been certified so far for the years 2022 and the provisional 2023 data as of 14 May. However, the applicable legal basis for Horizon Europe states a target of EUR 1 billion, so the partners other than the Union are expected to reach and exceed the IKAA target for certified contributions well before Horizon Europe programme end.

([142]) Amount of certified IKAA as per legal reporting deadline of 31 May 2023 set by the Horizon Europe legal basis

([143]) Following REPowerEU, the Commission topped up the overall budget of the Clean Hydrogen JU with an additional funding of EUR 200 million, so as to double the number of Hydrogen Valleys in the EU by 2025. This amount is not part of the core JU budget (of Horizon Europe) and therefore will not be reported here. However, it is expected to be matched by the same amount by the private members.

([144]) Reporting JU activities that may trigger additional investments than the ones of the Programme and excluding the ones reported under KPI 8 and KPI 9. This table reports an approximate figure, which are explained in Section 1.7.3.

([145]) Amount of 1.7 billion is expected to be reached by the end of the Horizon Europe (HE) programme, and € 566 million have been certified so far for the years 2022 and the provisional 2023 data as of 14 May. However, the applicable legal basis for Horizon Europe states a target of EUR 1 billion, so the partners other than the Union are expected to reach and exceed the IKAA target for certified contributions well before Horizon Europe programme end.

([146]) Please note that there can be an overlap among the different priorities, as certain activities may contribute to more than one of them. Nevertheless, as contribution to the Green Deal is the primary objective of the Clean Hydrogen JU and in essence all its budget is directed towards to associated activities, we consider that 100% of the budget goes into that direction.

([147]) Total committed EU + Private contributions, as reported in the last Clean Hydrogen JU Annual Activity Report for its predecessor FCH 2 JU.

([148]) An effort has been made to report on this indicator despite certain unclarity on its exact definition, even after the four workshops organised by the DG R&I on the KPIs in February and March 2023. We expect its reporting will be improved in the future, after the JUs have received better guidance, leading to possible changes in the reporting methodology. For AAR23 and similar to AAR22, the JU reports on the international (non-EU, non-Associated countries) applicants in JU Calls for Calls 2022 and Call 2023. For the baseline the figure during the whole period of H2020 is reported. This selection allows for comparability and the possibility to provide a baseline. It is important to note that compared to 2022 the number of associated countries has increased, most notably including UK. This has led unavoidably to a big decrease of the KPI, from its value of 167 in AAR22. For comparability purposes we will also report the baseline assuming the same associated countries as currently for Horizon Europe, which also led to the drop from the AAR22 value of 276.

N°	CRITERION ADDRESSED	PROPOSED COMMON INDICATORS	BASELINE	RESULTS FOR 2023	TARGET 2027
5	**Transparency and openness**	Share & type of stakeholders and countries invited/engaged ([149])	Please see Table 52	Please see Table 53	N/A
6	**Transparency and openness**	No and types of newcomer members in partnerships and their countries of origin (geographical coverage)	N/A	N/A	N/A (150)
7	**Transparency and openness**	No and types of newcomer beneficiaries in funded projects (in terms of types and countries of origin)	Please see Table 54	Please see Table 55	N/A
8	**Coherence and synergies**	Number and type of coordinated and joint activities with other European Partnerships	N/A ([124])	Coordinated Call for Proposals 0 Systematic Collaboration 3 Ad hoc Collaboration 5	N/A
9	**Coherence and synergies**	Number and type of coordinated and joint activities with other R&I Initiatives at EU / national/regional/sectorial level	Coordinated Call for CProposals 1 ([151]) Hydrogen Valleys 3 Co-funding 9 ([152])	Coordinated Call for Proposals 0 Hydrogen Valleys 13 Co-funding 0 Formal Collaboration 3 Ad-hoc Collaboration 10 Various Activities 4	N/A
10	**Coherence and synergies**	Complementary and cumulative funding from other Union funds (Horizon Europe, National funding, ERDF, RRF, Other cohesion policy funds, CEF, DEP, LIFE, other)	6.88% ([153])	0 ([154])	N/A
11	**International visibility and positioning**	Visibility of the partnership in national, European, international policy/industry cycles ([155])	N/A ([124])	See below table	N/A

([149]) An effort has been made to report on this indicator despite certain unclarity on its exact definition, even after the four workshops organised by the DG R&I on the KPIs in February and March 2023. We expect its reporting will be improved in the future, after the JUs have received better guidance, leading to possible changes in the reporting methodology. For AAR23 and similar to AAR22, the JU reports on the project beneficiaries in JU for Calls 2022 and Call 2023. For the baseline the figure during the whole period of H2020 is reported. This selection allows for comparability and the possibility to provide a baseline.
([150]) See explanation in section 1.7.3.3 on KPI-6
([151]) Project JIVE, supported also by CEF and different regions.
([152]) Projects CHIC, HyFIVE (suppoted by ERDF), PACE, ene.field, HyBalance (receiving regional co-funding), ELCOGEN (private company, receiving funding for its 4 JU supported projects from EIB, Finland and SME instrument).
([153]) Complementary and cumulative funding from other Union or national funds as a percentage of the total FCH 2 JU budget. The reported percentage can be disaggregated to National/Regional Funding (6.19%) and CEF funding (0.69%).
([154]) Although there are parallel actions of the projects to secure complementary funding, these were not clearly reported by end of 2023. Quantitative data will hopefully become available as of 2024 or later. This table will report an approximate figure, which will be explained in Section 1.7.2.
([155]) For a detailed list of activities in year 2023 please see Table 14 below.

Table 52. Number and type of stakeholders (i.e. applicants) and their countries of origin, H2020 (baseline) ([156])

COUNTRY	HES	PRC	PUB	REC	OTH	GRAND TOTAL
AE	1					1
AT	4	36	2	6	3	51
BE	3	35	4	7	14	63
BG	1	5	2	2	1	11
CA	1	1				2
CH	5	31		8	1	45
CL		1			1	2
CN	3					3
CR		1				1
CY		4	2		1	7
CZ	3	13	1	3		20
DE	20	216	4	21	8	269
DK	1	34	6	3	2	46
EE	2	5		1		8
EL	7	24	1	6	1	39
ES	11	80	6	18	4	119
FI	4	16		3		23
FR	6	110	10	11	2	139
HR	2	4		2		8
HU	1	1				2
IE	3	7				10
IL	2	3				5
IS		6	2		1	9
IT	21	98	4	13	8	144
JP	1			1		2
KR				2		2
LT	2	2		2		6
LU		1				1
LV	2	5			1	8
MA					1	1
MH		1				1
MK		1	1			2
MT	1	1	1		1	4
NL	8	78	10	6	4	106
NO	5	44	3	7	5	64
PA		1				1
PL	8	11	2	4		25
PT	4	15	1	3	1	24
RO	4	7		2		13
RS				1		1
SE	4	24		3	1	32

([156]) Types of organisations: [HES]: Higher Education Schools, [PRC]: Private Companies, [PUB]: Public Companies, [REC]:Research Centres, [OTH]: Other

COUNTRY	HES	PRC	PUB	REC	OTH	GRAND TOTAL
SI	2	11	1	4		18
SK	2	3				5
TN	1	2				3
TR	4	10		1		15
TW				1		1
UA		3		3		6
UK	21	91	6	5	6	129
US	1	5			1	7
ZA	10	1				11
Grand Total	**181**	**1 048**	**69**	**149**	**68**	**1 515**

Table 53. Number and type of stakeholders (i.e. applicants) and their countries of origin, Clean Hydrogen JU, 2023

COUNTRY	HES	PRC	PUB	REC	OTH	GRAND TOTAL
AE		1		1		2
AT	1	11	2	2	1	17
AU	1			1		2
BA	1					1
BE	7	48	2	4	8	69
BG	4	27	3	2	5	41
BR		2				2
CA		1				1
CH	2	17	2		2	23
CI		1				1
CV			1			1
CY	3	15	2		3	23
CZ	1	6		2	2	11
DE	9	93	1	9	4	116
DK	1	20	7	3	4	35
DZ			1			1
EE		12	2	1	3	18
EG	1	2	1			4
EL	6	41	7	1	5	60
ES	10	77	3	11	6	107
FI	2	28	5		5	40
FR	19	138	7	8	7	179
GH	1				1	2
HR	5	6	5	2	1	19
HU	1	2		2	2	7
IE	1	7	1	3		12
IL	1	17	2			20
IN		1				1
IS			1			1
IT	11	83	6	4	10	114

COUNTRY	HES	PRC	PUB	REC	OTH	GRAND TOTAL
KE	1	2				3
KR		1				1
KZ			1			1
LB				1		1
LT	1	5		1	3	10
LU	1	14	1	1	1	18
LV	2	9	3	1	2	17
LY				3		3
MA	1	2		2		5
MD			1			1
ME	1					1
MK				1		1
MT		1				1
MU					1	1
MZ			1		1	2
NA		1				1
NG		2				2
NL	2	74	3	5	3	87
NO	3	13	2	3	2	23
NZ					1	1
PL	7	29		9	6	51
PT	4	26	3	9	4	46
RO	3	12	4	1	4	24
RS	1	1		1	1	4
RW	1	1				2
SA	1					1
SE	3	20		2		25
SI		9	1	1	1	12
SK	1	18	2		3	24
TN	2	1		1		4
TR	7	45	4	3	6	65
UA	2	4	3	3		12
UK	11	30	1	2	2	46
US	1	1				2
ZA	3	1				4
Grand Total	**147**	**978**	**91**	**106**	**110**	**1 432**

Table 54. Number and type of newcomer beneficiaries in funded projects (baseline) ([157])

COUNTRY	HES	OTH	PRC	PUB	REC	GRAND TOTAL
AT	1	1	14	1	5	22
BE		5	14	2	6	27
BG	1					1

([157]) Newcomers compared to FP7. As the H2020 Programme continues, the number of beneficiaries continues to change, which is the reason for the small difference from the reported baseline of AAR22.

COUNTRY	HES	OTH	PRC	PUB	REC	GRAND TOTAL
CA	1					1
CH	3	1	11			15
CL		1				1
CN	2					2
CY			2			2
CZ			2	1	3	6
DE	6	3	84		2	95
DK		1	10	2	1	14
EE	1		1			2
EL		1	5	1		7
ES	4	3	37	7	4	55
FI			6		1	7
FR	8	1	55	5	6	75
HR	1		1			2
HU	1		1			2
IE	1		2			3
IL			1			1
IS			1	1		2
IT	4	2	42		3	51
JP					1	1
KR					1	1
LU			1			1
LV		1	3			4
MA		1				1
MH			1			1
MT				1		1
NL	2	3	51	13	3	72
NO	1	2	31	1	2	37
PA			1			1
PL	1		3		2	6
PT	1		5		1	7
RO	2				1	3
SE	1		9	1		11
SI			3	2		5
SK			1			1
TR	1		3			4
UA	1					1
UK	4	4	23	3	1	35
US			3			3
ZA	1					1
Grand Total	**49**	**30**	**427**	**41**	**43**	**590**

Table 55. Number and type of newcomer beneficiaries in funded projects of the Clean Hydrogen JU, 2023 ([158])

COUNTRY	HES	OTH	PRC	PUB	REC	GRAND TOTAL
AT			3	1	1	5
AU	1				1	2
BE	2	5	11	1		19
BG	1	3	9		1	14
BR			2			2
CH		1	7	1		9
CY		1	2			3
CZ			2		1	3
DE	1		30		3	34
DK		2	14			16
EE		2	8	1	1	12
EG			1			1
EL		1	24	3		28
ES	2	1	29		5	37
FI	1	1	12			14
FR	6	5	66	8	2	87
HR	3		6	1		10
HU		1				1
IE	1	1	7	1	2	12
IT	4	5	36	2	4	51
KE	1					1
KR			1			1
LT		1				1
LU	1		11	1	1	14
LV		1	1	1		3
MA	1				1	2
MK					1	1
MU		1				1
NG			1			1
NL		2	22		2	26
NO		2	1			3
PL	1	2	5		1	9
PT	3	4	8	3	4	22
RO		2				2
SA	1					1
SE			5		1	6
SI			8	1	1	10
SK			1			1
TR	3		8	1	2	14
UA	1		3			4
UK	1	1	12			14

([158]) Newcomers compared to FP7 and H2020.

COUNTRY	HES	OTH	PRC	PUB	REC	GRAND TOTAL
US	1			1		2
Grand Total	**36**	**45**	**356**	**27**	**35**	**499**

Table 56. International visibility ([159])

National Events	4 (national info days in France, Spain, Italy, UK)
International Events/Exhibitions	5 (HyVolution, Hannover, Hydrogen Valleys, Hydrogen Week, World Hydrogen Summit)
International Webinars and Workshops	7 Re-launch event of the Hydrogen Valleys Platform 2.0! Workshop: Towards an EU Roadmap for Hydrogen Valleys – Regional actors and their role Webinar: What do Europeans know about hydrogen technologies? A state of play of public awareness, acceptance and uptake of hydrogen technologies European Hydrogen Observatory Relaunch 2 IN 1 WORKSHOP: Clean Hydrogen JU AEMEL Project Findings & JRC Testing Methodology on Electrolyser Degradation European Hydrogen Ports Network event Hydrogen for Clean Transport Conference 2023 (H2ME project) JUST GREEN AFRH2ICA Promoting a JUST transition to GREEN hydrogen in AFRICA
Publications	6 Programme Review Report Success Stories Ports study reports (parts 1,2,3) Call FAQ Awareness of Hydrogen Technologies – Survey Report Generate Synergies with Member States and Regions : Assessment of hydrogen policies and funding strategies
Platforms	3 Mission Innovation Hydrogen Valley Platform european Hydrogen Observatory European Hydrogen Refuelling Station Availability System
Social Media	38,584 followers on linkedin and 8.930 followers on twitter; 594 followers on Youtube
Website	107.464 visitors engaged during the year
Media outreach	A total of 28 media articles have been published, with a potential to reach out to up to 6,942,354 people (total of declared monthly audience).
Newsletter outreach	13 983 subscribers

([159]) Please note that all communication actions, events and campaigns of the JU have by default an international audience, which varies according to the type of action and its desired impact. The target groups identified in the yearly communication plan include stakeholders, partners and general public in all EU countries as well as beyond (i.e. in the case of the Mission Innovation platform). More details on the communication activities can be found in Section 2.1.

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5.5.5. Scoreboard of Key Performance Indicators specific to Clean Hydrogen JU ([160])

Table 57. Scoreboard of KPIs specific to the Clean Hydrogen JU

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	2.52	21%	15	30	40		On track
	1b. Circular and sustainable solutions	% of JU budget	< 12	6%	5	10	15		On track
2. Early research projects		% of budget	102	13%	10	10	10		On track
3. Demonstration projects		# of projects	432	19	20	40	60		On track
4. Education and training		# of projects	42	3	2	4	6		On track
5. Monitoring technology progress		*Qualitative indicator*	N/A	Please see section 1.5.1	N/A	N/A	N/A		On track
6. Supporting EC in H2 market uptake		*Qualitative indicator*	N/A	Please see Section 1.6	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/A5	N/A	754	75	100	N/A5
	7b. Improvement in the quality of Life Cycle Assessments (LCA)	Quality of LCA submitted by projects (rating in %)	602	N/A5	N/A	65	70	75	N/A5
8. Capital cost of hydrogen applications	8a. Capital cost of electrolysers	% reduction across electrolyser technologies	100	N/A5	N/A	65	55	45	N/A5
	8b. Capital cost of heavy-duty road applications	Cost of FC module CAPEX in €/kilowatt	1,500	N/A5	N/A	420	290	100	N/A5
9. Research and Innovation Synergies		# of projects	52	12	5	10	20		On track
10. Public perception of hydrogen		*Qualitative indicator*	N/A	Activities under Section 2.1 & projectHYPOP6	N/A	N/A	N/A		On track
11. Total persons trained		# of persons in thousands	52	N/A5	N/A	110	160	240	N/A5

([160]) Following the implementation of the KPIs certain issues were identified and corrected. Thus, the KPI definitions, the exact methodologies followed, units reported, etc. may have changed, following also the related SRIA amendment in 2024. A detailed description methodology followed will be published on the Clean Hydrogen JU website (https://www.clean-hydrogen.europa.eu/knowledge-management/strategy-map-and-key-performance-indicators_en).

KPI NAME		UNIT OF MEASUREMENT	BASELINE	ACTUAL 2023 [1]	TARGET 2023	TARGET 2025	TARGET 2027	AMBITION 2030	STATUS
12. Patents and publications		# of patents / publications	122/ 289	21 /224	17/ 100	20/ 400	25/ 450		On track 7
13. Promoting cross-sectoral solutions		% of budget	152	14	10	15	25		On track 3
Impacts* (KPIs reporting progress of hydrogen sector at EU level, to which the Clean Hydrogen JU is contributing)									
14. Expected avoided emissions		Million tonnes of CO2-eq/year	0.085	0.178	N/A	N/A	N/A	223	Off track 9
15. Deployment of electrolysers		Gigawatt	0.077	0.1748	4	6	10	40	Off track 9
16. Market uptake of clean hydrogen		Mt of clean hydrogen consumed	0.008	0.01968	0.7	1	2	10	Off track9
17. Total cost of producing renewable hydrogen		€/kg	8	6.868	6.5	5.5	4.5	3	On track
18. Size of private hydrogen sector	18a. Activity in terms of companies	# of companies	300	1,4138	1,000	1,500	2,000	–	On track
	18b. Activity in terms of projects in the pipeline (ongoing or under construction)	# of Projects	50	1138	200	500	800	–	On track10
	18c. Electrolyser manufacturing capacity	GW/year	1	4.898	5	17.5	30	–	On track10

(*) The set of KPIs under "impact" report the progress of the hydrogen sector at EU level, to which the Clean Hydrogen 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 Clean Hydrogen JU, helping to identify where more effort should also be placed by the Clean Hydrogen JU in the coming years.**

(1) The latest values available by end of 2023 are reported. For KPIs (#1-4, 9, 13) these reflect the signed grants of Call 2022 and Call 2023. For the KPIs on project results (#7, 8 and 11) there is nothing to report yet, as the first grants where only signed in 2023. For KPI 12 the latest data are reported, as reported in this Annual Activity Report of (AAR 23). All KPIs on impacts (14-18) come from the latest available data on the European Hydrogen Observatory, but most concern year 2022 (due to lag for collecting the data). For the qualitative KPIs (#5-6, 10), these are described in AAR 2023.

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

(3) First relevant project was signed only in first half of 2023, more are expected to be signed the coming years. Results will become available gradually as the projects advance, mostly towards the end of the projects.

(4) Target for 2025 measured against SRIA 2024 targets, while targets for 2027 and 2030 measured against SRIA 2030 targets.

(5) https://www.clean-hydrogen.europa.eu/projects-repository/hypop_en

(6) Reported figures come from Annex 5.4 of the Annual Activity Report and refer to awarded patents. Current source of data is eGrants and the Clean Hydrogen JU data collection, but it is considered incomplete, especially in relation to patents. The Clean Hydrogen JU is currently working with JRC to improve the data collection methodology concerning this series.

(7) Calculated from the European Hydrogen Observatory; data from 2022 for KPI-14 to KPI-17, from May 2023 for KPI-18b, while for KPI-18a and KPI-18c from November 2023. KPI-17 was calculated using the methodology proposed by the Observatory contractors.

(8) 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.

(9) Expected to be on track in 2024, based on project announcements.

Clean Hydrogen Partnership
EUROPEAN PARTNERSHIP
Co-funded by the European Union

5.5.6 Key performance indicators specific to the Clean Hydrogen Joint Undertaking – Administrative

Table 58. Administrative KPIs specific to the Clean Hydrogen JU

FIELD	KPI NAME	UNIT OF MEASUREMENT	RESULTS FOR 2023
HR	Vacancy rate (%)	Vacancy rate (%)	Vacancy rate= 6.9 %
JU EFFICIENCY	Time to sign (TTS) grant agreements from the date of informing successful applicants (information letters)	Average TTS in calendar days Maximum TTS in calendar days	Average TTS: 133 days Maximum TTS: 320 days (after approval of a request for GAP extension by the consortium)
	Administrative budget: Number and % of total of late payments	Number and % of total of late payments	% of late payments: 6% Number of late payments: 25

5.6. IKAA Report

H2020 programme

Besides in-kind contributions in projects (IKOP), in accordance with Council Regulation (EU) 559/2014 of 6 May 2014 establishing the FCH 2 JU, members other than the Union shall provide under H2020 programme in-kind contributions of at least **EUR 285 000** over the period 2014–2024, consisting of the costs incurred by them in implementing additional activities outside the work plan of the FCH 2 Joint Undertaking, contributing to the objectives of the FCH Joint Technology Initiative.

The last Horizon 2020 reporting exercise for IKAA took place in 2021 with total certified IKAA for the entire H2020 programme 2014-2019 amounting to EUR 1 039 000. Due to the high amount of certified IKAA, there were no additional plans adopted for years 2021 & 2022, nor for the year 2023 for Horizon 2020.

The additional activities for the H2020 programme consist of investments in the following main fields:

- Transportation (FC cars, FC buses, FC range extenders, material handling vehicles, Auxiliary Power Units for aviation and trucks);
- Transport Infrastructure (hydrogen refuelling infrastructure, including on-site green H2 production);
- Hydrogen production (large scale green hydrogen production via electrolysis, hydrogen purification, power-to-hydrogen and storage of renewables);
- Heat and power equipment (distributed power generation FC applications, self-sufficient household systems, back-up systems, manufacturing facilities);
- Regulations, standards and education (energy storage roadmaps, including dissemination activities and awareness, commercialisation strategies, patents).

Further information on the IKAA for H2020 is available in the annual activity reports of the FCH 2 JU and its successor, the Clean Hydrogen JU, published on the Clean Hydrogen JU website under:

https://www.clean-hydrogen.europa.eu/about-us/key-documents/annual-activity-reports_en

Horizon Europe programme

In line with COUNCIL REGULATION (EU) 2021/2085 of 19 November 2021 establishing the Joint Undertakings under Horizon Europe, Hydrogen Europe Industry and Hydrogen Europe Research Members of the Clean Hydrogen Joint Undertaking have submitted their second Additional Activities Plan covering the period of 1 January 2023 – 31 December 2023 as an annex to the Annual Work Plan 2023, as an Annex to the main part

of the work programme, where the planned additional activities are presented according to categories outlined by Article 78 of the COUNCIL REGULATION (EU) 2021/2085.

The IKAA 2023 Plan included Additional Activities for a total amount of EUR 904.78 million.

As per Article 11(2) of the SBA, by 31 May each year at the latest, the private members shall report to their respective governing board on the value of the in-kind contributions.

According to the Horizon Europe legal basis, a certificate of the in-kind contributions to additional activities (IKAA) must be provided for contributions of private members for activities contributing to the objectives of the Clean Hydrogen Joint Undertaking.

In terms of valuing these contributions, the costs shall be determined in accordance with the usual cost accounting practices of the entities concerned, to the applicable accounting standards of the country where the entity is established, and to the applicable International Accounting Standards and International Financial Reporting Standards. The costs shall be certified by an independent audit body appointed by the entity.

The purpose of the IKAA certificate is to provide the EU granting authority with sufficient information on the value of private contributions from the members of the Clean Hydrogen Joint Undertaking other than the Union who shall make or arrange for their constituent or affiliated entities to make a total contribution of at least EUR 1 000 000 000.

At the moment of preparing the 2023 annual accounts for the Clean Hydrogen JU and drafting the AAR, only the final figures for IKAA 2022 were available with IKAA 2022 data collection closed end of 2022, and IKAA 2023 reporting was still ongoing, with the aim to report the provisional IKAA 2023 certified by 31 May 2024 in the final version of the AAR 2023 in June 2024.

The total value of the final certified **IKAA contributions for the year 2022 is EUR 240 429 088.41**, and the reported 2022 IKAA not certified at 31/12/2023 amounts to another EUR 245 128 513.94. No further 2022 IKAA certificates are to be received, so certified IKAA 2022 figures are final.

For the ongoing 2023 IKAA reporting, the **provisional figure of the certified IKAA contributions by end of May 2024 is EUR 444 905 473.40** – this figure is expected to grow further by end of 2024 with 2023 IKAA reporting to be closed by 31/12/2024.

During 2023, the Corporate IKAA Planning & Reporting COMPASS IT tools developed by the EC/ DG RTD in consultation with a working group from all JUs became available for JU use as follows: IKAA Reporting Workflow was launched in spring 2023, and the IKAA Planning workflow in autumn 2023. As the two workflows are expected to follow the logical sequence of Planning -> to feed into Reporting, further customizations were ongoing in early 2024, so for the purposes of this AAR 2023, IKAA reporting was done outside of the systems.

The Clean Hydrogen JU IKAA team presented the IT IKAA Planning and Reporting tools and functionalities to the Clean Hydrogen JU members HER & HEI, who expressed initial concerns on the new roles and responsibilities added for their HER & HEI members with respect to registration and appointing IKAA reporters per member to encode IKAA plans and reports per entity in the tools, and on the need to validate and verify the IKAA plans and reports by an external auditor as per the Clean Hydrogen JU past practices.

Later discussions in December 2023 explored the option for HER & HEI, as the sole founding members of the Clean Hydrogen JU, to do the IKAA planning & reporting on behalf of their members, by assigning the IKAA reporter role to the external auditors to collect and verify data in line with the past practices, and to encode data in the IT tools under the categories listed in Art. 78 of the COUNCIL REGULATION (EU) 2021/2085. This approach is under discussion and to be agreed on, yet it seems to be a working solution for HER /HEI and their members, based on past experiences while solving issues of unregistered HER/HEI members and IKAA data quality and external verification.

What concerns the technicalities of introducing past IKAA plans in the IT tools, EC/ RTD & DIGIT can help by uploading the historical plans into the IKAA tool for all JUs, once the past IKAA Plan data is submitted to them via agreed-upon inter-JU synchronised table.

It is expected that with the IT tools, the IKAA planning & reporting process would become easier & more transparent for both the members and the Clean Hydrogen JU.

Table 59. IKAA report for year 2023

ADDITIONAL ACTIVITIES REPORT 2023 DETAILED CERTIFIED IKAA FOR 2023		
Description of the AA	Type of contributor	Certified IKAA value for 2023 (€)
A. Pre-commercial trials and field tests	Private members	4 852 766.13
B. Proof of concept	Private members	41 464 189.31
C. Improvement of existing production lines for up-scaling	Private members	81 338 367.75
D. Large scale case studies	Private members	201 176 172.83
E. Awareness-raising activities on hydrogen technologies and safety measures	Private members	99 676.00
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	Private members	39 027 429.56
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	Private members	71 583 031.90
H. Other, contributing to the JU objectives	Private members	5 363 839.92
TOTAL CERTIFIED IKAA		**444 905 473.40**

TOTAL CERTIFIED IKAA 2023: BREAKDOWN PER COUNTRY	
Country	**Value (€)**
AT	7 713 640.93
DE	260 337 530.87
ES	1 598 974.69
FI	11 677 223.30
NL	5 355 816.23
NO	101 707 625.00
Others	56 514 662.38
TOTAL CERTIFIED 2023 IKAA	**444 905 473.40**

DETAILED CERTIFIED IKAA FOR 2023 PER OBJECTIVE		
DETAILED DESCRIPTION OF THE AA	TYPE OF CONTRIBUTOR	CERTIFIED VALUE AA FOR 2023 (IN €)
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	218 480.00
B. To contribute to the implementation of the 2020 European Commission's Hydrogen Strategy for a climate neutral Europe	Private members	81 018.42
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	284 456.71
D. To stimulate research and innovation on clean hydrogen production, distribution, storage and end use applications	Private members	3 758 440.00
E. Improve, through research and innovation, including activities related to lower TRLs, the cost-effectiveness, efficiency, reliability, quantity and quality of clean hydrogen solutions, including production, distribution, storage and end uses developed in the Union	Private members	510 371.00
SUB TOTAL (A)		**4 852 766.13**
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	70 357.00
B. To contribute to the implementation of the 2020 European Commission's Hydrogen Strategy for a climate neutral Europe	Private members	4 698 670.00
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	146 460.05
D. To stimulate research and innovation on clean hydrogen production, distribution, storage and end use applications	Private members	331 293.49
E. Improve, through research and innovation, including activities related to lower TRLs, the cost-effectiveness, efficiency, reliability, quantity and quality of clean hydrogen solutions, including production, distribution, storage and end uses developed in the Union	Private members	35 998 542.00
I. 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	218 866.77
SUB TOTAL (B)		**41 464 189.31**

C. Improvement of existing production lines for up-scaling		
B. To contribute to the implementation of the 2020 European Commission's Hydrogen Strategy for a climate neutral Europe	Private members	1 156 011.87
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	51 703 908.00
D. To stimulate research and innovation on clean hydrogen production, distribution, storage and end use applications	Private members	1 289 582.00
E. Improve, through research and innovation, including activities related to lower TRLs, the cost-effectiveness, efficiency, reliability, quantity and quality of clean hydrogen solutions, including production, distribution, storage and end uses developed in the Union	Private members	25 366 169.00
F. Strengthen the knowledge and capacity of scientific and industrial actors along the Union's hydrogen value chain while supporting the uptake of industry-related skills	Private members	1 822 696.88
SUB TOTAL (C)		**81 338 367.75**

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	54 206 918.44
B. To contribute to the implementation of the 2020 European Commission's Hydrogen Strategy for a climate neutral Europe	Private members	115 910 179.08
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	1 592 975.00
D. To stimulate research and innovation on clean hydrogen production, distribution, storage and end use applications	Private members	4 199 058.34
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	21 532 252.72
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	220 436.00
G. Carry out demonstrations of clean hydrogen solutions with a view to local, regional and Union-wide deployment, aiming to involve stakeholders in all Member States and addressing renewable production, distribution, storage and use for transport and energy-intensive industries as well as other applications	Private members	3 514 353.25
SUB TOTAL (D)		**201 176 172.83**

E. Awareness-raising activities on hydrogen technologies and safety measures		
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	99 676.00
SUB TOTAL (E)		**99 676.00**

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	2 701 223.56
B. To contribute to the implementation of the 2020 European Commission's Hydrogen Strategy for a climate neutral Europe	Private members	306 004.00
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	35 139 287.00
A. To stimulate research and innovation on clean hydrogen production, distribution, storage and end use applications	Private members	37 382.00
B. 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	810 051.00
C. 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	33 482.00
SUB TOTAL (F)		**39 027 429.56**

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	31 493 757.96
A. 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	498 580.89
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	38 090 094.05
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	1 500 599.00
SUB TOTAL (G)		**71 583 031.90**

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	1 016 609.00
B. To contribute to the implementation of the 2020 European Commission's Hydrogen Strategy for a climate neutral Europe	Private members	3 068 714.92
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	551 280.00
E. Improve, through research and innovation, including activities related to lower TRLs, the cost-effectiveness, efficiency, reliability, quantity and quality of clean hydrogen solutions, including production, distribution, storage and end uses developed in the Union	Private members	611 204.00

F. Strengthen the knowledge and capacity of scientific and industrial actors along the Union's hydrogen value chain while supporting the uptake of industry-related skills	Private members	23 151.00
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	92 881.00
SUB TOTAL (H)		**5 363 839.92**
TOTAL CERTIFIED IKAA		**444 905 473.40**

Table 60. Total IKAA, by country, year 2023

TOTAL IKAA 2021-2023 (EVOLUTION- VALUE IN €)		
Planned IKAA	Reported IKAA with pending certification	Certified IKAA
Planned IKAA 2022 & 2023: 520 million + 904 million respectively No IKAA plan or Report done in 2021 = 0	Non-certified IKAA for 2022 = €245 128 513.94	IKAA 2022 certified = EUR 240 429 088.41 IKAA 2023 certified = EUR 444 905 473.40

5.7. Draft/final annual accounts (Optional)

5.7.1. Balance Sheet

Table 61. Balance sheet (EUR)

	NOTE	31.12.2023	31.12.2022
NON-CURRENT ASSETS			
Intangible assets	2.1	990.04	3 969.58
Intangible assets under construction	2.1	–	–
Property, plant and equipment	2.2	89 229.96	136 260.15
Long term pre-financing	2.3	249 580 601.80	64 904 581.37
		249 670 821.80	**65 044 811.10**
CURRENT ASSETS			
Short term pre-financing	2.3	56 677 296.36	46 252 801.52
Exchange receivables and non-exchange recoverables	2.4	90 692 093.15	47 053.847.78
Cash and cash equivalent	2.5	–	–
		147 369 689.51	**93 306 649.30**
TOTAL ASSETS		**397 040 511.31**	**158 351 460.40**
CURRENT LIABILITIES			
Short term provisions	2.6	–	–
Payables and other liabilities	2.7	122 618 423.02	110 975 331.31
Accrued charges and deferred income	2.8	39 123 975.09	49 915 404.59
		161 742 398.11	**160 890 735.90**
TOTAL LIABILITIES		**161 742 398.11**	**160 890 735.90**
Contribution from Members	2.9	1 904 513 506.67	1 580 943 012.81
Accumulated deficit		(1 583 482 288.31)	(1 455 733 390.07)
Economic result of the year		(85 733 105.16)	(127 748 898.24)
TOTAL NET ASSETS		**235 298 113.20**	**(2 539 27550)**
LIABILITIES AND NET ASSETS		**397 040 511.31**	**158 351 460.40**

5.7.2. Statement of financial performance

Table 62. Statement of financial performance (EUR)

	NOTE	2023	2022
REVENUE			
Revenue from non-exchange transactions			
Recovery of operating expenses	3.1	2 422 224.07	1.563.445.88
Other non-exchange revenue	3.2	–	–
Revenue from exchange transactions	3.3		
Financial revenues		–	0.03
Other exchange revenue		12 489.05	35 732.09
TOTAL REVENUE		**2 434 713.12**	**1 599 178.00**
EXPENSES			
Operating costs	3.4	(81 940 105.91)	(123 005 176.97)
Staff costs	3.5	(3 337 901.67)	(3 359 274.02)
Financial expenses	3.6	(2 366.64)	–
Other expenses	3.7	(2 887 144.06)	(2 983 625.25)
TOTAL EXPENSES		**(88 167 818.28)**	**(129 348 076.24)**
ECONOMIC RESULT OF THE YEAR		**(85 733 105.16)**	**(127 748 898.24)**

Cash flow statement

Table 63. Cash flow statement (EUR)

	2023	2022
Economic result of the year	(95 000 800.58)	(127 748 898.24)
Operating activities		
Depreciation and amortisation	59 147.69	65 280.69
(Increase)/decrease in pre-financing	(194 804 533.81)	15 739 328.78
(Increase)/decrease in exchange receivables and non-exchange recoverables	(43 638 245,37)	(37 407 905.64)
Increase/(decrease) in payables	19 307 707.98	51 961 471.39
Increase/(decrease) in accrued charges & deferred income	(9 484 631.81)	251 094.51
Increase/(decrease) in cash contributions	298 672 392.41	77 924 492.06
Increase/(decrease) in in-kind contributions	24 898 101.45	19 235 775.56
Other non-cash movements	–	–
Investing activities		
(Increase)/decrease in intangible assets and property, plant and equipment	**(9 137.96)**	**(20 639.11)**
NET CASHFLOW	0,00	0,00
Net increase/(decrease) in cash and cash equivalents	–	–
Cash and cash equivalents at the beginning of the year	–	–
Cash and cash equivalents at year-end	–	–

Statement of changes in net assets: not applicable

	CONTRIBUTION FROM MEMBERS	ACCUMULATED SURPLUS/ (DEFICIT)	ECONOMIC RESULT OF THE YEAR	EUR '000 NET ASSETS
BALANCE AS AT [YEAR N-2]				
Allocation [YEAR N-2] economic result				
Cash contribution				
Contribution in-kind				
Economic result of the year				
BALANCE AS AT [YEAR N-1]				
Allocation [YEAR N-1]economic result				
Cash contribution				
Contribution in-kind				
Economic result of [YEAR N-1]				
BALANCE AS AT [YEAR N]				

5.8. Materiality criteria

The '**materiality**' concept provides the executive director with a basis for assessing the importance of the weaknesses/risks identified and thus whether those weaknesses should be subject to a formal reservation to his/her declaration. The same materiality criteria are applicable to the FP7 and H2020 programmes.

When deciding whether or not something is material, **qualitative and quantitative** terms have to be considered.

In **qualitative** terms, when assessing the significance of any weakness, the following factors are taken into account:

- the nature and scope of the weakness;
- the duration of the weakness;
- the existence of compensatory measures (mitigating controls which reduce the impact of the weakness);
- the existence of effective corrective actions to correct the weaknesses (action plans and financial corrections) which have had a measurable impact.

In **quantitative** terms, in order to make a judgement on the significance of a weakness, the potential maximum (financial) impact is quantified.

Although the Clean Hydrogen JU control strategy is of a multi-annual nature (i.e. the effectiveness of the Clean Hydrogen JU's control strategy can only be assessed at the end of the programme, when the strategy has been fully implemented and the errors detected have been corrected), the Executive Director is required to sign a declaration of assurance for each financial year. In order to determine whether to qualify his declaration of assurance with a reservation, the effectiveness of the Clean Hydrogen JU's control system has to be assessed, not only for the year of reference, but more importantly, with a multi-annual outlook.

The **control objective** for JU is to ensure that the '**residual error rate**', i.e. the level of errors which remain undetected and uncorrected, does not exceed 2 % by the end of the Clean Hydrogen JU's programme. Progress towards this objective is to be (re)assessed annually, in view of the results of the implementation of the *ex post* audit strategy. As long as the residual error rate is not (yet) below 2 % at the end of a reporting year within the programme's life cycle, a reservation would (still) be made. Nevertheless, apart from the residual error rate, the executive director may also take into account other management information at his/her disposal to identify the overall impact of a weakness and determine whether or not it leads to a reservation.

If an adequate calculation of the residual error rate is not possible, for reasons not involving control deficiencies, the consequences are to be assessed quantitatively by estimating the likely exposure for the reporting year. The relative impact on the declaration of assurance would then be considered by analysing

the available information on qualitative grounds and considering evidence from other sources and areas (e.g. information available on error rates in more experienced organisations with similar risk profiles).

Considering the crucial role of *ex post* audits in the Clean Hydrogen JU's control system, its effectiveness needs to check whether the scope and results of these audits are sufficient and adequate to meet the control objectives.

EFFECTIVENESS OF CONTROLS

The **starting point** to determine the effectiveness of the controls in place is the 'representative error rate' expressed as a percentage of errors in favour of the Clean Hydrogen JU detected by *ex post* audits measured with respect to the amounts accepted after *ex ante* controls.

According to the Clean Hydrogen JU *ex post* audit strategy approved by the governing board, the representative error rate will be based on the simple average error rate (AER) for a stratified population, from which a representative sample has been drawn according to the following formula:

$$AER\% = \frac{\Sigma\,(err)}{r} = RepER\%$$

Where:

Σ **(err)** = sum of all individual error rates of the sample (in %). Only those errors in favour of the Clean Hydrogen JU will be taken into consideration.

n = sample size

Second step: calculation of **residual error rate**:

To take into account the impact of the *ex post* controls, this error level is to be adjusted by subtracting:

errors detected and corrected as a result of the implementation of audit conclusions;

errors corrected as a result of the extrapolation of audit results to non-audited contracts with the same beneficiary.

This results in a residual error rate, which is calculated by using the following formula:

$$RepER\% = \frac{(ResER\% * (P\text{-}A) - (RepERsys\% * E)}{P}$$

Where:

ResER% = residual error rate, expressed as a percentage.

RepER% = representative error rate, or error rate detected in the representative sample, in the form of the AER, expressed as a percentage and calculated as described above (AER%).

RepERsys% = systematic portion of the RepER% (the RepER% is composed of complementary portions reflecting the proportion of 'systematic' and 'non-systematic' errors detected) expressed as a percentage.

P = total amount in EUR of the auditable population.

A = total of all audited amounts, expressed in EUR.

E = total non-audited amounts of all audited beneficiaries. This will comprise the total amount, expressed in EUR, of all non-audited validated cost statements for all audited beneficiaries, excluding those beneficiaries for which an extrapolation is ongoing.

This calculation will be performed on a point-in-time basis, i.e. all the figures will be provided as of a certain date.

5.9. Results of technical review (not applicable)

5.10. List of acronyms

AAR	annual activity report
ABAC	accrual-based accounting
AEL	alkaline electrolysis
AER	average error rate
AIB	Association of Issuing Bodies
AWP	annual work programme
BOA	back-office arrangement
CAPEX	capital expenditure
CAS	Common Audit Service
CBE	Circular Bio-based Europe
CEF	Connecting Europe Facility
CEF-T	Connecting Europe Facility – Transport
CERT-EU	Cybersecurity Service for the Union Institutions, Bodies, Offices and Agencies
CHP	combined heat and power
CIC	Common Implementation Centre
CINEA	European Climate, Infrastructure and Environment Executive Agency
CORDA	Common Research Data Warehouse
CRM	critical raw material
D & E	dissemination and exploitation
DG	directorate-general
ECA	European Court of Auditors
EDCTP3	European and Developing Countries Clinical Trials Partnership 3
EECS	European energy certificate system
EHS&CP	European Hydrogen Sustainability and Circularity Panel
EHSP	European Hydrogen Safety Panel
EU-Rail	Europe's Rail
FCEV	fuel cell electric vehicle
FCH	fuel cells and hydrogen
FCHO	Fuel Cells and Hydrogen Observatory
FP7	seventh framework programme
GO	guarantee of origin
H2020	Horizon 2020
HR	human resources
HRS	hydrogen refuelling station
IAS	Internal Audit Service
ICT	information and communications technology
IEA	International Energy Agency
IHI	Innovative Health Initiative
IKAA	in-kind contribution to additional activities
IKOP	in-kind contribution to operational activities
IPHE	International Partnership for Hydrogen and Fuel Cells in the Economy
IR	innovation radar
IT	information technology
JRC	Joint Research Centre
JU	joint undertaking
KIP	key impact pathway
KPI	key performance indicator
MAWP	multiannual work programme
N/A	not applicable
NGC	non-governmental certificate
NZIA	Net-zero Industry Act
PDA	project development assistance
PEM	proton exchange membrane
PEMEL	proton exchange membrane electrolysis
PEMFC	proton exchange membrane fuel cell
PMO	Paymaster Office

PNR	pre-normative research
R & I	research and innovation
RCS	regulations, codes and standards
RCS SC	Regulations, Codes and Standards Strategy Coordination
RED	renewable energy directive
SMEs	small and medium-sized enterprises
SBA	Single Basic Act
SOA	state of the art
SOC	solid oxide cell
SOEC	solid oxide electrolyser cell
SOEL	solid oxide electrolysis
SOFC	solid oxide fuel cell
SRG	States Representatives Group
SRIA	strategic research and innovation agenda
Sysper	système de gestion du personnel
TIM	tools for innovation monitoring
TRL	technology readiness level
TRUST	Technology Reporting Using Structured Templates
TTG	time to grant
TTI	time to inform
TTP	time to pay

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