ANNUAL ACTIVITY REPORT 2020

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

EUROPE DIRECT is a service to help you find answers to your questions about the European Union

Freephone number (*):

00 800 6 7 8 9 10 11

(*) Certain mobile telephone operators do not allow access to 00 800 numbers or these calls may be billed

www.fch.europa.eu
Email: fch-ju@fch.europa.eu

Publication: February 2021, in Belgium

Legal notice

Printed in Belgium

Publicly available

ANNUAL ACTIVITY REPORT 2020

In accordance with Article 17 of the Statutes of the FCH 2 JU annexed to Council Regulation (EU) No. 559/2014 and with Article 23 of the Financial Rules of the FCH 2 JU.

The annual activity report will be made publicly available following its approval by the Governing Board.

TABLE OF CONTENTS

FACTSHEET

NAME	Fuel Cells and Hydrogen 2 Joint Undertaking
OBJECTIVES	a) To contribute to the implementation of Regulation (EU) No. 1291/2013, and in particular the Secure, Clean and Efficient Energy Challenge and the Smart, Green and Integrated Transport Challenge under part III of I of Decision 2013/743/EU (b) To contribute to the objectives of the Joint Technology Initiative on Fuel Cells and Hydrogen, through the development of a strong, sustainable and globally competitive FCH sector in the Union
FOUNDING LEGAL ACT	Council Regulation (EU) No. 559/2014 of 6 May 2014 – OJ L169/108-129 of 7.6.2014
EXECUTIVE DIRECTOR	Bart Biebuyck
GOVERNING BOARD	Chair: Valérie Bouillon-Delporte Vice-Chair: Patrick Child (in 2020) ; Rosalinde van der Vlies (2021) Governing Board composition: http://www.fch.europa.eu/page/governing-board
OTHER BODIES	States Representative Group, Scientific Committee, Stakeholder Forum
STAFF	24 temporary agents and 3 contract agents
2020 BUDGET	EUR 104.2 million of which EUR 98.3 million (in terms of commitment appropriations) allocated to operational activities and EUR 5.9 million to administrative expenses
BUDGET IMPLEMENTATION	94 % in terms of commitment appropriations 95 % in terms of payment appropriations
GRANTS	131 signed for a total value of EUR 625.6 million at end of 2020
STRATEGIC RESEARCH AGENDA	Multi-Annual Work Plan 2014-2021 Addendum to the MAWP endorsed by the Governing Board on 15 June 2018
CALL IMPLEMENTATION	Number of calls launched in 2020: 1 Number of proposals submitted: 71 Number of eligible proposals: 71 Number of proposals funded: 22 Global project portfolio (since setting up): 155 projects under FP7 (of which 152 are closed and 3 are open) and 131 signed projects under H2020 (of which 26 are closed and 105 are open) Number and value of tenders (if any): 3 studies were contracted in 2020 for a total value of EUR 1.6 million
PARTICIPATION, INCLUDING SMES	Total number of participations in funded projects: 1 471 of which: % of SMEs: 23 % of SME funding: 30

FOREWORD

Without a doubt, 2020 was a very important year for hydrogen. On 8 July, the European Commission launched the European Hydrogen Strategy and the Clean Hydrogen Alliance. The Hydrogen Strategy recognises the important role of research and innovation (R&I) in achieving the 2030 goals and proposes the establishment of the Clean Hydrogen partnership. At the same time, 2020 was a challenging year for many, when we needed to adapt our way of working while achieving our objectives and meeting European citizens' expectations.

During 2020, we continued to focus on outreach and dissemination of project results in order to show citizens and policymakers the potential of the fuel cell and hydrogen technology and the major achievements in this public-private partnership.

The highlight of the year was the first European Hydrogen Week, which was jointly organised with the European Commission (EC) Directorate-General (DG) GROW and the German Presidency. During this week, more than 10 000 people joined one or multiple sessions. In addition, webinars to disseminate our study results each drew more than 1 000 attendees. Consequently, going virtual enabled us to disseminate results to a much wider public than in the past.

With 283 projects, a combined public-private investment of over EUR 2.0 billion has been realised since 2008. 2020 was the last year for the FCH 2 JU to launch a call for proposals and, despite the pandemic, interest was very high and some great projects were selected for funding. Furthermore, we have noticed that the impact of COVID-19 on current projects has been relatively small and most remain on track to achieve their objectives.

Despite the pandemic, the FCH 2 JU achieved the second best budget execution ever, and reached excellent leverage effects and a low error rate. This demonstrates that FCH 2 JU continues to provide an excellent example of a mature, sound and well-controlled environment. This success is achieved thanks to the hard work and dedication of many people, passionate to tackle climate change: colleagues at the European Commission, members of our Governing Board, the States Representative Group, the Scientific Committee, and the many stakeholders who give their valuable inputs on our plans and activities.

Finally, I would like to thank my entire team in the Programme Office who, every day in these difficult times, give the best of themselves to serve the interests of European citizens.

Enjoy the read!

Bart BIEBUYCK
FCH 2 JU Executive Director

EXECUTIVE SUMMARY

2020 was a key year for the FCH 2 JU in the context of the European Commission's adoption on 8 July of the EU Hydrogen Strategy[1] in line with the NextGenerationEU[2] recovery package and the European Green Deal[3]. It was marked by the first European Hydrogen Week[4], greater public awareness, progress in both project achievements and in outreach and dissemination activities, significant feedback to policy and the further development of initiatives (synergies with regions and with other partnerships), increased digitalisation of activities, excellent budget execution, and a continuous strong internal control framework.

Highlights during the year include:

Operational and communication activities

- The organisation of the first European Hydrogen Week, an entire week of events from 23 to 27 November 2020 dedicated to the essential role of hydrogen in reaching the EU's commitment to achieve carbon neutrality by 2050. It included the European Hydrogen Forum co-organised with DG GROW, a policy conference entitled 'PrioritHy', under the German Presidency and co-organised with Germany's National Organisation Hydrogen and Fuel Cell Technology (NOW) GmbH , the FCH 2 JU Awards, as well as the **Programme Review Days** (PRD), which provided an excellent visibility platform for more than 100 projects currently on-going under FCH 2 JU.

- Communication activities were developed to raise awareness and reach out to a more diverse audience. Because of the pandemic, the strategy shifted towards online activities and events, and increased the number and diversity of participants. Over 10 000 unique participants followed the European Hydrogen Week and more than 10 000 subscribers are registered for the FCH 2 JU newsletter.

- Progress continued in all areas: in the transport sector, covering a wide range of vehicles (various car models, buses, heavy-duty trucks, rail and aviation applications) and an expanding network of hydrogen refuelling stations (HRS); and in the energy sector, including stationary applications, hydrogen production, hydrogen storage and distribution in cross-cutting activities (pre-normative research (PNR), safety, education and training), as described under Section 1.2.1 of this report and in more detail in the 2020 Programme Review Report[5].

- The FCH 2 JU is part of the Horizon 2020 Dissemination and Exploitation Network established by DG R&I under the H2020 Strategy for a common dissemination and exploitation of research and innovation data and results. It actively contributes to the six working groups set up in this context and supports the key outcomes of these groups, which comprise: a) The new Collaborative Framework for Feedback to Policy (F2P Framework), based on the consulting engagement in the existing process of R&I policy feedback performed by the Internal Audit Service (IAS), and the lessons learned from its piloting; b) the renewed (post-2020) Dissemination and Exploitation (D&E) Strategy and its governance; c) the 2021-22 D&E Action Plan; d) consultation on CORDIS orientations; e) the 'Go to Market' guidance for project officers; and f) input for the D&E sections of the proposal and reporting templates. It is worth highlighting that, in 2020, a total of 24 project results were uploaded on the **Horizon Results Platform (HRP)**[6] (10 in 2019), 25 additional innovations and 33 innovators of 15 FCH 2 JU projects have been identified on the **EU Innovation Radar Platform**[7], 11 % of the total **Support Services for Exploitation of Research Results**[8] (SSERR), which ran from 2015 to 2020 in all Seventh Framework Programme (FP7) and H2020 implementing bodies/JUs, were distributed to FCH 2 JU projects, and 4 FCH 2 JU projects have already applied or indicated their interest in the Horizon Results Booster[9], the successor of the SSERR, which entered into force in May 2020.

1 https://ec.europa.eu/energy/sites/ener/files/hydrogen_strategy.pdf

2 https://ec.europa.eu/info/files/eu-budget-powering-recovery-plan-europe_en

3 https://ec.europa.eu/commission/presscorner/detail/en/IP_19_6691

4 https://www.fch.europa.eu/european-hydrogen-week

5 The report will be published in the course of 2021 on the FCH 2 JU website: https://www.fch.europa.eu/page/programme-posters-and-presentations-2020

6 https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/horizon-results-platform

7 https://www.innoradar.eu/

8 http://sserr.meta-group.com/SitePages/default.aspx

9 https://www.horizonresultsbooster.eu/

- Policy support was also pursued including, among others:

  - The launch of CertifHy3[10], a study on accelerating the deployment of Guarantees of Origin (GO) schemes for hydrogen and for the design of a voluntary scheme for compliance with the Renewable Energy Directive (RED II) targets. It succeeds the first two phases of the CertifHy project, an EU-wide certification system that covers both GOs – to disclose the origin of green and low-carbon hydrogen to end-users – and supply certificates

  - Completion of the study on 'Opportunities arising from the inclusion of Hydrogen Energy Technologies in the National Energy & Climate Plans (NECPs)'[11]

  - The public launch of the Fuel Cells and Hydrogen Observatory[12] (FCHO) in collaboration with DG R&I. The portal will become a precious tool for all policymakers and other stakeholders interested in the use of fuel cells and hydrogen technologies as a decarbonisation solution primarily in the energy and transport sectors.

- Synergies were further developed both with regions and with other agencies and joint undertakings including, for example:

  - as part of the Regions Initiative[13] under development since 2018, the entry into force in June 2020 of the pilot Project Development Assistance (PDA) which supports 11 public regional and local authorities from across the EU to develop their concepts for regional FCH projects into detailed work plans. It is noteworthy that more than half of the projects selected are from regions that had no specific track record in deploying hydrogen-related projects.

  - exchanges with the Executive Agency for Small and Medium-sized Enterprises (EASME)[14] and the Innovation and Networks Executive Agency (INEA)[15] to better understand the opportunities that the European city and island facilities managed by these two executive agencies could bring to the FCH community.

  - development of hydrogen valleys and ecosystems: under the FCH 2 JU-supported project BIG HIT[16], the Hydrogen Territories Platform[17] (HTP) was launched. To foster the adoption of FCH solutions on islands, two other projects are being supported by FCH 2 JU: HEAVENN, which started in 2020 and GreenHysland, which starts in 2021. Furthermore, a Hydrogen Valley Platform[18] was developed under the umbrella Mission Innovation 'Renewable and Clean Hydrogen' innovation challenge[19].

  - a study on the use of hydrogen and fuel cells for aircraft propulsion[20] was commissioned jointly with Clean Sky 2 JU and its promising results were presented on 22 June during a digitally hosted event.

Support activities and internal control environment

- **Budget execution** remained **excellent** at 94.4 % in terms of commitment appropriations and 95.3 % for payment appropriations.

- The smooth administrative functioning of the FCH 2 JU was further enhanced with the upgrade of the eSubmission module to allow the automatic registration of tenders within the EC Document Management IT System (ARES). Since the FCH 2 JU is using the latest version of eSubmission, the publication, submission and reception of offers, opening and evaluation stages are now fully digital. In addition, in 2020, FCH 2 JU migrated to EU Sign, and now applies a **Qualified Electronic Signature (QES)**[21] on its contracts, which facilitates

10 https://www.certifhy.eu/

11 https://www.fch.europa.eu/publications/opportunities-hydrogen-energy-technologies-considering-national-energy-climate-plans

12 https://www.fchobservatory.eu/

13 https://www.fch.europa.eu/page/fch-regions-hub

14 https://ec.europa.eu/easme/en

15 https://ec.europa.eu/inea/en

16 https://www.bighit.eu/

17 www.h2territory.eu

18 https://www.fch.europa.eu/page/mission-innovation-hydrogen-valleys-platform

19 http://mission-innovation.net/our-work/innovation-challenges/renewable-and-clean-hydrogen/

20 https://www.fch.europa.eu/publications/hydrogen-powered-aviation

21 QES is fully compliant with EU Regulation No. 910/2014 (eIDAS Regulation): https://www.eid.as/

business processes by significantly reducing the time and cost of signing a contract. Preparatory work for enhanced digitalisation included the **Data Protection Impact Assessment (DPIA)** carried out jointly with five other joint undertakings on the deployment of Microsoft 365 services. An action plan was set up to implement the required mitigation measures to ensure full compliance with the EUDPR (EU data protection) and to deploy these services during 2021.

- Leverage effect and in-kind contributions

By the end of 2020, the FCH 2 JU had supported 131 projects under the H2020 programme for a combined public-private investment close to EUR 1.2 billion. Together with its additional activities, FCH 2 JU managed to achieve a combined amount of private-public investment for the H2020 programme of over EUR 2 billion.

- *Ex-post* audits and error rates

Despite the COVID-19 situation, there were no significant delays in the execution of *ex-post* audits, either for FP7 or for H2020.

- FCH 2 JU managed to successfully close all previously launched FP7 audits, confirming the final error rate for the FP7 programme at a multi-annual level well below the 2 % threshold.

- FCH 2 JU achieved **statistically representative results from H2020 *ex-post* audits to form a solid base for an *ex-post* pillar of declaration on assurance**, confirming the continuing trend from previous years in the residual error rate on FCH 2 JU contribution of below 2 %.

- COVID-19 considerations for the risk assessment

In 2020, in addition to a regular risk-assessment exercise, FCH 2 JU organised a special brainstorming session with the attendance and participation of all members of staff, chaired by the Executive Director (ED), to identify any new emerging COVID-19 risks.

- IAS and internal control

In 2020, the IAS concluded that the FCH 2 JU had set up an efficient and effective internal control system for the implementation and closing of grant agreements under the H2020 programme[22]. In addition, the auditors identified the following strengths in the FCH 2 JU that are contributing to effective grant implementation under H2020:

- In order to reinforce *ex-ante* controls and prevent significant findings during *ex-post* audits, the JU has introduced an extra step as a preventive control: assessment of the financial risk of the top non-audited beneficiaries with the help of a self-assessment questionnaire.

- The JU is making efforts to ensure a high proportion of projects benefit from the EC's tools and initiatives to boost dissemination and exploitation. It also hired a Dissemination and Exploitation Officer to help facilitate these activities.

- Special COVID-19 measures were put in place in the IT area, in particular:

  - There was high resilience among staff members concerning targeted phishing attacks. Each time they occurred they were well identified and corrective action was taken.

  - The level of security and protection on the infrastructure was improved with the adoption of Microsoft Defender for Endpoint, following the advice of CERT-EU.

  - Staff and/or the management was informed on an ad-hoc basis about issues occurring in other agencies which were relayed by CERT-EU to highlight potential risk(s).

22 Final audit report on Horizon2020 grant implementation in the FCH 2 JU, ref. Ares(2021)340613.

INTRODUCTION

Council Regulation No. 559/2014 set up the current Fuel Cells and Hydrogen Joint Undertaking (FCH 2 JU) under the Horizon 2020 Framework Programme as a unique institutionalised public-private partnership supporting research, technological development and demonstration (RTD) activities in FCH technologies in Europe, aiming to accelerate their commercialisation by 2020. This demonstrates the EU's continued confidence and support for fuel cells and hydrogen (FCH) as key technologies (fuel cells as an energy-efficient converter and hydrogen as a clean-energy carrier) for decarbonising Europe's energy system and creating a secure, sustainable energy supply capable of generating new jobs.

Conscious of its dependence on imports of energy resources, mainly from unstable countries, the EU has set targets to reduce the related risks. This is stated in the EC's 2014 Energy Security Strategy[23] which focuses on the need for improved energy efficiency as well as on the requirement to increase the EU's own energy production, to diversify supply sources and routes, to consolidate its internal energy system, and to protect its critical infrastructure.

In that respect, the EC has identified hydrogen as an energy carrier that can both diversify supply sources, decarbonise the energy system and integrate high shares of renewables sources.

Hydrogen storage solutions were first acknowledged[24] as an important energy-storage option for developing an affordable and efficient energy market, facilitating the integration of variable renewable energy sources. The role of hydrogen as a solution that can decarbonise the EU's gas network and increase security of supply was highlighted in the proposed update of the EU Gas Directive[25]. Hydrogen's important role in the integration of renewable energy sources is emphasised in the revised RED II[26], establishing a binding EU target of at least 32 % for 2030. RED II calls on Member States to establish a methodology for GOS of renewable gases (including hydrogen) and consequently a certification system.

In December 2018, Member States also submitted their draft integrated National Energy and Climate Plans (NECPs)[27] for the period 2021-2030. Several already mentioned (renewable) hydrogen as a crucial energy carrier to decarbonise their entire economy. This was confirmed both with the final NECPs submitted in 2020 and also with a number of national hydrogen strategies that were published, and continue to be published, by the Member States. A study[28] carried out for FCH 2 JU analyses all NECPs and concludes that major opportunities for hydrogen already appear before 2030, with the large-scale deployment of renewable and low-carbon hydrogen expected to take off as of 2030.

Similarly for the transport sector, the 'Clean Mobility Package' proposed more stringent CO_2 emission standards for new passenger cars and vans, accelerating the transition to low- and zero-emission vehicles. In particular, the first-ever EU-wide CO_2 emission standards for heavy-duty vehicles, adopted in 2019[29], set targets for reducing the average emissions from new lorries for 2025 and 2030. At the same time, it identified hydrogen infrastructure as one of the main solutions and part of the trans-European deployment of an Alternative Fuels Infrastructure[30]. In 2018, there was a global agreement for the first time within the International Maritime Organization on targets to reduce the greenhouse gas (GHG) emissions from maritime transport by a minimum of 50 % by 2050 and phase them out completely before the end of the century. This represents a substantial challenge and the possibility of using fuel cells, together with hydrogen or other zero-carbon fuels, as a very promising energy source for large-scale shipping.

At the international level, during the Paris climate conference (COP21) in December 2015, 195 countries adopted the first-ever universal, legally binding global climate deal. The agreement sets out a global action plan to put the world on track to avoid dangerous climate change by limiting global warming to 2 °C '*... and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius*'. In November 2018, the EC published its 2050 long-term strategy[31] calling for a climate-neutral Europe by 2050 (COM (2018) 773). The strategy analysed different pathways for achieving this goal, concluding that all carbon-free or low-carbon energy carriers, including low-carbon hydrogen, will be necessary to achieve Europe's ambitious climate neutrality goal by 2050.

23 European Energy Security Strategy, (SWD(2014) 330 final).

24 https://ec.europa.eu/energy/sites/ener/files/documents/swd2017_61_document_travail_service_part1_v6.pdf

25 https://ec.europa.eu/info/news/commission-proposes-update-gas-directive-2017-nov-08_en

26 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2018.328.01.0082.01.ENG&toc=OJ:L:2018:328:TOC

27 https://ec.europa.eu/energy/en/topics/energy-strategy-and-energy-union/governance-energy-union/national-energy-climate-plans

28 https://www.fch.europa.eu/publications/opportunities-hydrogen-energy-technologies-considering-national-energy-climate-plans

29 https://ec.europa.eu/clima/policies/transport/vehicles/heavy_en

30 https://ec.europa.eu/transport/themes/urban/cpt_en

31 https://ec.europa.eu/clima/policies/strategies/2050

In December 2019, the EC President presented the European Green Deal[32], a new growth strategy for Europe aiming to transform the Union into a modern, resource-efficient and competitive economy. At the core of the European Green Deal lies the need to fight climate change. On March 2020, the EC proposed a European Climate Law[33], capturing the climate-neutrality objective in EU law. At the same time, it underlined the need to review the EU's targets for 2030 and define a trajectory compatible with the climate-neutrality objective by 2050. To this end, in September 2020, the EC adopted the 2030 Climate Target Plan[34], proposing the ambition to reduce the increase in GHG emissions for 2030 from 40 % to at least 55 %, setting Europe on a cost-effective path for climate neutrality by 2050.

In July 2020, the EC adopted the Strategy for Energy System Integration[35] and Hydrogen Strategy[36]. Together, they aim to address a vision on how to accelerate the transition towards a more integrated and clean energy system, in support of a climate-neutral economy. The Energy System Integration strategy addresses the planning and operation of the energy system 'as a whole', across multiple energy carriers, infrastructures, and consumption sectors. It sets out 38 actions to implement the necessary reforms, including the promotion of renewable and low-carbon fuels, including hydrogen, for sectors that are hard to decarbonise.

The Hydrogen Strategy aims to create an enabling environment to scale up renewable hydrogen supply and demand for a climate-neutral economy. It also tries to address the issue that the majority of hydrogen production today is fossil-based, as low-carbon hydrogen has yet to become cost competitive. To achieve this, the Strategy outlines a number of key actions and presents three strategic phases in the timeline up to 2050.

Building on the EC's new Industrial Strategy for Europe[37] and the Recovery Plan for Europe[38], the Strategy sets out a vision of how the EU can turn hydrogen into a viable solution to decarbonise different sectors over time. Most notably, it sets the ambitious goal of installing at least 6 GW of renewable hydrogen electrolysers in the EU by 2024 and 40 GW of renewable hydrogen electrolysers by 2030.

As regards all the policy developments in 2020, as mentioned above, the FCH 2 JU has addressed them through many actions, research and demonstration activities, both in line with the above-mentioned EU-wide objectives as well as with all of its objectives as listed in Council Regulation No. 559/2014 of 6 May 2014. The Annual Activity Report (AAR) highlights the main activities and the achievements of FCH 2 JU in 2020 in line with the Annual Work Plan (AWP) 2020 adopted by the Governing Board (GB) on 13 December 2019.

32 European Green Deal Communication, COM(2019) 640 final.

33 https://ec.europa.eu/clima/policies/eu-climate-action/law_en

34 2030 Climate Target Plan Communication, COM(2020) 562 final.

35 Strategy for Energy System Integration, COM(2020) 299 final.

36 A Hydrogen Strategy for a climate neutral Europe, COM(2020) 301 final.

37 New Industrial Strategy for Europe, COM(2020) 102 final.

38 Europe's moment: Repair and Prepare for the Next Generation, COM(2020) 456 final.

01
IMPLEMENTATION OF THE ANNUAL WORK PLAN 2020

1.1 KEY OBJECTIVES 2020 AND ASSOCIATED RISKS

The overall objective of FCH 2 JU is to implement an optimal R&I programme at the EU level to develop a portfolio of clean and efficient solutions that exploit the properties of hydrogen as an energy carrier and FC as energy converters to the point of market readiness. This will provide feedback and related support to EU policies on sustainable energy and transport, climate change, the environment and industrial competitiveness, as embodied in the Europe 2020 strategy, and job creation. It will also help to achieve the EU's overarching goal of smart, sustainable and inclusive growth. The programme's overall direction is guided by its multi-annual plans: Multi-Annual Implementation Plan (MAIP) for 2008-2014 under FP7 and MAWP for 2014-2020 under Horizon 2020. These plans specify targets for the state of FCH technologies in Europe (covering cost, durability and performance) and specific key performance indicators (KPIs). The programme's progress and therefore scientific/technological achievements are always assessed according to the progress towards achieving these targets and KPIs. As the technology has progressed substantially in recent years and new applications have begun to emerge, these KPIs (fixed in 2014) were revised and included in an addendum to the MAWP, endorsed by the FCH 2 JU GB on 15 June 2018. The main objectives and achievements are presented in Section 1.2.

Leverage effect in H2020

A key objective and measure of the JUs' success is their capacity to leverage private funding.

On the one hand, calculation of the leverage effect takes into account the operational component (private financial and in-kind contributions to projects for each euro committed by the EC) and, on the other hand, any additional leverage (private contributions to additional activities not directly linked to the project portfolio but contributing to the JUs' overall objectives).

The Council Regulation establishing the FCH 2 JU[39] explicitly mentions **the minimum target leverage effect over the whole 2014–2020 period at 0.57**[40].

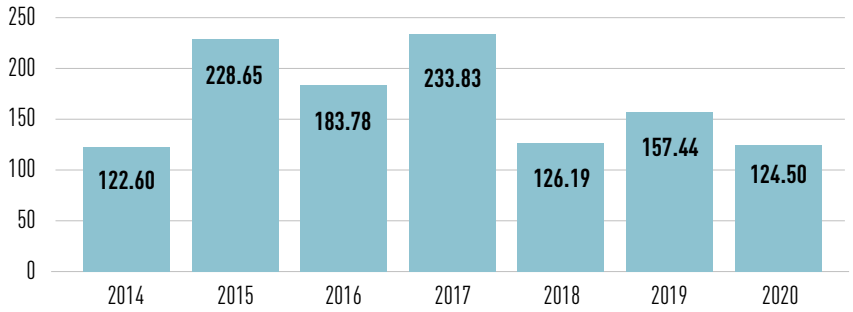
In 2020, the FCH 2 JU aimed to demonstrate to the European Council and European Parliament that the overall commitment of the industry and research has significantly surpassed the minimum requirement of EUR 380 million for H2020.

By the end of 2020, under the H2020 programme, the FCH 2 JU had supported **131 projects for a combined public–private investment close to EUR 1.2 billion**.

39 Council Regulation (EU) No. 559/2014 of 6 May 2014 establishing the Fuel Cells and Hydrogen 2 Joint Undertaking.

40 Total minimum contribution from members other than the EU (EUR 380 million) over the total EU contribution (EUR 665 million).

FIGURE 1: TOTAL COMMITTED PRIVATE AND PUBLIC INVESTMENT IN FCH 2 JU ACTIONS OVER 2014-2020 IN EUR MILLION



In addition, in 2020, industry and research members achieved a total of EUR 876.55 million of additional activities certified (covering the years 2014-2019) with a reported outlook of EUR 218.52 million additional activities for 2020, arriving at **estimated certified additional activities for the H2020 programme for 2014-2020 of an amount surpassing EUR 1 billion**.

This demonstrates the sector's continuous huge willingness to invest and grow.

For a detailed calculation of the leverage-effect formula, the following contributions made by members other than the EU and their constituent or affiliated entities have been considered:

- contributions to the **administrative costs** of the FCH 2 JU;
- co-financing required to carry out R&I actions supported by the FCH 2 JU (i.e. contributions to indirect actions through **co-funding FCH 2 JU projects** (so-called IKOP);
- contributions towards additional activities by members other than the EU or their constituent or affiliated entities, as specified in an additional activities plan. These **additional activities** (so-called **IKAA**) should represent contributions to the broader Fuel Cells and Hydrogen Joint Technology Initiative and the sector as a whole.

The amounts of each contribution, as at 31 December 2020, are detailed in the tables below.

Administrative costs

TABLE 1: MEMBERS' FINANCIAL CONTRIBUTIONS TO FCH 2 JU ADMINISTRATIVE COSTS IN 2014-2020

CONTRIBUTIONS TO ADMINISTRATIVE COSTS RECEIVED BY 31 DECEMBER 2020/ YEAR	INDUSTRY GROUPING	RESEARCH GROUPING	TOTAL
	CASH IN EUR MIL.	CASH IN EUR MIL.	CASH IN EUR MIL.
2014	0.26	0.04	**0.30**
2015	0.41	0.07	**0.48**
2016	0.40	0.07	**0.47**
2017	0.05	0.01	**0.06**
2018	2.01	0.33	**2.34**
2019	2.31	0.38	**2.68**
2020	2.05	0.33	**2.38**
Total 2014-2020	**7.49**	**1.22**	**8.71**

The lower cash contributions until 2017 can be explained by the fact that the administrative costs were also funded by FP7 contributions.

In-kind contributions in operational activities (IKOP)

The table below provides an overview of private-sector co-financing in all FCH 2 JU projects signed up until 31 December 2020. The total amounts committed per FCH 2 JU member, per all private partners and per the EU are broken down according to individual Calls.

When comparing total private contributions in projects to the total EU contribution, a close parity of 1:1 can be observed (EUR 617 million of EU committed contribution vs. EUR 559 million of private contributions).

TABLE 2: IN-KIND CONTRIBUTIONS AND EU CONTRIBUTIONS FOR GRANTS UNDER CALLS 2014-2020

CALL YEAR	NUMBER OF PROJECTS	TOTAL EU CONTRIBUTION (A) IN EUR MIL.	COMMITTED IN-KIND CONTRIBUTIONS (IKOP) FROM MEMBERS (B) IN EUR MIL.	COMMITTED IN-KIND CONTRIBUTIONS FROM NON-MEMBERS (C) IN EUR MIL.	TOTAL COMMITTED PRIVATE CONTRIBUTIONS (D = B + C) IN EUR MIL.	TOTAL COMMITTED EU + PRIVATE CONTRIBUTIONS (E = A + D) IN EUR MIL.
Call 2014	15	80.15	26.82	15.63	42.45	122.60
Call 2015	15	107.09	61.76	59.80	121.56	228.65
Call 2016	19	88.02	5.99	89.77	95.76	183.78
Call 2017	24	114.32	16.37	103.14	119.51	233.83
Call 2018	19	71.61	17.41	37.17	54.58	126.19
Call 2019	17	69.13	15.24	73.07	88.31	157.44
Call 2020	22	86.84	14.98	22.67	37.66	124.50
TOTAL	**131**	**617.16**	**158.58**	**401.25**	**559.83**	**1 176.99**

Considering that the funding rates in projects follow H2020 rules (i.e. up to 100 % of direct costs in research and innovation actions (RIAs) and coordination and support actions (CSAs) and up to 70 % in innovation actions (IAs)), these private contributions are significantly higher than was initially foreseen. This is due to the fact that most of the largest demonstration projects have effective funding rates lower than 70 % (of direct costs) as they are very close to the market.

In-kind contributions in additional activities (IKAA)

The underlying purpose of additional activities is to demonstrate private investments in the sector and ensure a balanced contribution is made by both private and public entities in the context of the partnership.

In 2020, members of Hydrogen Europe and Hydrogen Europe Research and their affiliate entities jointly delivered a cumulative amount of EUR 876.55 million certified IKAA (for the period 2014-2019), which is three times more than the minimum requirement for IKAA of EUR 285 million, as defined in the Council Regulation.

In addition, for 2020, the members reported a preliminary figure of EUR 218.52 million of additional activities, bringing an overall estimated certifications for H2020 to over EUR 1 billion.

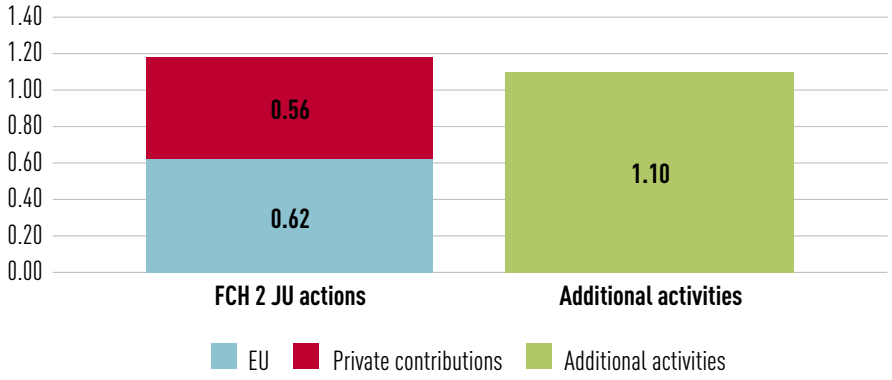
TABLE 3: IN-KIND CONTRIBUTIONS IN ADDITIONAL ACTIVITIES FOR THE PERIOD 2014-2020

IKAA IN EUR MILLION	2014/2015	2016	2017	2018	2019	2020	TOTAL
Certified IKAA as at 31 December 2020	217.56	164.65	107.34	177.45	209.55	-	**876.55**
Estimated IKAA - Preliminary Report 2020*						218.52	218.52
TOTAL IKAA	**217.56**	**164.65**	**107.34**	**177.45**	**209.55**	**218.52**	**1 095.07**

** Estimated figures for the year 2020, reported to the FCH 2 JU GB based on information available as of 31 January 2021, subject to certification later in 2021.*

When comparing committed EU and private funds in the FCH 2 JU actions with the amount of the additional activities for the years 2014-2020, a very interesting picture appears, at the end of 2020, which is illustrated below:

FIGURE 2: EU/PRIVATE INVESTMENTS IN FCH 2 JU ACTIONS VS. IKAA FOR 2014-2020, IN EUR BILLION



More details on in-kind contributions for additional activities can be found in Section 1.7.

Values of leverage effect for the Calls concluded by December 2020

The following values have been taken into account to combine an operational component and additional activities part of private investments over public investment in the FCH 2 JU:

(A) Leverage effect – members only as of 31 December 2020 = (**8.71** + **158.57** + 876.55 / 617.16) = 1 044 / 617 = **1.69**

In other words, for every EUR 1 of EU contribution for all FCH 2 JU signed H2020 grant agreements up to 31 December 2020, members of Hydrogen Europe Industry and Hydrogen Europe Research committed to spend EUR 1.69 either on FCH 2 JU projects or in certified additional activities.

The leverage effect of 1.69 only takes into account members of Hydrogen Europe Industry and Hydrogen Europe Research and is almost three times higher than a target leverage effect, as defined in the FCH 2 JU founding regulation.

(B) Leverage effect – all private partners as of 31 December 2020 = (**8.71** + **559.82** + 876.55 /617.16) = 1 445 / 617 = **2.34**

This formula is fully aligned with the method used in the Staff Working Document (SWD) accompanying the Interim Evaluation of the PPPs[41].

Compared to the previous formula (A), the leverage effect of 2.34 takes into consideration all private partners' contributions to FCH 2 JU actions.

In other words, for 1 EUR of EU contribution for all FCH 2 JU signed H2020 grant agreements until 31 December 2020, the private partners committed to spend EUR 2.34 either on FCH 2 JU projects or on certified additional activities.

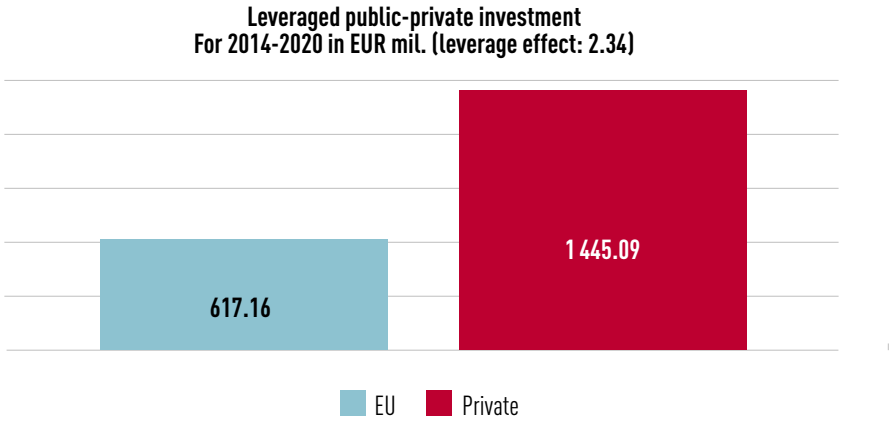
(C) Leverage effect – all private partners as of 31 December 2020 (including estimated additional activities of members for 2020) = (**8.71** + **559.82** + 1095.07 / 617.16) = 1 664 / 617 = **2.70**

41 http://ec.europa.eu/research/evaluations/pdf/20171009_a187_swd.pdf, page 44, Table 12.

This third calculation also encompasses reported members' additional activities for 2020. In other words, for EUR 1 of EU contribution for all FCH 2 JU signed H2020 grant agreements until 31 December 2020, the private partners committed to spend EUR 2.70 either on FCH 2 JU projects or on additional activities.

While the definite amount of leveraged funding will only be known at the end of the JU's operations, current values for the leverage effect point to private-sector **committed funding** that **already exceeds the set targets by as much as four times the minimum**.

FIGURE 3: TOTAL COMMITTED PRIVATE AND PUBLIC INVESTMENT IN FCH 2 JU OVER THE PERIOD 2014-2020 (COMMITTED PRIVATE FUNDING IN ALL SIGNED FCH 2 JU ACTIONS AND CERTIFIED ADDITIONAL ACTIVITIES 2014-2019) UP TO 31 DECEMBER 2020 (FORMULA B)



Risk assessment in 2020

Risk management is a crucial part of the strategic decision-making process. Robust risk management frameworks help to ensure that taxpayers' money 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, regardless of their level, share the responsibility for risk management. The ED is accountable to the GB and is ultimately responsible for managing the FCH 2 JU's activities and achieving its objectives and must ensure that its critical risks are known and managed appropriately.

Relationship with Internal Control Framework

On 16 August 2018, the FCH 2 JU GB adopted a new Internal Control Framework (ICF) – stemming from the most updated internationally acknowledged Committee of Sponsoring Organizations of the Treadway Commission (COSO) model of internal control, in line with the EC's ICF.

Risk assessment is one of the five key ICF components and consists of the four (4) principles #6-9:

	ICF COMPONENTS AND PRINCIPLES
RISK ASSESSMENT	6. The organisation specifies objectives with sufficient clarity to enable the identification and assessment of risks relating to objectives.
	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.
	8. The organisation considers the potential for fraud in assessing risks to the achievement of objectives.
	9. The organisation identifies and assesses changes that could significantly impact the system of internal control.

Risk identification and assessment

In 2020, with the assistance of the Internal Control and Audit Manager, the management conducted an annual risk assessment for the purpose of identifying, analysing and responding to key risks (including fraud) across all of the FCH 2 JU Programme Office (PO) areas of responsibility.

Risk identification in FCH 2 JU starts with an assessment of the relevance of the risks identified in the previous risk-assessment exercises and continues with the identification of any new relevant risks.

The aim of this annual exercise was **to identify risks that could harm achievements of the FCH objectives**, including (among others) operational, financial and compliance risks.

Due to COVID-19 circumstances, the focus of the 2020 annual risk assessment exercise, conducted in October 2020, was to evaluate existing risks and action plans specifically in view of the COVID-19 situation.

During the exercise, the following aspects of all the risks presented in AWP 2020 were assessed (in view of COVID-19):

1. Relevance of the risk -> is the risk still present? Has it materialised?

2. Rating the risk -> did the rating (in terms of impact/likelihood) increase or decrease?

3. Relevance and fulfilment of the action plan -> should we continue/expand/reduce action plans?

In addition to the regular risk-assessment exercise, **a special brainstorming session chaired by the ED, in which all members of staff participated, was conducted to identify any new COVID-19 emerging risks.**

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

The table below summarises the outcome of the exercise on risks and fulfilment of the action plans, as of 31 December 2020:

TABLE 4: FULFILMENT OF THE ACTION PLANS

	RISK IDENTIFIED (AWP 2020)	ACTION PLAN (AWP 2020)	ACTION PLAN – STATUS AT 31 DECEMBER 2020
MEDIUM	Due to Brexit, the participation of UK entities in the programme (representing a significant part of FCH 2 JU funding) during project execution can be adversely affected, including fluctuations in project budgets and commitments from UK-based companies.	Follow up developments closely; maintain active dialogue with the EC. Contingency plans are in place for continuation of the projects, even if no agreement is reached on Brexit.	Risk was contained, no issues identified during Call 2020. In addition, we did not detect any cases of underperforming in project execution related to Brexit. Brexit agreements were reached. The risk for the H2020 programme has been removed.

MEDIUM	Representative error rate may increase due to the simplified *ex-ante* controls under H2020 agreed horizontally for the research family. Consequently, there is a risk of obtaining a qualified opinion and of not getting the discharge from the European Parliament due to the fact that the Court of Auditors' threshold for representative error rate stays at the level of 2 %.	Annual analytical risk assessment at the beneficiary level and subsequent introduction of the targeted *ex-ante* controls for the projects / beneficiaries with higher identified inherent risk. Application of the feedback from *ex-post* audits and lessons learnt from *ex-ante* controls, e.g. by accompanying auditors on the missions for FCH audits. Continuation of interactive financial webinars for complex projects or where there are numerous newcomers in the consortia in the first 12 months of the project.	In 2020, the following actions were successfully performed: Annual analytical risk assessment at the beneficiary level and subsequent introduction of the targeted *ex-ante* controls for the projects / beneficiaries with higher identified inherent risk. Application of the feedback from *ex-post* audits and lessons learnt from *ex-ante* controls, e.g. from accompanying auditors on the missions for FCH audits. Continuation of interactive financial webinars for complex projects or where there are numerous newcomers in the consortia in the first 12 months of the project. Additional review of potential financial risks within the FCH 2 JU's top beneficiaries, followed up by bilateral telcos.
MEDIUM	Transition to the new EU Data Protection Regulation (EUDPR). If roles, responsibilities and processes involved in staff working with personal data are unclear, are not defined or do not match the new EUDPR, this may lead to personal data not being properly managed and to litigation and sanctions.	Ensure that responsibilities and processes involved in staff working with personal data are clear and fully in accordance with the processes under the new EUDPR (for example, privacy by design and privacy by default). Continuous dialogue with the Common Implementation Centre (CIC) with whom the FCH has 'joint ownership' of part of the processed personal data. The implementation steps in the Data Protection Action Plan for transition to EUDPR for 2019 included the setting up of several extra internal processes and tools which would bring additional safeguards at the date they come into production. Further staff training/awareness sessions. Newly developed tools and applications, including third-party services are to be reviewed for compliance with the EUDPR already at their design stage.	In 2020, the following actions were successfully performed: HR & IT areas -> A DPIA was performed with regard to the future use of Microsoft Office 365 services. As regards Microsoft Office Teams, a pilot was launched internally for use in parallel with the DPIA. Migration to new IT tools -> an assessment from the data protection point of view must be conducted before the deployment of any new tool; this assessment will be included in the 'threshold assessment' model already used by the FCH 2 JU. Training on greater awareness among team members on data protection requirements, took place in 2020. Privacy statements on the website were updated in 2019 and 2020. The register of records was updated in accordance with the requirements of the EUDPR. The register per se was migrated to a fully digital solution; in addition, it was made available to the public on the FCH 2 JU website ('GDPR register').
MEDIUM	The general increase in the FCH digital footprint (e.g. progressive transfer and management of information in the Cloud, and use of online tools), coupled with an increase in 'cyber-attacks' worldwide, are raising the possibility of cyber-attacks used to gain access to FCH 2 JU restricted/sensitive information.	Mitigating actions include raising awareness among staff and mechanisms to prevent attacks, including: - better *ex-ante* and *ex-post* security system controls for automated attacks - further business continuity plan (BCP) training and tests.	In 2020, we raised the level of general awareness, and in particular: - there was high resilience from staff members concerning targeted phishing attacks. On each occasion, these were well identified and corrective action was taken; - the level of security and protection on the infrastructure was improved with the adoption of Microsoft Defender for Endpoint, following the advice of the CERT-EU; - staff and/or the management was informed on an ad-hoc basis about issues occurring in other agencies and relayed by CERT-EU to highlight potential risk(s)[42]; - the CERT-EU monitoring in place on the JU's common infrastructure helped to identify unnecessary traffic that could be targeted for intrusion[43]

42 CERT-EU daily reporting extracts: iPhone critical updates, WhatsApp data leak, (Report for 2020 Q4 – Direct threats to EU institutions, bodies and agencies, EU-I compromised by a threat actor looking for COVID-19 information, EUIBA targeted for the second time by the same threat actor, EU-I compromised, stolen information put up for sale, etc.).

43 CERT-EU revealed a 'DNS query to malicious URLs' in October which was stopped. It was a false positive due to the recent use of Europa Analytics but the traffic was well monitored and actions taken in due time to identify and tackle the potential risk identified.

The outcomes of the 2020 risk assessment workshop on new or continuing risks for 2021 are included in the AWP 2021.

In 2020, in addition to a regular risk assessment exercise and COVID-19 risk-assessment exercise, **FCH 2 JU participated in the 'Risk assessment peer review exercise 2020'** which brought together **all decentralised agencies to discuss the critical risks** identified by each one individually. Agencies working in the same area or facing similar types of risks were encouraged to share their risk assessments to enable **an exchange of best practices on methodology**, helping to promote coherence in the identification and assessment of risks and in developing responses to them.

FCH 2 JU participated in this peer review exercise for the second year in the **Support business and innovation cluster**, together with the following entities: BBI JU, BEREC Office, CPVO, ECSEL JU, EIT, EMSA, ENISA, F4E JU, EuroHPC JU.

As the overarching themes were quite similar to those identified in the previous exercise, with the obvious appearance of **COVID-19-related risks as a new topic**, all the risks and mitigating measures were assessed from the COVID-19 angle. This helped the FCH 2 JU to become fully informed of the shared concerns and to improve the preparations and outcomes for its own COVID-19 risk-assessment exercise.

1.2 RESEARCH AND INNOVATION ACTIVITIES

1.2.1 SCIENTIFIC AND TECHNOLOGICAL ACHIEVEMENTS

The main objective of FCH 2 JU is to develop a portfolio of clean, efficient and affordable solutions for European energy and transport systems. Thanks to the partnership between leading research organisations and industrial companies, FCH 2 JU activities cover all stages of product development from low technology readiness level (TRL) research to large demonstration projects.

Section 1.2.1 presents the main achievements in 2020 for all activities, as identified by the Programme Office with the collaboration of the EC's Joint Research Centre during the annual review of the programme. To facilitate the reader, these are split into the main pillars of transport and stationary applications, hydrogen production, hydrogen storage-distribution-purification, and cross-cutting activities. Due to the large number of achievements in transport, these are divided again into demonstration activities per transport mode and per research-oriented activities.

1.2.1.1 DEMONSTRATION ACTIVITIES IN TRANSPORT APPLICATIONS

Light-duty vehicle demonstration

The demonstration of light-duty vehicles and buses is one of the FCH 2 JU's success stories. These activities continued in 2020 and were widened with new demonstration projects focusing on heavy-duty trucks and hydrogen-fuelled maritime vessels. Activities are also starting to take shape for railway and aviation solutions.

The FCH 2 JU is funding the demonstration of 1 860 light-duty vehicles, 963 of which have already been deployed.

From May 2019 to May 2020, car demonstration activities continued successfully with 219 cars and vans deployed in the H2ME[44], H2ME 2[45] and ZEFER[46] projects. H2ME has 285 vehicles in operation and H2ME 2 already has 355 of the 1 200 vehicles planned. ZEFER is deploying a fleet of fuel cell electric vehicles (FCEV) achieving high mileage: it has 57 taxis in Paris plus 50 private hire cars and 10 Metropolitan Police Service vehicles in London.

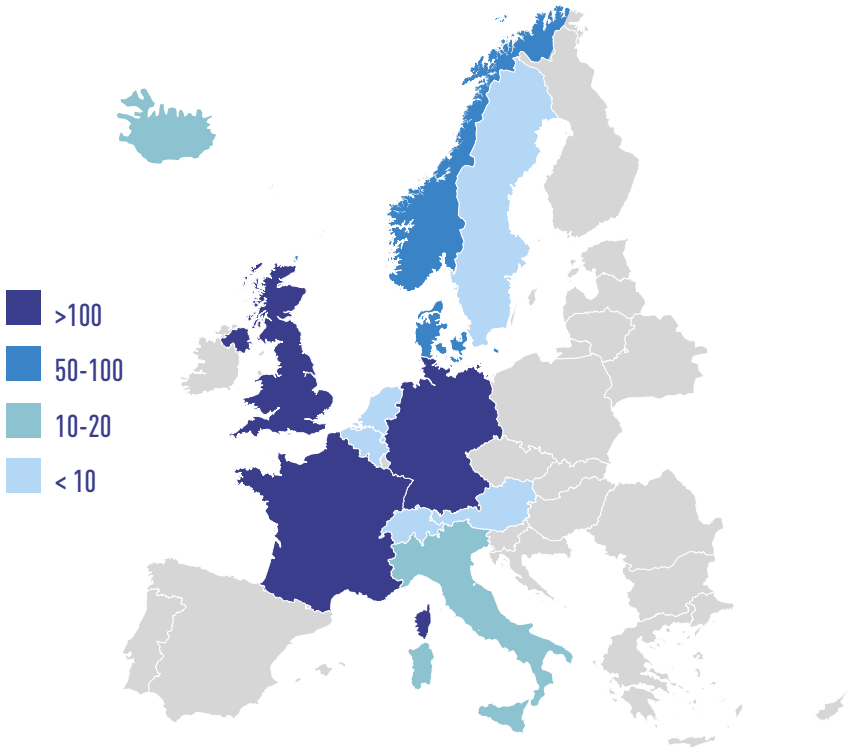
Different FCEV cars and vans are being deployed in eight EU Member States plus UK, Norway, Iceland and Switzerland as shown in Figure 4. The deployed models range from private small cars, such as 'microcabs' specifically designed for city transport, to medium/large cars. New FCEV models are also coming into demonstration, such as the Hyundai Nexo, the Daimler GLC F-Cell and the second generations of the Toyota Mirai and the Renault Kangoo Z.E Hydrogen.

44 https://www.fch.europa.eu/page/transport#H2ME

45 https://www.fch.europa.eu/page/transport#H2ME%202

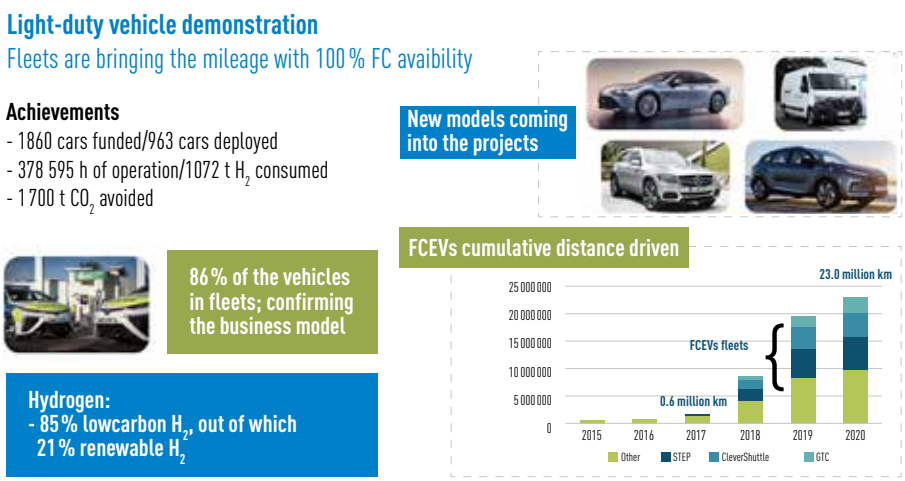
46 https://zefer.eu/

FIGURE 4: DISTRIBUTION OF FCEV DEPLOYED BY FCH 2 JU DEMONSTRATION PROJECTS



Based on data collected in 2020 in Technology Reporting Using Structured Templates (TRUST)[47] on the performance of 597 cars (running in 2019), these vehicles travelled at least 8.9 million kilometres (km) with a reported consumption of 91.5 tonnes of hydrogen. In comparison to the 2018 figures of 5.2 million km travelled and a consumption of 57 tonnes, this significant increase is the result of the new taxi-fleet operations and the more intensive use of deployed cars. In total, FCH 2 JU-funded cars have now travelled a total of almost 23 million km and consumed over 172 tonnes of hydrogen since 2016, avoiding emissions of about 1.7 tonnes of CO_2. The deployed fleets have largely contributed to the significant rise of the cumulative distance travelled by FCEVs, as shown in Figure 5.

FIGURE 5: CUMULATIVE DISTANCE DRIVEN BY FCH 2 JU DEMONSTRATED LIGHT-DUTY VEHICLES



47 https://www.fch.europa.eu/projects/knowledge-management

The average fuel consumption of 1.07 kilogramme (kg) per 100 km is lower than the MAWP 2020 target (1.15 kg per 100 km) and as such this target is considered to have been achieved. The average vehicle availability reached 99.4 % in 2019 which means the expected MAWP 2020 targets for availability (98 %) and FC system durability (5 000 hours) have also been accomplished. The FCEV have been demonstrated as reliable, with driving ranges equal to those of conventional light-duty vehicles.

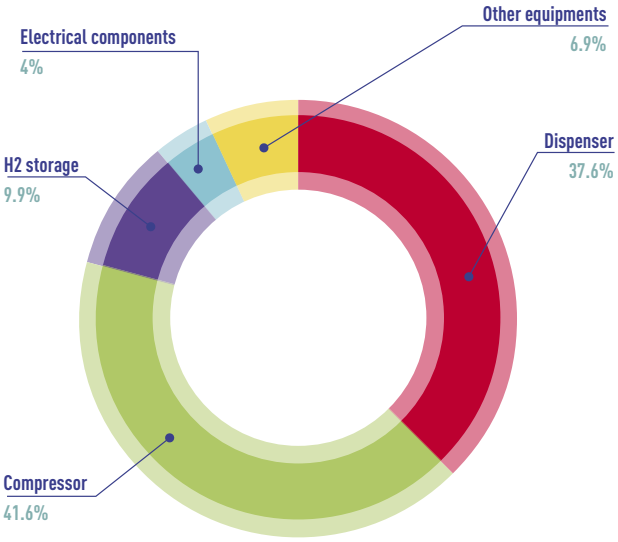
Hydrogen refuelling stations

The geographical coverage of the hydrogen-refuelling infrastructure is expanding into new cities and regions, supporting the growing number of FCEVs being deployed. The EU HRS availability system[48], an initiative funded by the FCH 2 JU, offers a portal providing information regarding the live status of each HRS in Europe. Currently, 144 HRS are connected and send live data. The total number of FCH 2 JU-funded HRS is 101 (including planned, deployed and two decommissioned units), 72 of which (53 for cars, 11 for buses, 8 for material-handling vehicles) have already been deployed (an increase on the 64 reported in 2019).

The deployment of HRS in regions in Germany (thanks to the H2ME project) is enabling the extended coverage by FCH 2 JU demonstration projects. In densely populated areas, such as London or Paris, the concentration of several HRS supports the emergence of, and enables the flexible service of a taxi fleet, or private car-hire systems. This has positively impacted the hydrogen sales, load and availability of the fuelling stations involved.

To date, the FCH 2 JU-funded HRS network for cars covers 8 countries and in 2019 delivered 66.3 tonnes of hydrogen through 30 904 refuelling operations. This represents 40 % of the total volume of hydrogen refuelled since 2016. The average HRS availability in 2019 was 92.6 % which is an improvement on the 90.4 % in 2018. Another main priority for HRS is the improvement of compression technologies and reducing the cost of the compressor which is still roughly half the cost of an HRS. Availability, energy consumption and noise are currently demanding additional R&I efforts. The major causes for station downtime are shown in Figure 6.

FIGURE 6: HRS DOWNTIME CAUSES



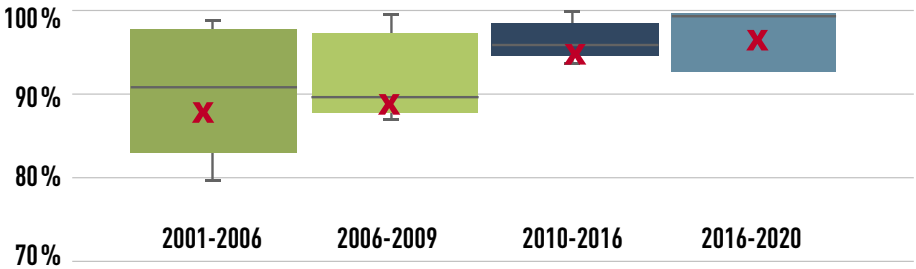
Projects report that 85 % of dispensed hydrogen (based on mass) was certified as low carbon. Of this, renewable hydrogen accounted for 21 %. The average cost of renewable hydrogen is 9.29 €/kg, thereby achieving the related MAWP 2020 target. The average capital expenditure (CAPEX) for hydrogen stations is 7.8 €/kg/day, which remains higher than the expected MAWP 2020 targets for station CAPEX of 4-2.1 €/kg/day.

FCH 2 JU has also funded the installation of 23 **refuelling stations for buses** in 10 European cities. The amount of hydrogen dispensed between 2016 and 2019 was almost 445 tonnes, 19.1 % of which was consumed in 2019 in 4 337 refuelling operations. Of this dispensed amount, 65 % is certified as renewable hydrogen.

48 https://www.fch.europa.eu/page/european-hydrogen-refuelling-station-availability-system

The average availability of HRS for buses was 99.9 % in 2019, surpassing the MAWP 2020 target. Figure 7 shows how the availability of buses HRS has improved across the years. Despite fluctuations in the reported average availability, the best values were close to 100 %, which demonstrates a strong performance for bus refuelling stations.

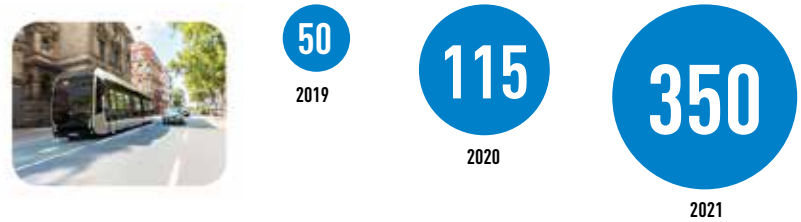
FIGURE 7: AVAILABILITY OF FCH 2 JU-FUNDED HRS FOR BUSES



FCB demonstration

European hydrogen FCB deployment activities can be considered as state-of-art worldwide, having grown considerably between earlier projects and the most recent ones, as shown in Figure 8. In this respect, the targeted bus prices, hydrogen price and maintenance costs are well in line with the MAWP targets.

FIGURE 8: EVOLUTION OF FCB IN OPERATION IN THE EU



In 2019, FCH 2 JU bus demonstration activities concerned the projects High V.LO-City[49], HyTransit[50], 3EMOTION[51], JIVE[52] and JIVE 2[53]. The High V.LO-City project ended in December 2019 and has put 14 FCBs into operation in four demonstration sites. In addition, HyTransit (which finished in March 2019) has deployed six hybrid FCBs in daily fleet service in Aberdeen (Scotland), operating them for four full years on long inter-urban routes. In 2019, 55 buses were deployed by FCH 2 JU in 10 cities, as depicted in Figure 9, while 290 FCBs – mainly from JIVE and JIVE 2 – are planned for deployment in the next few years.

49 https://www.fch.europa.eu/page/transport-and-refuelling-infrastructure#High%20V.LO-City

50 https://www.fch.europa.eu/page/transport-and-refuelling-infrastructure#HyTransit

51 https://www.fch.europa.eu/page/transport-and-refuelling-infrastructure#3EMOTION

52 https://www.fch.europa.eu/page/transport#JIVE

53 https://www.fch.europa.eu/page/transport#JIVE%202

FIGURE 9: DISTRIBUTION OF BUSES DEPLOYED BY THE FCH 2 JU DEMONSTRATION PROJECTS

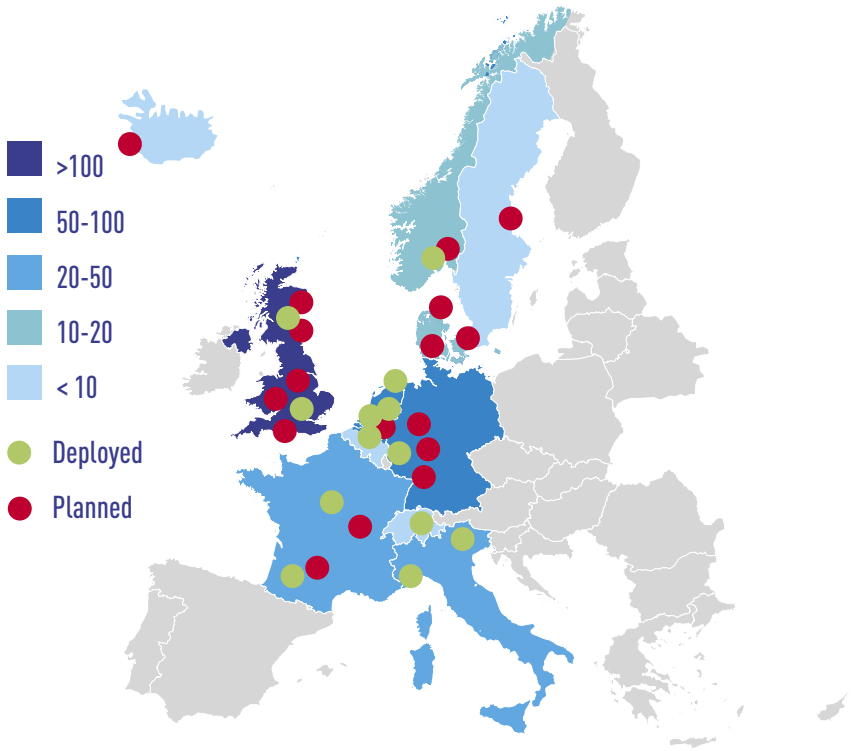
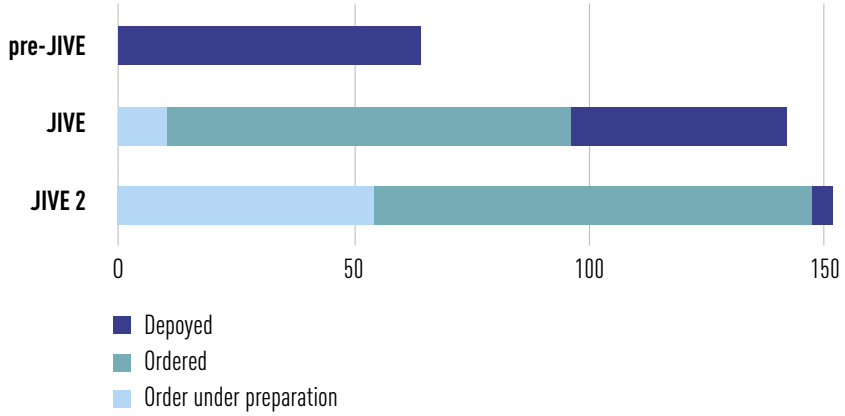
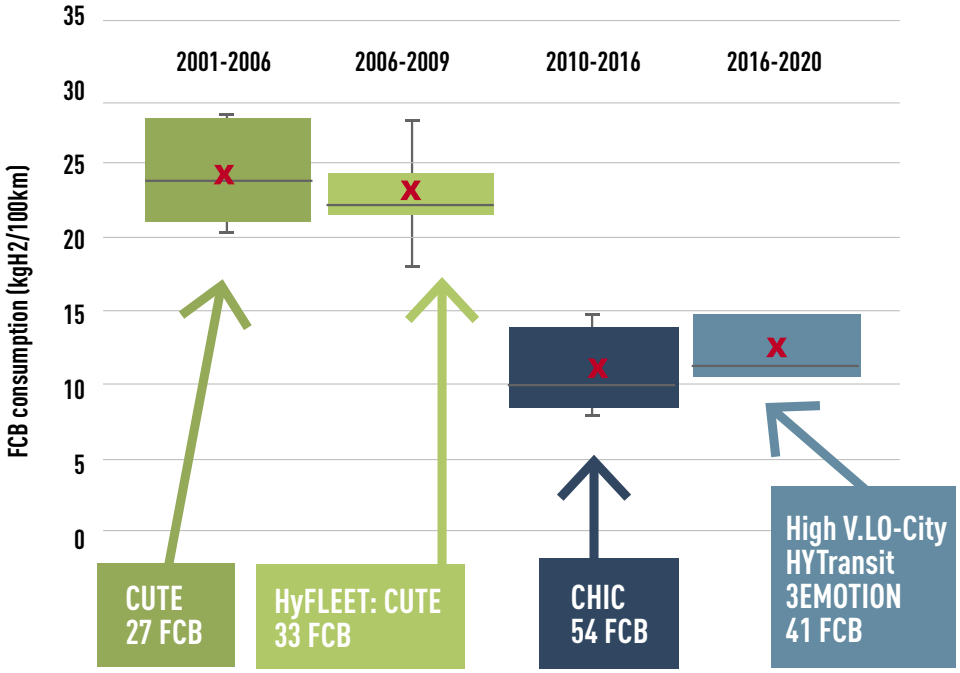


FIGURE 10: FCH 2 JU BUS DEPLOYMENT STATUS



As regards the bus demonstration projects which were reported in TRUST between 2016 and 2019, a total distance of over 7.9 million km was accumulated, with almost 1 million km travelled in 2019 alone. In the last three years, over 508 tonnes of hydrogen have been consumed by buses, 17 % of which occurred in 2019. FCB fuel consumption has improved in the last years, as shown in Figure 11. In 2019, the average fuel consumption was 11 kg hydrogen per 100 km while the minimum fuel consumption was reported at 8 kg H2/100 km, reaching the 2020 MAWP target (the values range from 8 to 10.2 kgH2/100 km).

FIGURE 11: EVOLUTION OF FCB HYDROGEN CONSUMPTION



Current bus demonstrations have provided positive evidence on the performance and functionality of hydrogen FCBs and associated refuelling infrastructure, progressively reducing barriers for their commercialisation. The 2020 MAWP targets for the costs of the FC system and vehicles (based on procurement prices) that were already achieved in 2018, were also confirmed in 2019. The 2020 MAWP targets for FC system durability (20 000 h) as well as those for yearly operating costs (16 000 €/kW) have yet to be fully achieved. In 2019, the average FCB availability was 78.2 %, although there is a significant spread in the reported values with the maximum availability being 98.8 %. This may reflect the impact of ageing fleets and the long period required to receive replacement parts from international suppliers.

As regards the beneficiaries involved, Figure 12[54] shows the connections between partners under this cluster of projects (as extracted from the Tools for Innovation Monitoring – TIM)[55]. The figure displays several groups of consortia with particular players providing links between these groups. The 'orange' cluster largely includes the fleets related to H2ME[56] and ZEFER[57], whilst the 'green' grouping includes the partners within the bus projects (e.g. High V.LO-City[58], HyTransit[59]). The 'purple' grouping includes the partners within the JIVE and JIVE 2[60] consortia. The key players providing links between these groups are Element Energy, which generally acts as a project coordinator, FC system suppliers such as Ballard, and HRS providers, such as Air Liquide.

54 The size of the node (circle) represents the number of projects a partner is involved in, whilst the thickness of the lines linking the nodes represents the number of projects two partners have in common. TIM indicates clusters of partners by colour, using its own algorithm. For clarity, only the partners involved in the largest numbers of projects are shown.

55 https://www.fch.europa.eu/page/tools-innovation-monitoring-tim

56 https://h2me.eu/

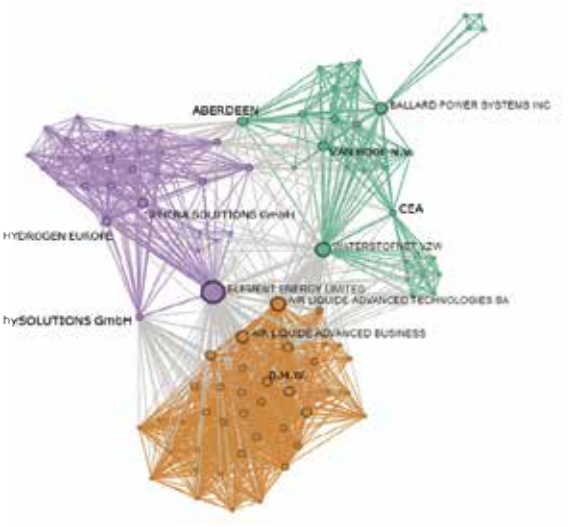
57 https://zefer.eu/

58 http://highvlocity.eu/

59 https://www.fuelcellbuses.eu/projects/hytransit

60 https://www.fuelcellbuses.eu/projects/jive

FIGURE 12: PARTICIPATION IN DEMONSTRATIONS OF HYDROGEN TECHNOLOGIES IN TRANSPORT, INCLUDING TOP FIVE PARTICIPANTS



PARTICIPANTS	NUMBER OF PROJECTS
Element Energy	8
Air Liquide Adv. Technologies	5
Waterstofnet	5
Air Liquide Adv. Business	4
Ballard	4

Heavy-duty trucks demonstration

FCH 2 JU demonstration activities on heavy-duty trucks started in 2018 with REVIVE[61] and expanded in 2019 with the H2HAUL[62] project.

The REVIVE project will demonstrate 15 heavy-duty refuse trucks at 8 sites across Europe. Eleven trucks have already been ordered and were still under construction in 2019. The REVIVE project may set the basis and state-of-the-art reference for future heavy-duty vehicle demonstration projects. Its activities also include life-cycle assessment (LCA) accounting for the project impact on reduction of CO_2 emissions, air pollution and noise.

The project 'Hydrogen fuel cell trucks for heavy-duty, zero emission logistics – H2HAUL' will lead to the deployment of 16 trucks in 4 countries, which will be operated for at least two years in day-to-day service. H2HAUL aims to significantly enhance the technical maturity of the heavy-duty trucks being developed by two major European original equipment manufacturers (OEMs) (IVECO FTP and VDL ETS). The design of three new types of FC trucks (including rigid and articulated vehicles up to 44 tonnes) is ongoing and specifications are being prepared as per specific customer requirements and mission profiles. In addition, three new HRS for refuelling trucks will be deployed in Belgium, France and Switzerland.

In addition to the above-mentioned demonstration activities, the FCH 2 JU has recently funded a study on European business cases for FCH trucks. The independent Study on Fuel Cells Hydrogen Trucks[63], commissioned by the FCH 2 JU, was released on 15 December 2020. It provides an in-depth analysis of the market potential of heavy-duty FCs underpinned with concrete case studies. By carefully assessing the total cost of ownership (TCO) elements and comparing the FCH option with diesel and other decarbonisation options (such as battery electric vehicle (BEV) and Catenary), the study has revealed that FC technology has a significant cost-down potential at scale. The TCO analysis indicates a clear trend towards cost competitiveness of FCH heavy-duty trucks by 2030, making the FCH option even cheaper than diesel in several use cases.

The study also revealed that, by 2030, there could be as many as 110 000 FCH trucks on European roads avoiding up to 11 million tonnes of CO_2. Furthermore, to gain a concrete perspective and apply the data-driven TCO analysis to case-specific scenarios, an analysis of nine different case studies was conducted. These explored potential opportunities for FCH technology and assessed the economic and technological feasibility of specific routes, operations and business cases. This analysis confirmed that FCH trucks are especially well suited to routes with a high daily range and, when compared to other zero-emission alternatives, FCH trucks offer superior performance in terms of range, refuelling time and payload capacity.

61 https://www.fch.europa.eu/page/transport#REVIVE

62 https://www.fch.europa.eu/page/transport#H2Haul

63 https://www.fch.europa.eu/publications/study-fuel-cells-hydrogen-trucks

FC applications in rail transportation

FCH technology is a promising option for replacing diesel combustion engines in rail transportation (see Figure 10). In 2019, the Shift2Rail Joint Undertaking and Fuel Cells and Hydrogen Joint Undertaking published the study 'Use of fuel cells and hydrogen in the railway environment'[64] to assess the state of the art and market potential of FCH in a railway environment. The key information identified in the study includes:

- FCH trains are cost competitive when designed for non-electrified lines over 100 km in length;
- FCH trains are especially viable for main routes with low utilisation (<10 trains per day);
- FCH trains are characterised by relatively fast refuelling (<20 minutes) and an operational time of 18 hours without refuelling;
- High hydrogen infrastructure and electricity costing less than 50 €/MWh provide favourable conditions for FCH technology.

FIGURE 13: HYDROGEN POTENTIAL FOR USE IN TRAINS

At specific circunstances H_2 is already competitive or the most economic zero emission solution

Challenges

- Rail vehicle design & powertrain system
  - Standard scalable design
  - FC bi-mode design and operation
- H_2 storage
- FC operational hours
- HRS
  - Design for fast fuelling
  - Density of the network
- Homologation

Call 2020: train project under negotiation

- By-mode multiple unit
- Homologation in three countries

Hydrogen-powered aviation

A new independent study, commissioned by Clean Sky 2 and FCH 2 JU on hydrogen's potential for use in aviation[65], was presented at an online event on 22 June 2020. The study found that hydrogen – as a primary energy source for propulsion, either for fuel cells, direct burn 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. Costing less than EUR 18 extra per person on a short-range flight, and reducing climate impact by 50 to 90 %, hydrogen could play a central role in the future mix of aircraft and propulsion technologies (see Figure 14).

In anticipation of these results, FCH 2 JU has already started activities on aviation. The HEAVEN[66] project focuses on demonstrating the airworthiness and economic viability of an FC/liquid-H_2-powered passenger aircraft and gathers reliability data for future certification. It has produced the conceptual design of the overall powertrain and safe liquid-H_2 storage. Meeting the main aircraft requirements is particularly difficult as no aviation regulation yet exists for liquid-H_2. The emergency power unit demonstrator is still under design and will have to be manufactured and assembled before functional and environmental tests start. Project FLHYSAFE[67] seeks to demonstrate a cost-efficient modular FC system for replacing most critical safety systems and for an emergency power unit to be used on-board a commercial airplane, providing enhanced safety functionalities. The system architecture has already been defined as a result of safety and functional analyses.

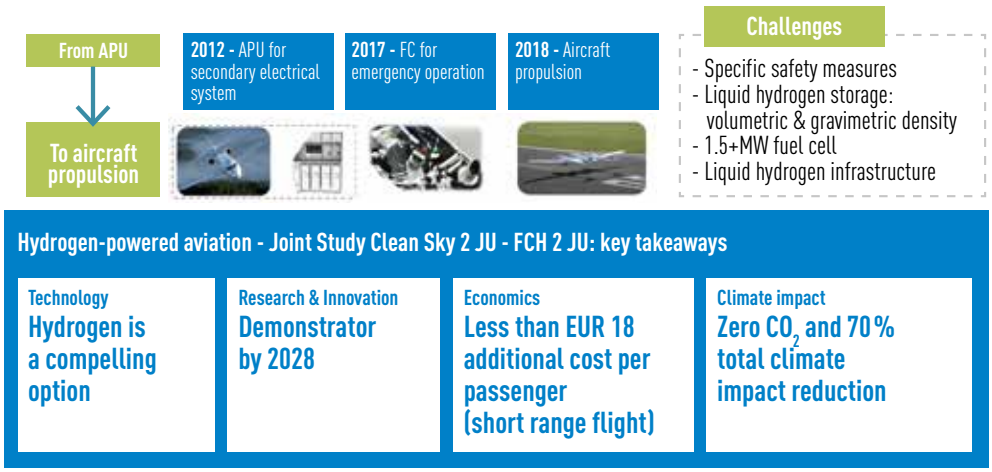
64 https://www.fch.europa.eu/publications/use-fuel-cells-and-hydrogen-railway-environment

65 https://www.fch.europa.eu/news/new-study-hydrogen-powered-aviation-preparing-take#:~:text=The%20study%20found%20that%20hydrogen,2035%20for%20short%2Drange%20aircraft

66 https://www.fch.europa.eu/page/transport#HEAVEN

67 https://www.fch.europa.eu/page/transport#FLHYSAFE

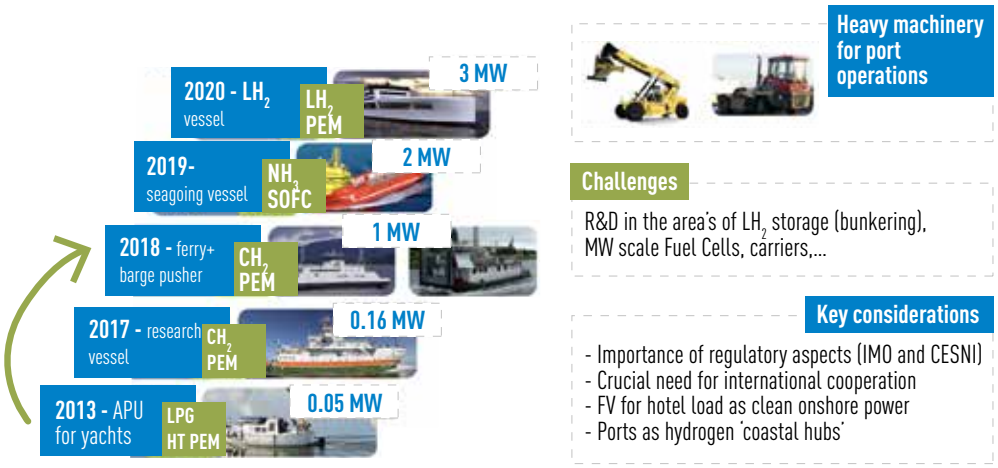
FIGURE 14: HYDROGEN POTENTIAL FOR USE IN AVIATION, TAKING STEPS TO ZERO-EMISSION AVIATION



Maritime applications

Today, hydrogen in the maritime sector is a topic of great interest due to expected changes in emissions regulation in the near term. The MARANDA[68] project is developing emission-free, hydrogen-fuelled proton exchange membrane (PEM)FC-based hybrid powertrain systems (3 x 82.5 kW AC) for marine applications. MARANDA achieved a significant improvement in stack durability and claimed an alternating current (AC) electric efficiency of 45 %. The project is in the system-integration phase and the validation phase is being prepared. MARANDA cooperates with the FLAGSHIPS[69] project on RCS and dissemination aspects.

FIGURE 15: MARITIME PROJECTS, EVOLUTION OF TECHNOLOGIES AND MAIN CHALLENGES



68 https://www.fch.europa.eu/page/transport#MARANDA

69 https://www.fch.europa.eu/page/transport#FLAGSHIPS

1.2.1.2 RESEARCH-ORIENTED ACTIVITIES FOR TRANSPORT APPLICATIONS

Development of non-noble metal catalysts

Research activities are focused on advancing EU know-how concerning novel materials, processes, architectures and optimised interfaces. In particular, projects have been focusing on the development of non-PGM, low-cost catalysts (PEGASUS[70], CRESCENDO[71]).

PEGASUS intends to come up with an experimental proof of concept for novel catalyst materials and structures by exploring promising routes to removing platinum (Pt) and other critical raw materials from the PEMFC cathode catalyst, while enabling efficient and stable oxygen reduction reaction electrocatalysis at a reduced loading of 2 mg/cm^2 (compared to the state of the art 5 mg/cm^2). CRESCENDO is researching a platinum group metals (PGM)-free PEMFC cathode and non-PGM, or ultra-low PGM hydrogen oxidation reaction (HOR) catalysts. The project is close to achieving the current density target of 75 mA/cm^2 against the 2016 state of the art of 60 mA/cm^2. An area-specific power density of 1.3 W/cm^2 has already been achieved compared to a target of 2 W/cm^2.

Innovative manufacturing

As shown in Figure 16, considerable progress has been achieved by projects involved in the manufacturing of stacks for automotive applications. Several have been focusing on delivering mature stack components and production lines able to meet automotive performance specifications in large volume production along with innovative quality and control techniques.

The 2020 review covered DOLPHIN, DigiMan[72], Fit-4-AMandA[73], INLINE[74], INN-BALANCE[75], INSPIRE[76] and GAIA[77]. The DOLPHIN project is planning the design and validation of an automotive stack of 5 kW, representative of a 100-kW power stack, able to reach both outstanding power density and enhanced durability under automotive conditions. An area-specific power density of 1.3 W/cm^2 has already been achieved compared to a target of 2 W/cm^2. DigiMan aims to demonstrate an automated production process capability within an automotive best practice. Among its outputs are proof-of-process demonstrator equipment and a blueprint design enabling an optimised manufacturing process for PEMFC. Fit-4-AMandA aims to modify the current design of PEMFC stacks and stack components and build an entirely new equipment facilitating automation of the stack assembly process, including inline non-destructive tests. INSPIRE developed and integrated advanced membrane electrode assembly (MEA) components into several iterations of automotive FC stacks. In 2019, it met all of its technical targets, including areal and volumetric power densities of 1.5 W/cm^2 and 4.8 kW/l respectively, and predicted durability in excess of 6 000 h with less than 10 % power degradation. The project was also within 10 % of its cost target (below 50 €/ kW for an annual production rate of 50 000 units). GAIA is developing high-power and high-current-density next-generation automotive MEAs.

70 https://www.fch.europa.eu/page/transport#PEGASUS

71 https://www.fch.europa.eu/page/transport#CRESCENDO

72 https://www.fch.europa.eu/page/transport#DIGIMAN

73 https://www.fch.europa.eu/page/transport#Fit-4-AMandA

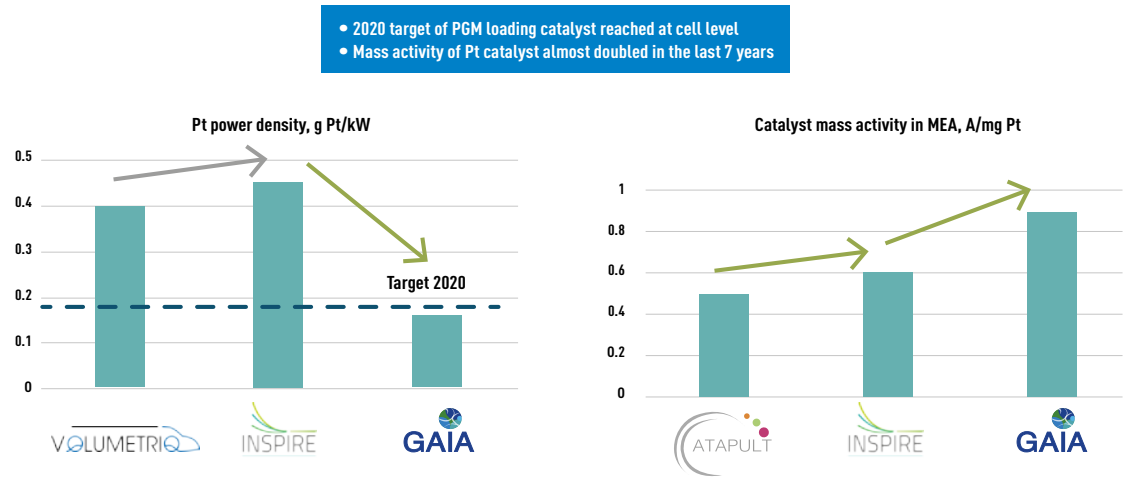
74 https://www.fch.europa.eu/page/transport#INLINE

75 https://www.fch.europa.eu/page/transport#INN-BALANCE

76 https://www.fch.europa.eu/page/transport#INSPIRE

77 https://www.fch.europa.eu/page/transport#GAIA

FIGURE 16: EVOLUTION OF RESULTS FOR CRITICAL RAW MATERIAL REDUCTION AND CELL PERFORMANCE



New developments in compression and storage technologies

The main priority for HRS is the improvement of compression technologies and a reduction in the cost of the compressor which still represents roughly half of the cost of an HRS. Availability, energy consumption and noise also require additional R&I efforts.

The 2020 portfolio for **research activities on refuelling (compression)** includes the projects COSMHYC[78] and COSMHYC XL[79] which are developing a hybrid compression solution by combining an innovative metal-hydride compressor with a mechanical compressor (1-1 000 bar). This new design allows for a reduction in CAPEX and OPEX, less noise, increased availability and therefore increases hydrogen delivery efficiency in HRS (COSMHYC) and extra-large HRS. In addition, the H2REF[80] project is demonstrating the use of a bladder accumulator technology applied to existing 700 bars refuelling solutions. A full-scale prototype system was built and a test cycle successfully operated at Haskel's new hydrogen test area located in Sunderland (UK).

The TAHYA[81] project aimed to develop an efficient **on-board storage hydrogen tank** according to OEM specifications, and contributed to GTR13[82] by revising the text of the R134 certification standard. This project achieved significant cost reductions and greater gravimetric efficiency reaching 508 €/kg and 6.5%, respectively. The Optimum CPV company (a subsidiary of Plastic Omnium) is setting up a manufacturing site to produce tanks for mobility application, using the results in tank design obtained by the TAHYA project; Anleg GmbH will commercialise a new on-tank-valve and gas-handling unit.

1.2.1.3 STATIONARY APPLICATIONS FOR HEAT AND ELECTRICITY PRODUCTION

The FCH 2 JU supports projects for all ranges of stationary power applications, from residential micro-scale combined heat and power (mCHP) for domestic and small commercial buildings (0.3-5 kW), through mid-sized installations for commercial and larger buildings (5-400 kW), to large-scale FC installation demonstrations (0.4-30 MW). FCs are showing great potential for the provision of heat and power in domestic and small commercial buildings. They have the advantages of high electrical and total efficiencies and are able to run on conventional heating fuels.

Combined heat and power for residential applications, μ-CHP

The PACE[83] project aims to facilitate large-scale deployment across Europe of FC-based μ-CHP. As shown in Figure 17, the number of systems sold via the project had reached 1 877 by April 2020, and 1 365 of a planned total of 2 800 systems have been installed.

78 https://www.fch.europa.eu/page/transport#COSMHYC

79 https://www.fch.europa.eu/page/transport#COSMHYC%20XL

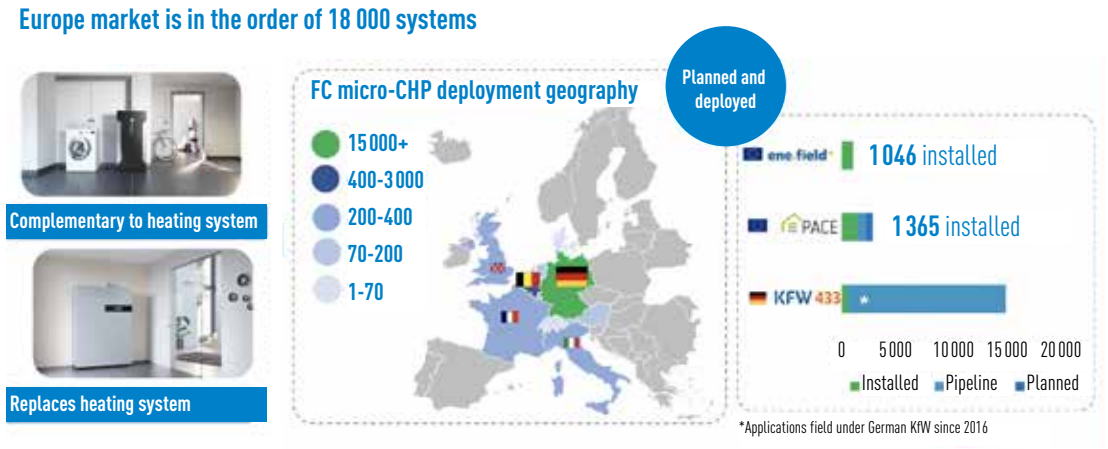
80 https://www.fch.europa.eu/page/transport#H2REF

81 https://www.fch.europa.eu/page/transport#TAHYA

82 https://globalautoregs.com/groups/110-gtr13

83 http://www.pace-energy.eu

FIGURE 17: DEPLOYED AND PLANNED FC MICRO-CHP INSTALLATIONS ACROSS THE EU



CHP for mid-size applications

FCH 2 JU is funding several demonstrations of **mid-size FC applications**. The DEMOSOFC[84] project is installing a 175-kWe demonstration system in a wastewater treatment plant, which is expected to supply approximately 30 % of the site's electricity consumption and almost 100 % of the thermal energy. To date, two of the three modules have been installed, totalling more than 13 600 hours of operation. Electrical efficiency (LHV) has reached 56 % and a thermal efficiency of 30-35 % (LHV) has also been achieved. For comparison, the MAWP 2020 targets are 41-60 % (LHV) electrical efficiency and 24-42 % (LHV) thermal efficiency. Furthermore, the emissions of nitrogen oxides (NOx), sulphur oxides (SOx), volatile organic compounds (VOC) and particulate matter (PM) have been below detection limits.

The ComSos[85] project aims to validate and demonstrate mid-sized solid oxide FC (SOFC)-based CHP systems in the power ranges of 10-12 kW, 20-25 kW, and 50-60 kW (mini FC-CHP) in industrial or utility service environments. Three SOFC system manufacturers (SOLIDPower, Sunfire and Convion Oy) are participating in this project. Early ComSos systems have achieved an electrical efficiency of >50 % LHV and NOx emissions of <40 mg/kWh. The first module, provided by Sunfire, has already been installed.

The CH2P[86] project is aiming to build a transition technology for HRS. The new system co-generates hydrogen, heat and electricity using SOFC technology supplied with natural gas or bio-methane. The goal of the CH2P system is to operate with higher efficiency, lower costs and reduced environmental footprint compared to conventional technologies. The project's main achievement concerns the successful testing of the 25 kW large stack module. The estimated cost of production is approximately 4 €/kg H2. The project has encountered significant technical issues with 'hot' system components which are crucial to system efficiency and reliability.

CHP for large-scale applications

Demonstrations of **large-scale FC systems**, such as the CLEARgenDemo[87] project, aimed to validate the technical and economic readiness of a 1 MWe PEMFC system operating on by-product hydrogen in a refinery. The FC system was installed on the island of Martinique in December 2019. The system achieved its electrical efficiency target (50 %) during factory acceptance tests and reached the MAWP 2020 CAPEX target (3 000 €/ kW) for large-scale systems. Furthermore, knowledge from this project will be taken up for a power-to-power national project in French Guiana.

Demonstration projects focusing on **off-grid applications** offer FC solutions both in remote places as well as in temporarily-powered event areas. The REMOTE[88] project aims to demonstrate the technical and economic feasibility of two FC-based hydrogen energy-storage solutions deployed in four demonstration sites, based on renewables (solar, wind, biomass, hydro) in isolated micro-grids or off-grid remote areas. To

84 http://www.demosofc.eu/

85 https://www.comsos.eu/

86 https://www.fch.europa.eu/page/energy#CH2P

87 https://www.cleargen.eu/

88 https://www.fch.europa.eu/page/energy#REMOTE

date, two demonstrations have been built and their installation is almost complete in Norway and Greece. Analysis of the technical, economic and regulatory framework was also performed. Design, engineering, planning for operation and maintenance and permitting procedures were assessed for all the demonstrations.

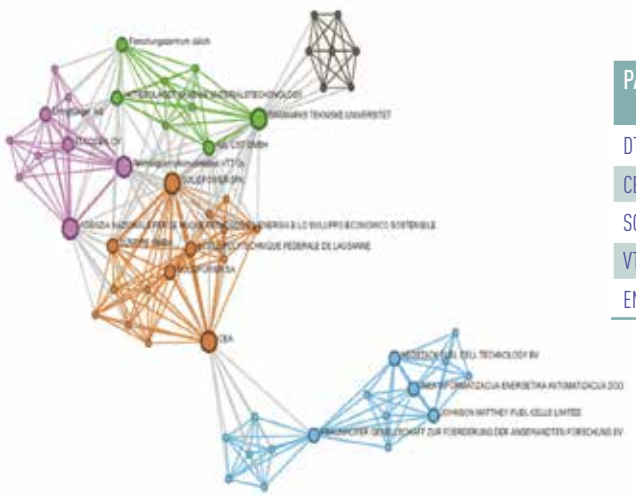
The EVERYWH2ERE[89] project aims to develop and demonstrate FC technology replacing diesel-fuelled temporary gensets as a zero-emission, zero-noise and cost-effective solution to be deployed across the EU. Eight FC-based power gensets (4 x 25 kW; 4 x 100 kW) fuelled by compressed hydrogen will be developed. The first two gensets have been finalised and a preliminary LCA completed together with a preliminary market assessment and logistic analysis.

The RoRePower[90] project aims to demonstrate SOFC systems for off-grid power generation in remote regions with harsh climatic conditions as well as the continuous power supplies of telecommunication towers, especially in emerging countries. One of the project's major achievements to date is the installation of the first RoRePower unit used in telecom application in Alaska. The Sunfire-Remote 400 prototype has run for 7 700 hours with a degradation of 0.63 %/1 000h over 85 cycles.

The ALKAMMONIA[91] project, which has finished, aimed to provide power in remote applications, using innovative and proven technologies: a highly efficient and low-cost alkaline FC system fed with hydrogen coming from an ammonia cracker system. The work on the fuel cell, balance of plants (BoP) and ammonia cracker were successful in achieving a number of the expected impacts. However, the critical failure of the cracker coil walls prevented the expected testing within the project's lifetime.

Figure 18 shows the connections between partners in those projects involved in **R&D for an FC system in stationary applications**. Although there are only a small number of projects covered (nine), there are clearly some strong connections between partners in different projects. Italy and Germany are the strongest contributors in this panel.

FIGURE 18: PARTICIPATION IN DEMONSTRATIONS OF HYDROGEN TECHNOLOGIES IN STATIONARY APPLICATIONS, INCLUDING THE TOP FIVE PARTICIPANTS



PARTICIPANTS	NUMBER OF PROJECTS
DTU	3
CEA	3
SOLIDPower	3
VTT	3
ENEA	3

Manufacturing processes and balance of plants designs for stationary applications

All the projects part of the 2020 portfolio developing innovative **manufacturing processes** and **BoP** designs for stationary applications have been concluded. Cell3Ditor[92] developed a 3D printing technique for the fabrication of SOFCs. This innovative manufacturing technology was developed in full and significantly reduced manufacturing costs, energy costs and environmental impacts. The intellectual property produced by the project has been protected by several patents and the commercial potential of the new manufacturing method has been assessed and deemed very promising.

89 https://www.fch.europa.eu/page/energy#EVERYWH2ERE

90 https://rorepower.com/

91 https://www.fch.europa.eu/page/stationary-power-production-and-combined-heat-and-power#ALKAMMONIA

92 http://www.cell3ditor.eu/

The qSOFC[93] project has also significantly driven down the manufacturing cost of SOFCs. The consortium has modified the manufacturing process to allow for the high-speed capacity necessary to achieve large manufacturing volumes. A new automated machine vision inspection system was used to improve quality assurance processes, and time-saving stack-conditioning procedures were developed.

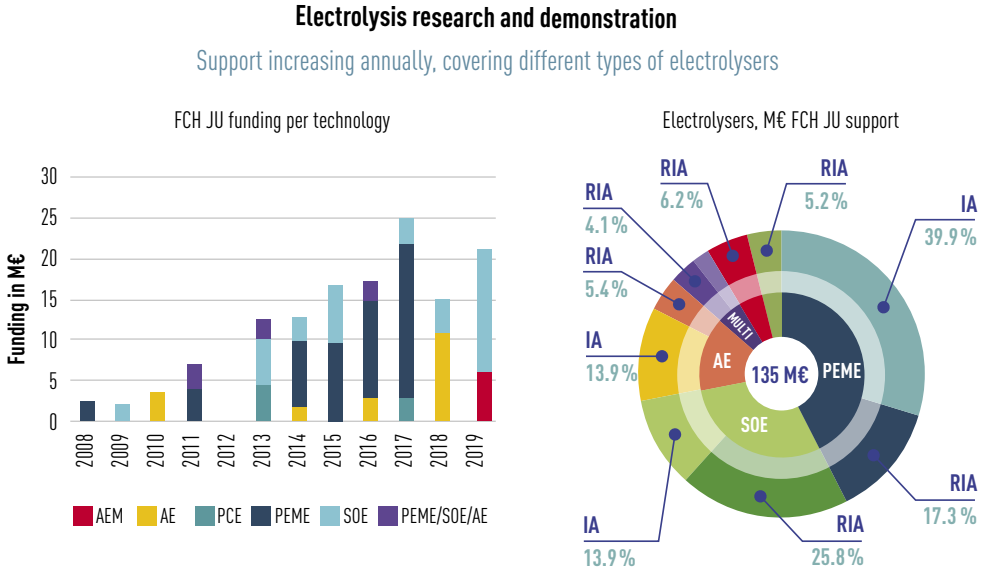
INNO-SOFC[94] has developed an innovative 50 kW SOFC system and developed a vision for a full value chain: from interconnects and stacks to end-users and application analysis. An INNO-SOFC system has been incorporated inside the Lempäälä (FI) smart grid. The results obtained from the qSOFC and INNO-SOFC projects have enabled the Elcogen company to receive a European Investment Bank quasi-equity to expand the current manufacturing and research capacity. A new factory with a capacity target of 50 MW/year will be located in Tallinn (EE).

MAMA-MEA[95] developed an innovative additive-layer deposition process using a single, continuous roll-to-roll manufacturing process for the PEMFC industry. The potential increase in the manufacturing rate volume is estimated to be over 10 times that of conventional state-of-the-art processes. The benefits also include reduced material use (including critical raw materials), waste and costs.

1.2.1.4 HYDROGEN PRODUCTION BY ELECTROLYSIS: INDUSTRY – ON-GRID AND OFF-GRID SERVICES

Since its creation in 2008, FCH JU has supported 68 projects related to renewable hydrogen production, storage and distribution with a budget of EUR 204 million which represents 18 % of FCH 2 JU overall support/funding. Two thirds of this budget (EUR 135 million) are allocated to electrolyser development and demonstrations. In particular, solid oxide electrolysis (SOE) technology has received more support in recent years (see Figure 19).

FIGURE 19: FUNDING FOR ELECTROLYSIS PROJECTS SINCE 2008 UNDER FCH JU AND FCH 2 JU



RTA: Research and Innovation Actions (RTD)
IA: Innovation Actions (Demo)

Figure 20 provides an overview of some of the most relevant electrolyser demonstration projects. In 2011, FCH JU activities began with the Don Quichote[96] project (PEM technology electrolyser) with a capacity of 150 kW. Eight years later, the REFHYNE[97] project will install a 10-MW PEM electrolyser, which is an increase of almost two orders of magnitude, while the Djewels[98] project will install an alkaline electrolyser with a capacity of 20 MW. Over the same period, FCH 2 JU support per MW installed has reduced by a factor of 50.

93 http://www.qsofc.eu/

94 http://www.innosofc.eu/

95 https://www.mama-mea.eu/

96 https://www.fch.europa.eu/page/hydrogen-production-and-distribution#Don%20Quichote

97 https://www.fch.europa.eu/page/energy#REFHYNE

98 https://www.fch.europa.eu/page/energy#Djewels

FIGURE 20: KEY LOW-TEMPERATURE ELECTROLYSIS DEMONSTRATION PROJECTS

Low-temperature electrolysis

Several low-temperature electrolysis demonstration projects are addressing the challenge of installing and operating an electrolyser in an industrial environment. The experience gained in these projects has helped to inform the European Hydrogen Strategy and will support the building up of the related value chain. The Demo4Grid[99] project is deploying a 4-MW alkaline electrolysis (AEL) (IHT) for providing **grid-balancing services** to a transmission system operator. The electrolyser should be able to ramp up to full power from stand-by mode in two seconds. The hydrogen produced will be used to refuel FC trucks and combusted to supply heat for an industrial bakery. Low-grade heat from the electrolyser will also be utilised. The region of Tyrolia in Austria, where the Demo4Grid site is located, has recently been extended to a number of other hydrogen projects, such as the deployment of FCEVs and plans to build a hydrogen train in Zillertal.

The HyBalance[100] project has installed a 1.25-MW PEM electrolyser (manufactured by Hydrogenics) in Hobro in northern Denmark. The electrolyser is able to provide electricity grid services with fast reaction times of less than two seconds (in hot conditions). The plant is certified by the Danish energy authorities as a bidder in all electricity markets. The plant's overall energy demand per kg of hydrogen produced has reached 56.5 kWh/kg H2 (achieving the project target of 57.5 kWh/kg H_2). The HyBalance plant has produced 120 tonnes of hydrogen since its inauguration in 2018, half for an industrial customer fed through a pipeline. The project has achieved close to 14 000 hours of operation. After the end of the demonstration phase, Air Liquide will continue to operate the site. The facility is used as a model for a larger plant to be built in Canada.

As the steel industry is contributing around 7 % of global CO_2 emissions, long-term decarbonisation options, such as direct reduction based on the use of renewable hydrogen, are being investigated. The production of hydrogen is being demonstrated at the Voestalpine steel plant in Linz, Austria as part of the H2Future project, where a 6-MW PEM electrolyser plant (manufactured by Siemens) has begun operation. The plant, with a rated system electrical efficiency of 79 % HHV, will be operated and tested with various use cases, linked to future operation modes. The installation has also been qualified to provide grid services. The project has contributed to the effort to harmonise testing protocols. If H2Future[101] proves to be successful, it can serve as a lighthouse project for the deployment of green hydrogen in major industrial sites.

At the launch of EU Hydrogen Strategy, European Commissioner for Energy Kadri Simson visited the REFHYNE[102] project in July 2020, where a 10- MW PEM electrolyser is under construction in the Wesseling refinery in Germany. The electrolyser from manufacturer ITM Power has a target energy demand for hydrogen production of 52 kWh/kg H_2. The project is aiming to demonstrate that providing renewable hydrogen for a refinery can be a viable business case, if additional revenues can be generated by providing primary and secondary grid-balancing services. Due to the flexible operation, the electrolyser can also support energy-intensive industries to achieve the high load factors required for a reduction of grid fees in Germany, which could be another revenue stream. The project has finalised the detailed design of the electrolyser system plant and its adaption to the refinery. All electrolyser stacks have been manufactured and have successfully completed testing before installation.

Other electrolysis projects are demonstrating the advantages of hydrogen for remote areas, providing the means to store energy and support the local network. The Haeolus[103] project is set to install a 2.5-MW electrolyser (manufactured by Hydrogenics) in an extreme and remote environment in Norway, inside the Arctic Circle close to the Raggovidda Wind Farm. This area has abundant renewable resources but a weak

99 https://www.fch.europa.eu/page/energy#Demo4Grid

100 https://www.fch.europa.eu/page/energy#HyBalance

101 https://www.fch.europa.eu/page/energy#H2Future

102 https://www.fch.europa.eu/page/energy#REFHYNE

103 https://www.fch.europa.eu/page/energy#Haeolus

grid connection. The owner of the wind farm is participating in Haeolus in order to develop a new business case by selling hydrogen instead of electricity. The electrolyser can be operated between 5-115 % nominal capacity and is therefore well suited to be coupled to fluctuating renewable energy sources.

The '**Building Innovative Green Hydrogen Systems in an Isolated Territory**' (BIG HIT)[104] project is taking steps to create a hydrogen valley in the Orkney Islands (Scotland). The Islands have over 50 MW of installed wind, wave and tidal capacity generating over 46 GWh per year of renewable electricity. Hydrogen is proposed as a solution to minimise the curtailment problems in Orkney caused by the weak connection with the UK mainland. The hydrogen produced is used locally in thermal, power (cogeneration) and transport applications. An important achievement of the project is that the main pieces of equipment have already been built: 5 hydrogen trailers (250 kg of hydrogen storage), a hydrogen catalytic boiler (30 kW), 1-MW electrolyser (ITM Power); 5 hydrogen FC vans and a 75-kW FC system for cogeneration. A demonstration of the system's full operability is expected soon.

Electrolysers' energy consumption is steadily decreasing for both PEMEL and AEL, in particular at the prototype level, which means that in a few years' time the efficiency of commercial models could see major improvements, given the appropriate level of support. In recent years, two innovative projects on PEMEL have focused on increasing current density and high output pressure.

The NEPTUNE[105] project (follow-up to HPEM2GAS[106]) addresses challenges associated with reducing capital costs and increasing the production rates and output pressures of water electrolysis, as is required for achieving large-scale applications of PEM electrolysers. NEPTUNE is developing a set of breakthrough solutions at material, stack and system levels to increase hydrogen pressure to the target of 100 bar output pressure and current densities to over 4 A/cm^2 for the base load, while keeping the nominal energy consumption below 50 kWh/kg H2. The novel solutions will be validated by demonstrating the potentially low-cost, robust and rapid-response electrolyser. Good results have been obtained at the small scale. The overall goal of the PRETZEL[107] project is to develop an innovative polymer-electrolyte-membrane electrolyser that provides significant increases in efficiency and operability to satisfy growing market demands, potentially offering a breakthrough in becoming a game-changer electrolyser. A key objective is the development of a novel PEM electrolysis system with a 25-kW electrical power consumption generating 4.5 m^3/h H_2 at the rated power. Output pressure is foreseen at 100 bar and feedwater temperature is expected up to 90 °C. The individual plant components have been tested, and the prototype system is currently being manufactured and should be tested for 2 000 h. The project shows promising experimental results. A small-scale electrolysis stack was tested at 6 A/cm^2 at 90 °C (beyond the 2020 MAWP target of 2.2 A/cm^2). The certification of system components has been completed and long-term testing is about to start, if delays due to COVID-19 can be avoided.

The QualyGridS[108] project, focusing on standardised qualifying tests on electrolysers for grid services ended successfully in 2020. It contributed to the creation of new market opportunities for investors in electrolysers and defined enhanced business cases for power-to-hydrogen (P2H) applications through the qualification of electrolysers to perform dynamically and thus enabling them to provide electricity grid-balancing services. Testing protocols for five different low-temperature electrolysers in various locations in Europe were compiled and submitted as a 'new work item proposal' at the ISO/TC 197 standardisation technical committee. In August 2020, the report was formally approved by the ISO/TC 197 members, which was a great success for the project. QualyGridS also provided relevant information for the JRC document on standardised testing protocols for electrolysers.

High-temperature electrolysis (HTE)

The Djewels project will prove the operational readiness of a 20 MW alkaline electrolyser for the production of green methanol in ordinary industrial and commercial situations. The project will boost the creation of advanced pressurised alkaline electrolysers by improving existing density electrodes aiming at standardised production. The projects GAMER[109], GrinHy2.0[110], SELySOs[111], REFLEX[112] and WASTE2GRIDS[113] are all aiming at improving high-temperature electrolysis (HTE) technology. WASTE2GRIDS is developing co-electrolysis and REFLEX is based on reversible Solid Oxide Cell (rSOC) . All these projects are focusing on improving lifetime and efficiency.

104 https://www.fch.europa.eu/page/transport#BIG%20HI

105 https://www.fch.europa.eu/page/energy#NEPTUNE

106 https://www.fch.europa.eu/page/energy#HPEM2GAS

107 https://www.fch.europa.eu/page/energy#PRETZEL

108 https://www.fch.europa.eu/page/energy#QualyGridS

109 https://www.fch.europa.eu/page/energy#GAMER

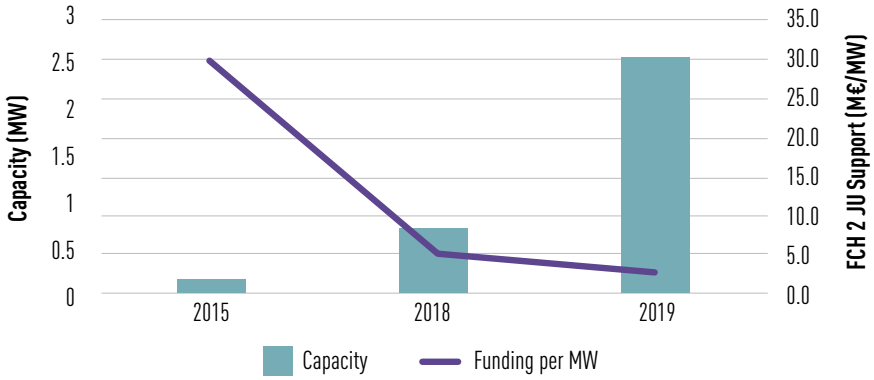
110 https://www.fch.europa.eu/page/energy#GrInHy2.0

111 https://www.fch.europa.eu/page/energy#SElySOs

112 https://www.fch.europa.eu/page/energy#REFLEX

113 https://www.fch.europa.eu/page/energy#WASTE2GRIDS

FIGURE 21: CAPACITY OF HTE DEMONSTRATION PROJECTS IN MW VS. FUNDING IN EUR MILLION PER MW



In recent years, there has been a marked increase in the capacity of HTE demonstration projects, despite receiving lower funding per MW (see Figure 21). HTEs are now being demonstrated in industrial environments such as a steel plant and a biorefinery.

Building on the success of the GrinHy[114] project, which reached 10 000h of operation in electrolysis mode, GrinHy2.0 aims to demonstrate, by the end of 2022, one of the world's largest high-temperature electrolysers from Sunfire with a capacity of 720 kW_{eLAC} and an electrical efficiency of 84 % LHV (which would be a substantial increase over the 78 % LHV achieved by GrinHy). By the end of 2022 it is expected to have been in operation for at least 13,000 hours, producing a total of around 100 tonnes of high-purity 'green' hydrogen in Salzgitter. It will use steam from industrial waste heat during at least 13 000 operational hours. To date, progress has been made towards preparing the installation site and final commissioning took place in 2020. The demonstration phase of the electrolyser has commenced. The MultiPLHY[115] project, which started in 2020, will finally install a 2.6-MW SOE (also manufactured by Sunfire) in a biofuels refinery.

The REFLEX project aims to develop and demonstrate an innovative renewable energy storage solution, the so-called 'smart energy hub'. The solution is based on reversible SOC (rSOC) technology, able to operate either in SOE mode or in SOFC mode. In the first case, it will store excess electricity to produce hydrogen. In the second case, when needed, it will produce electricity (and heat) from hydrogen or any other fuel available locally. To date, the project has made improvements to performance and durability in rSOC operation. In terms of current density, the improved cells are operating at 1.25A/cm^2 in electrolysis mode, surpassing the project's own target.

The SElySOs project aimed to improve the lifetime and performance of SOE electrodes. Furthermore, the goal was to better understand the processes causing degradation on both SOE electrodes, by combining experiments with theoretical modelling. Models of SOE and steam-CO_2 electrolysis cells were developed and validated, covering the transport of mass, heat and charge, as well as chemical and electrochemical kinetics. As for the experimental work, nickel (Ni)-based materials were further developed and the performance of different Ni-free cathodes was assessed. The synthesis method for perovskite material electrodes was validated, and these electrodes were found to keep their oxidative state in all operating environments. The project has been successful in reducing the area-specific resistance of the fuel electrode and the catalyst loading.

The Waste2GridS project is developing a concept for integrated power-balancing plants based on waste gasification and reversible SOFCs. The project is investigating possible business cases and which conditions are favourable for the deployment of these balancing plants.

The GAMER[116] project has developed an innovative and potentially cost-effective tubular proton ceramic electrolyser (PCE) stack. It will produce pressurised hydrogen up to 30 bar at high electrical efficiency. The achievements in terms of performance and degradation for the demonstration unit at 10-kW level, if maintained at full scale, could make this tubular PCE stack configuration a game-changer. Among the advantages of this concept is the lower operating temperature (600 °C) which reduces degradation, enabling the use of cheaper materials. The stack is expected to produce hydrogen with a high heating value (HHV) efficiency between 73-77 % for the electrolyser system, including BoP (steam available). Design and experimental work is complemented by numerical modelling and simulations. Because of the many innovations applied, the project had to overcome several engineering/manufacturing difficulties. However, testing the cell components has revealed good structural stability while the cells' performance and operability has been confirmed. The GAMER multidisciplinary design tool for electrolyser systems has been selected as a key innovation by the European Commission Innovation Radar[117].

114 https://www.fch.europa.eu/page/energy#GrInHy

115 https://www.fch.europa.eu/page/energy#MultiPLHY

116 https://www.fch.europa.eu/page/energy#GAMER

117 https://www.innoradar.eu/innovation/34899

Other hydrogen production routes

The BIONICO[118] project has built the largest catalytic membrane reactor for direct biogas-to-hydrogen reforming in the world. The reactor was designed to efficiently produce 100 kg H_2/day by combining reforming at low temperatures (around 550 °C) as well as purification in one reactor. Simulations have shown that an efficiency of 72 % can be reached. THE BIOROBURplus[119] project technology will also contribute to the efficient conversion of biogas to hydrogen, which could benefit the biogas sector. The oxidative steam-reforming process allows for flexible operation. The reactor concept has a high level of thermal integration that should help to reach an efficiency of >80 % HHV. Suitable catalyst material and structured supports have been selected, tested and optimised for the reformer's operating conditions (>700 °C).

The FCH 2 JU is also supporting hydrogen production methods at a lower TRL. Solar thermochemical production has much promise due to the potentially high solar-to-hydrogen efficiency (35-50 %, compared to PV+EL efficiency of around 12 %). A small-scale pilot reactor was set up at the Plataforma Solar de Almeria (ES) during the HYDROSOL-II project[120]. During HYDROSOL-3D[121], the demonstration at was constructed at a larger scale and then operated in the HYDROSOL-PLANT[122] project. The plant design is based on modular receiver-reactors that are placed in the solar tower, and heliostats that have to be periodically refocused, depending on the energy demand of the process. The HYDROSOL-beyond[123] project is currently addressing what was learnt from the HYDROSOL-PLANT project and is addressing issues at the material and component level while trying to demonstrate the production of hydrogen using 750-kWth solar reactors on the solar platform in Almeria (operating the reactor at 1 100 °C). The most promising design solutions will ultimately be demonstrated at the solar plant, with the aim of reaching TRL5.

The PECSYS[124] project is targeting the development of an integrated photovoltaic (PV)-electrochemical cell device. Several concepts have been investigated, such as hybridisation with PEM and alkaline electrolysis cells, and detached and PV-integrated concepts. The PV integrated alkaline electrolyser prototypes using CIGS PV modules achieved a solar-to-hydrogen conversion efficiency of over 10 % for a solar collection area of 100 cm^2. This configuration does not require any platinum group metals (PGM) as a catalyst. Direct integration with a PEM electrolyser was also investigated. During the demonstration phase, an average solar-to-hydrogen conversion efficiency of about 12 %, far surpassing the target of 6 %, was achieved for a 2 m^2 PV module directly connected to a 21-cell PEM electrolyser stack.

1.2.1.5 HYDROGEN STORAGE, DISTRIBUTION AND PURIFICATION

The HyCARE[125] project is developing a prototype large-scale hydrogen storage tank based on solid-state storage. An innovative aspect is the incorporation of heat storage which will improve efficiency. If successful, this system will be the largest demonstration of stationary solid state hydrogen storage in Europe, with a capacity of 50 kg of hydrogen stored. This storage technology also has safety advantages due to the low storage pressure of less than 50 bars.

The HySTOC[126] project aims to demonstrate the feasibility of liquid organic hydrogen carrier (LOHC)-based solutions for hydrogen distribution and storage, in particular for supplying HRSs. The toluene-based compound used has a gravimetric capacity of 6.23 % and can be cycled up to 750 times. The project has developed a fully automated hydrogen storage and release system. To date, the LOHC-based logistic concept for hydrogen transportation has been developed between two locations in Finland. An LCA has been performed to assess the environmental impacts of the LOHC-based hydrogen transport solution developed.

The HyGrid[127] project aims to develop, scale-up and demonstrate a novel membrane-based hybrid technology for the direct separation of hydrogen from natural gas grids in industrially relevant conditions – more than 25 kg H_2/day could be processed with this concept. The latest experiments show promising results in terms of costs (target of 1.5 €/kg H_2) and efficiency. Prototypes of system components have already been built and the project is in the scaling-up phase.

118 https://www.fch.europa.eu/page/energy#BIONICO

119 https://www.fch.europa.eu/page/energy#BIOROBURplus

120 http://www.hydrosol-beyond.certh.gr/C4F2A0FD.en.aspx

121 https://www.fch.europa.eu/page/hydrogen-production-and-distribution#HYDROSOL-3D

122 https://www.fch.europa.eu/page/hydrogen-production-and-distribution#HYDROSOL-PLANT

123 https://www.fch.europa.eu/page/energy#HYDROSOL-beyond

124 https://www.fch.europa.eu/page/energy#PECSYS

125 https://www.fch.europa.eu/page/energy#HyCARE

126 https://www.fch.europa.eu/page/energy#HySTOC

127 https://www.fch.europa.eu/page/energy#HyGrid

The MEMPHYS[128] project targeted the development of a standalone hydrogen-purification system based on an electrochemical hydrogen purification (EHP) system. The focus was on high contaminant tolerance at low system cost, making the system suitable for different applications. The main project targets are to purify 5 kg H_2/day with an energy consumption of <5 kWh/kg H_2 and a hydrogen recovery rate of >90 %. The targeted recovery rate and efficiency was reached in short-stack tests.

1.2.1.6 CROSS-CUTTING ACTIVITIES

Significant achievements have been recorded in cross-cutting activities, thereby indirectly supporting all other hydrogen technology applications. The ID-FAST[129] and AD ASTRA[130] projects have **performed PNR research** to improve FC testing methodology. ID-FAST is developing accelerated stress tests (AST) for PEMFC for automotive applications, and a methodology enabling the prediction of durability. A major part of the work is dedicated to understanding real-life degradation behaviour and identifying the impact of individual stressors. Similarly, AD ASTRA is studying the lifetime performance of high-temperature FCs and electrolytic cells, aiming to publish ASTs able to quantify stack degradation.

Also contributing to the advancement of PNR/RCS, the HYDRAITE[131] project has studied the effects of hydrogen fuel impurities on the performance of FC systems for automotive applications. This work brought about the setting up of the first three European certified laboratories capable of measuring hydrogen impurities against the entire set of species defined by the specifications laid down in the international standards. A further important project output will involve supporting international standardisation activities in the field.

In terms of **hydrogen safety**, the PRESLHY[132] project is studying the safety of liquid hydrogen, with the very ambitious goal of closing knowledge gaps related to its behaviour in accident conditions. It is the first EU project for more than 10 years dedicated to the behaviour of liquid hydrogen. Considering the large volumes of hydrogen expected to be moved around in the near future, there are still several aspects of liquid-hydrogen release, evaporation and interaction with the environment which need to be understood to prevent accidents and mitigate consequences. Another knowledge gap is related to the behaviour of hydrogen releases in confined spaces, such as tunnels and underground garages. Project HyTunnel-CS[133] is working on tools which will provide recommendations for safer use of hydrogen vehicles and the more effective and safer intervention of first responders. Findings from these projects will be used to improve existing international standards and to formulate new safety requirements for future standards and regulations. In addition to this work on specific safety aspects, it should be mentioned that an integrated approach to the safety dimension of the FCH 2 JU is being provided by the work of the European Hydrogen Safety Panel (see Section 1.2.4).

As regards **education and training**, the NET-Tools[134] project focuses on the development of new e-education methods based on ICT tools, to enhance the knowledge, productivity and competitiveness of those interested in FCH technology deployment. The tangible output from NET-Tools will be an e-learning platform based on open-source software. Complementary to NET-Tools, to a certain extent, the TeacHy[135] project is developing learning tools and materials addressing a broad range of users, primarily university students (undergraduates and postgraduates) and including vocational training. The major objective is a EU-harmonised MSc degree on FCH technologies. One of the participating universities has already certified this qualification, but the first-year trial had to be postponed due to the COVID-19 emergency. The third project in this area is FCHgo![136] which is developing education tools directed at schools. The final product will be a toolkit with narrative explanations of the technology and guidelines for teachers.

With reference to sustainability, although there were no projects in this area in 2020, the preparatory work performed in the 2019-2020 period enabled the design of three Call topics for the AWP2020. These new activities will focus on recycling, eco-design guidelines and the life-cycle sustainability assessment methodology.

Figure 22 is a TIM plot showing the partners in the eight projects considered this year which are performing cross-cutting activities. The main contributors to the cross-cutting projects are research centres and universities, with many participating in multiple projects. Germany (eight projects), France (seven) and Italy (six) are present in the most projects, whilst the Danish Technical University alone is involved in five projects.

128 https://www.fch.europa.eu/page/energy#MEMPHYS

129 https://www.fch.europa.eu/page/cross-cutting#ID-FAST

130 https://www.fch.europa.eu/page/cross-cutting#AD%20ASTRA

131 https://www.fch.europa.eu/page/cross-cutting#HYDRAITE

132 https://www.fch.europa.eu/page/cross-cutting#PRESLHY

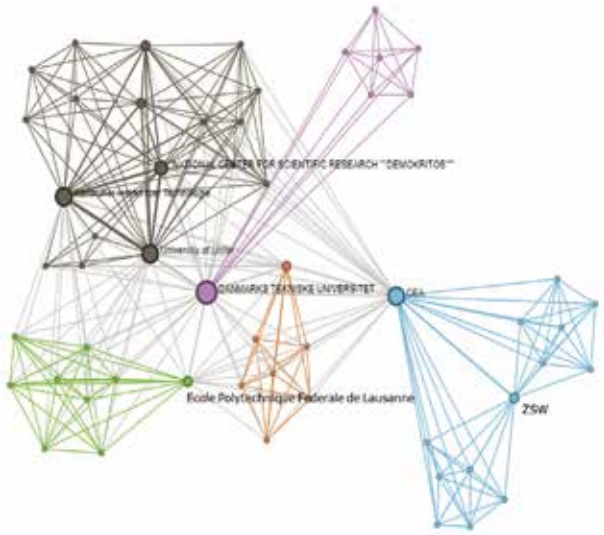
133 https://www.fch.europa.eu/page/cross-cutting#HyTunnel-CS

134 https://www.fch.europa.eu/page/cross-cutting#NET-Tools

135 https://www.fch.europa.eu/page/cross-cutting#TeacHy

136 https://fchgo.eu/

FIGURE 22: TIM PLOT SHOWING THE PARTICIPANTS IN EIGHT PROJECTS INVOLVED IN CROSS-CUTTING ACTIVITIES, THE INSET TABLE SHOWS THE TOP FIVE PARTICIPANTS



PARTICIPANTS	NUMBER OF PROJECTS
DTU	5
Karlsruhe Institute of Technology	4
CEA	4
University of Ulster	4
Demokritos	3

1.2.2 KNOWLEDGE MANAGEMENT

Knowledge management activities[137] have continued with the use of TRUST as the central data-collection tool enabling comprehensive data collection and analysis, complemented by additional tools.

According to the annual planning and in line with their contractual obligations, in late April 2020, ongoing projects (78 in total) were requested to provide data concerning their R&I results generated in 2019. The primary aim of this exercise was to assess the projects' progress against the targets defined in the MAWP 2014-2020[138] (and its Addendum[139]). The submission was performed either through TRUST, for technology-related indicators (68 projects reporting), or through an EU Survey questionnaire (78 projects reporting). At the start of the data-collection exercise, improvements were made to the existing templates, both for TRUST and the EU Survey. In addition, two new templates on 'heavy-duty trucks' and 'H_2 carriers' were created. Projects are encouraged to open up the data (make public the relevant KPIs reached) as much as possible, whilst all confidential data are appropriately cleaned and anonymised.

The data-collection exercise was completed successfully (again) in 2020, with all projects answering the questionnaires and providing timely input on most of the queries. TRUST data-collection activities continued to be streamlined with the annual Programme Review exercise, which provides a detailed analysis of the projects' results.

The results and reported progress were included as content during the portfolio analysis for the Programme Review 2020, which is currently being finalised, with its preliminary results presented in Section 1.2.1 as well as in the PRD event, including the project officers' portfolio overviews and project posters[140]. In November 2020, the Programme Review Report 2019[141] was published, delayed by the COVID-19 situation.

Looking at the bigger picture, the data-collection exercise has proved valuable for many reasons. Primarily, because with data from five calendar years having been collected (2015-2019) so far, it is now possible to perform historical analyses and comparisons of the available data more easily, mapping the technology's progress against key MAWP KPIs over time. At the same time, this information can become important input for identifying research gaps and properly directing R&I in those sectors that are lagging or have the greatest need.

137 https://www.fch.europa.eu/projects/knowledge-management

138 https://www.fch.europa.eu/sites/default/files/FCH%202%20JU%20MAWP-%20final%20%28ID%204221004%29.pdf

139 https://www.fch.europa.eu/sites/default/files/MAWP%20final%20version_endorsed%20GB%2015062018%20%28ID%203712421%29.pdf

140 https://www.fch.europa.eu/page/programme-posters-and-presentations-2020

141 https://www.fch.europa.eu/publications/programme-review-report-2019

On 15 September 2020, the FCHO launch event[142] took place online with around 1 000 participants from European and national institutions, industry and associations from around the world. The FCHO[143] provides data and up-to-date information on the entire hydrogen sector. It focuses on technology and market statistics, socio-economic indicators, policy and regulation, as well as financial support. According to the first available statistics for the months of October and November, the FCHO had more than 4 500 visitors and over 1 000 content downloads, indicating the high interest in the topic and related information.

Concerning other activities, as part of the JRC's Rolling Plan 2018-2020, the FCH-adapted TIM97 database, initially developed in 2018, was further adapted and expanded to include scientific publications, patents, participation in projects and others which have been mapped according to authors' organisations. The existing eight FCH 2 JU TIM datasets were further expanded to cover on-board storage applications. This enables the joint undertaking to better track developments in FCH technologies and the related impact of FCH 2 JU funding. A dedicated web page on the FCH 2 JU website hosts these related TIM spaces[144] and makes them available to the public. Moreover, FCHO sources the data for publications from TIM, extracted on annual basis.

Finally, as part of knowledge management activities, FCH 2 JU is participating in IEA Task 41 (see also Section 1.2.7.International Cooperation). The task has four subtasks, each contributing to the overall goal of providing updated parameters describing hydrogen technologies, as well as to developing knowledge of how to model hydrogen in the value chain. The main objectives of this task are to provide an updated and updatable long-lasting database on hydrogen technologies enabling improved modelling, understanding and decision-making.

1.2.3 RCS SC GROUP ACTIVITIES

The industry-led Regulations, Codes and Standards Strategy Coordination (RCS SC) group, composed of 18 representatives from Hydrogen Europe and Hydrogen Europe Research, is supported by the EC's JRC and the FCH 2 JU PO.

The RCS SC group coordinates the strategy on RCS within the FCH 2 JU, with a focus on identifying the strategic themes for RCS development and their proposed follow-up. The aim of this work is to provide the FCH 2 JU programme with evidence-based analysis of urgent priorities for PNR and standardisation needs supporting the design of the future annual work plans.

In general, RCS activities consist of identifying and prioritising RCS needs of strategic importance for the EU. In addition, the necessary PNR activities to support the RCS priorities are identified.

In 2020, the RCS SCG members centred their activity around the following items:

1) Participation in the **Workshop on Safety of Electrolysis** organised by the FCH 2 JU with the support of the European Hydrogen Safety Panel (EHSP)[145]. The workshop was held on 18 November 2020 with the participation of the 15 FCH 2 JU projects which involve electrolysers. The projects presented their project-specific approaches and experiences regarding safety planning, regulation codes and standards, risk assessment, and incidences specifically related to electrolysis. Several RCS SCG members were involved in the event and the RCS SCG chair provided a concise and complete overview on applicable, electrolysis-specific RCS.

2) Follow-up of activities ongoing in 2020 concerning standardisation in support of European legislation. RCS SCG members have been involved in the mapping of standards deemed necessary for the future in the general area of hydrogen, predominantly focused on the power-to-gas area, and requirements to enable the gas grid to be used either for blends or for '100 %' hydrogen in the future, although including a number of other areas.

1.2.4 EUROPEAN HYDROGEN SAFETY PANEL (EHSP)

The FCH 2 JU launched the European Hydrogen Safety Panel (EHSP)[146] initiative in 2017. Its mission is to assist the FCH 2 JU, at both the programme and project level, in ensuring that hydrogen safety is adequately managed, and to promote and disseminate H_2 safety culture within and outside the FCH 2 JU programme.

142 https://www.fch.europa.eu/news/fch-observatory-go-source-date-information-about-hydrogen-and-fuel-cells-sector-now-live

143 https://www.fchobservatory.eu/

144 https://www.fch.europa.eu/page/tools-innovation-monitoring-tim

145 https://www.fch.europa.eu/news/results-fch-ju-workshop-safety-electrolysi

146 https://www.fch.europa.eu/page/european-hydrogen-safety-panel

The EHSP comprises a multidisciplinary pool of experts – 14 experts in 2020 – grouped in ad-hoc working groups (task forces) according to the tasks to be performed and their expertise. Collectively, the EHSP members have the necessary scientific competencies and expertise to cover the technical domain needed to make science-based recommendations to the FCH 2 JU.

The following sections provide a summary of the activities performed by the EHSP during 2020, per task force:

a) Support at project level

ESHP activities coming under this category aim to coordinate a package of measures to avoid any accidents by integrating lessons learnt on safety, expertise and planning into FCH 2 JU-funded projects by ensuring that all projects address and incorporate the state of the art in hydrogen safety appropriately.

In 2020, the EHSP updated the **safety planning guidance**[147] document for HFC projects drafted in 2018, with the aim of widening its scope with a more comprehensive approach, from safety planning to safety management. The document provides information on safety planning, monitoring and reporting for the HFC projects (and programmes) concerned in Europe and provides an integrated approach to project safety planning, monitoring and reporting needs to best address technical and organisational aspects related to hydrogen safety. The updated document is expected to be published in early 2021.

As part of the activities within this task force, the EHSP also developed a checklist for both existing and upcoming FCH 2 JU projects, based on criteria related to safety aspects. The checklist is being used to support the assessment of all FCH 2 JU projects from a safety-related perspective, and will become an additional tool to identify projects that are likely to be followed up, contacted or supported by the EHSP. The Panel also provided support for a project consortium which did not have its own safety expertise or wanted an independent view.

Finally, within the activities carried out in supporting specific projects, the online **Safety of Electrolysis Workshop**[148] was held on 18 November 2020 with the participation of the 15 FCH 2 JU projects involving electrolysers as mentioned under section 1.2.3. In total, more than 85 participants were connected online and a summary report alongside the presentations will be hosted on the EHSP web page on the FCH 2 JU website for public dissemination.

b) Support at programme level

EHSP work under this category includes a set of activities intrinsically linked with the activities of the previous task force but with a broader and cross-cutting dimension, focusing on the FCH 2 JU programme itself and how safety-related aspects can be enhanced within the overall programme and activities.

In 2020, activities within this task force concerned updating the strategic document to set out a **Multi-Annual Work Plan 2020–2024 for the EHSP.** The document describes EHSP activities within the hydrogen safety community as a framework until 2024. It includes background information on the EHSP initiative and its mission, vision, objectives and operation. It also gives details of past and current activities, current and future relationships between the EHSP and other organisations involved in hydrogen safety worldwide, profiles a work plan for the coming years, etc. The document provides a clear framework for EHSP activities in the years to come.

In addition, following the activities initiated last year, the EHSP supported the FCH 2 JU in identifying safety issues and looking into what still might require support within the programme in order to better understand and assess the current and near-future needs in hydrogen safety.

Moreover, as part of the activities within this task force, the EHSP also developed a procedure for an incident response aiming at providing a structured response to any incident or safety threat to a project.

Furthermore, the EHSP participated in the 7th International Hydrogen Infrastructure Workshop (Tokyo, 25 February 2020) and in the Center for Hydrogen Safety Europe Conference 2020, organised by AIChe (held virtually on 20-22 October 2020).

Finally, the EHSP is keeping in contact with the International Association IA HySafe and the American Hydrogen Safety Panel (HSP) traditionally supported by US DOE's Fuel Cell Technologies Office. More systematic cooperation with these two organisations is foreseen as from 2021.

147 https://www.fch.europa.eu/sites/default/files/Safety_Planning_for_Hydrogen_and_Fuel_Cell_Projects_Release1p31_20190705.pdf

148 https://www.fch.europa.eu/news/results-fch-ju-workshop-safety-electrolysis

c) Data collection and assessment

As learning from others is an essential feature of a high-level safety culture, activities in this category are centred on the collection and analysis of hydrogen-safety-related data to derive lessons learned and provide further general recommendations for all stakeholders.

During 2020, EHSP activities in this category concluded the assessment[149] initiated the previous year on safety data and events included in the revamped European Hydrogen Safety Reference Database (HIAD 2.0) managed by the JRC and supported by the FCH 2 JU.

In close collaboration with the JRC, EHSP members completed the review and assessment of more than 550 events, up from 272 in 2018, and the lessons learned and statistical results from this assessment have been prepared. The report, which will be publicly available on the EHSP web page on the FCH 2 JU website early in 2021, will provide a clear view on the current situation concerning the European Hydrogen Safety Reference Database, and foundations for future research in this field.

Furthermore, in 2020, the EHSP concluded the import of historic cases from the University of Warwick database and other cases from the French ARIA database (Analysis, Research and Information on Accidents).

d) Public outreach

Framed within the context of the intended broad information exchange, the EHSP has updated its comprehensive **communication strategy 2020–2024**.

The document outlines specific considerations for the EHSP communication strategy and the inherent challenges associated with the safe implementation of hydrogen as an energy carrier in society. It suggests clear and measurable communication goals and objectives, provides an analysis of the target audience for communication, prioritised by groups, etc. It also gives a summary of the relevant communication channels and a list of key messages for the most relevant target audiences.

Moreover, a generic slide pack for EHSP presentations has been updated, a set of frequently asked questions (FAQs) related to hydrogen safety has been drafted, and a list of seven common questions concerning hydrogen and hydrogen safety have been selected and worked on.

All these documents are under final internal revision and will be published soon.

1.2.5 COLLABORATION WITH THE JRC

The EC's JRC undertakes high-quality research in the FCH field, which is of considerable relevance to the implementation of FCH 2 JU activities.

In 2016, a Framework Contract between FCH 2 JU and JRC was drawn up for the Horizon 2020 programme. The scope of this Framework Contract covers the activities the JRC provides at the level of the FCH 2 JU programme. These activities are outlined in annual Rolling Plans which also detail the specific deliverables to be provided against payment (heading B of Article 2 in the Framework Contract).

The annual Rolling Plan 2020 constituted part of the AWP 2020, with an indicative budget of EUR 930 000 foreseen from the FCH 2 JU operational budget. The JRC activities covered by the Framework Contract were planned and agreed between the JRC and the PO, with the involvement of one representative each from Hydrogen Europe and Hydrogen Europe Research.

In line with the JRC's mission, these support activities have primarily contributed to the formulation and implementation of the FCH 2 JU strategy and activities in the areas of RCS, safety, harmonisation of testing protocols, and technology monitoring and assessment.

JRC support to the formulation and implementation of the RCS strategy

JRC supports the industry-led RCS SCG. In general, RCS activities should consist of identifying and prioritising RCS needs of strategic importance for the EU. In addition, the necessary PNR activities in support of the RCS priorities should be identified. JRC continued its multi-annual background actions underpinning RCS development, such as co-chairing the RCS working group of the International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE), the UNECE GTR13 Phase 2 on the safety of FCEVs, and involvement in the CEN/CENELEC Joint Technical Committee 6 on hydrogen technologies. JRC also organised a workshop in October on the research priorities in hydrogen safety for maritime applications, with the participation of relevant FCH 2 JU projects.

149 https://www.fch.europa.eu/sites/default/files/Assessment%20and%20lessons%20learnt%20from%20HIAD%202.0%20-%20Final%20publishable%20version%20%28version%201.3%29.pdf

JRC's direct contribution to implementing the RCS strategy

The JRC single-cell hardware, developed to allow the harmonised testing of PEMFC, is undergoing experimental validation. The hardware blueprint was made available to the ID-FAST project, as well as to other stakeholders who expressed an interest in it and signed a non-disclosure agreement. In 2019, the JRC facilitated the manufacturing of the cells for ID-FAST. In agreement with the ID-FAST partners, in 2020, JRC took certain measures to identify and address manufacturing defects and a new collaborative testing plan was agreed. An open-source hardware licence is being drawn up for future dissemination of the hardware.

The JRC is also leading the initiative to set up **EU harmonised terminology for hydrogen generated by electrolysis**. A technical report has been produced and agreed with the working group on harmonisation activities for high-temperature electrolysers. It has been published on the FCH 2 JU website for public stakeholder consultation[150].

In view of harmonisation activities for low-temperature electrolysis, a JRC technical report on EU harmonised protocols for the testing of low-temperature water electrolysers is being finalised and will be published soon on the FCH 2 JU website. The report received exhaustive feedback during the public stakeholder consultation, indicating a high level of interest in this topic.

JRC's contribution to programme monitoring and assessment

The JRC has supported knowledge management through technology monitoring and assessment of the FCH 2 JU project portfolio. An in-depth analysis was carried out on the programme's progress against the MAWP KPIs for electrolysers and stationary FC technologies. These reports consider the performance of projects against the overall programme targets for the technologies, using KPIs for assessment. The purpose of this exercise is to assess whether and how the programme has enhanced the state of the art for electrolysers and stationary FCs and to identify potential research gaps. Public versions of these reports will be made available in early 2021.

The JRC has published the report **Guidelines for Programme-level Target Setting**[151], with recommendations for selecting and defining KPIs and how to record and evaluate state-of-the-art data, as well as methodological tools to reach targets. This methodology has been taken up in the on-going process of drafting the Multi-Annual Workplan of the Clean Hydrogen Partnership, ensuring that the process is transparent and well-documented. The JRC is continuing to support this work.

In collaboration with the knowledge management team, the JRC has populated and revised the TIM system (see Section 1.2.2) with customised FCH technology fields and the addition of the transport technology field. The European Media Monitor (EMM) is regularly maintained and monitoring is being constantly improved. The JRC carried out the 2019 annual Programme Review and the resulting report was used to prepare the public version which can be accessed on the FCH 2 JU website.

It is also reviewing project deliverables related to LCA. Its previous work on this topic had identified some gaps regarding LCA methodology, and a corresponding Call topic was included in the AWP 2020.

JRC's contribution to safety and safety awareness

The Hydrogen Events and Lessons LEarNed (HELLEN) is a database for safety-related events occurring during the life of FCH 2 JU projects, and is part of the strategy on hydrogen safety in the FCH 2 JU programme. Since HELLEN has the same structure as the public database HIAD2.0[152], it is not only a repository of safety information, but also includes, whenever possible, lessons learned while aiming to continuously improve and communicate safety aspects. The JRC collects and analyses all reported incidents and informs the PO by means of an annual report.

Complementary to HELLEN, HIAD2.0 is used to collect publically available safety-related events regarding all hydrogen applications. The JRC is cooperating with the EHSP (see 1.2.4) on the improvement of HIAD2.0. In the period 2019-2020, the EHSP and JRC provided more than 500 additional events to the 400 already available in their database. Of a total of more than 990 events, 600 have been validated and over 100 events have been deleted. JRC has validated the events provided by the EHSP and improved the overall quality of data, in term of accuracy and traceability.

150 https://www.fch.europa.eu/news/give-us-your-feedback-jrc-technical-report-%E2%80%93-eu-harmonised-terminology-hydrogen-generated

151 https://ec.europa.eu/jrc/en/publication/guidelines-programme-level-target-setting

152 https://ec.europa.eu/jrc/en/publication/hiad-hydrogen-incident-and-accident-database

The JRC enables FCH 2 JU participation in Task 38: Power-to-Hydrogen and Hydrogen-to-X, which ended in 2020), Task 39 (Maritime Transport) and in Task 41 (Data and Modelling) of the IEA Hydrogen Implementing Agreement, for all of which common, agreed input is delivered (see also Section 1.2.7.International Cooperation).

1.2.6 SUPPORT TO FCH 2 JU POLICIES AND FUNDING/FINANCIAL ENGINEERING

Policy support and feedback

Throughout its mandate, the FCH 2 JU has contributed to a large and diverse number of activities for multiple EC services (and accordingly provided the necessary feedback for further policy development). Although contributions have varied in content and format, they all share the common goal of providing fact-based information on the state of the art of FCH technologies and their contribution to EU initiatives and policies, especially in the energy, transport and industry sectors, as well as to competitiveness and growth and to the environment policy files.

Last year, FCH 2 JU activities were numerous, mainly due to publication of the first-ever European Hydrogen Strategy[153] in July 2020. FCH 2 JU contributed to this by providing the necessary evidence base supporting the strategy's underpinning objectives.

In practical terms, the FCH 2 JU support to policies meant taking part in a number of technical groups organised by the EC and other international bodies, taking an active role during the meetings, providing written technical input, the organisation of events, and ensuring that FCH technologies are properly represented in the relevant sectors and files of policymakers.

As in previous years, supporting DGs ENER, R&I, MOVE and CLIMA, the FCH 2 JU continued to actively follow and contribute to the European Strategic Energy Technology Plan (SET-Plan) activities during 2020, Action 6 'Energy Efficiency for Industry' and Action 8 on 'Renewable Fuels'. In 2020, work for the Implementation Working Group for Action 6 was facilitated by consultancy Ecorys and focused on establishing a structure around thematic groups. A cross-cutting thematic group on 'Enablers' was set up covering hydrogen, renewables and CO_2 which can be expanded to ammonia and energy storage. This group is currently engaging with Member States and industry. Action 8 work is being facilitated by the SET4BIO[154] project. Work focused on reviewing Member States' National Energy and Climate Plans (NECPs) in relation to biofuels and hydrogen – the FCH 2 JU gave a presentation on the findings of a study it had supported on the subject. The group also came up with contributions to the Clean Energy Transition Partnership SRIA and the 2020 SET-Plan reporting on generating input for SET-Plan strategic documents. The FCH 2 JU is included in the core group of the action.

In 2020, the FCH 2 JU continued to provide input to the drafting of the STRIA roadmap on alternative fuels. In addition, it attended meetings of the EU-funded project ART Fuels Forum[155] under the project 'Support for alternative and renewable liquid and gaseous fuels forum (policy and market issues)'. The ART Fuels group has gathered alternative renewable fuels producers as well as OEMs to discuss existing barriers to the penetration of these fuels in transport. The ART Fuels Forum project ended in December 2020.

Under the wing of the JRC, the FCH 2 JU participated in the International Energy Agency's Hydrogen Technology Collaboration Programme (TCP) Task 38 'Power-to-Hydrogen and Hydrogen-to-X' and Task 39 'Hydrogen in maritime transport'. Task 38 work was completed in 2020 and a final report produced. The FCH 2 JU is now participating in the new Task 41 on 'Data and Modelling'. "Looking ahead, there is room to take part in other tasks, such as the tasks currently in definition related to (a) Renewable Hydrogen Production, and (b) Underground Hydrogen Storage." Furthermore, at the international level and to foster collaboration, the Call for proposals 2020 encouraged the participation of developing world countries supported by the Climate Technology Centre & Network (CTCN) under the UN Environment Programme[156]. It is pleasing to see that several of these countries are now represented in a number of projects.

The FCH 2 JU also continued to work on developing a GO Scheme for Green and Low-Carbon Hydrogen, an effort that started back in 2014 with the first 'CertifHy' project[157]. Continuing in CertifHy2, the work involved gaining practical experience with an operational pilot to identify and address practical issues raised by the implementation of the GO scheme which was designed as part of CertifHy1 and to ensure compatibility with the evolving EU legislation. A highly inclusive stakeholder platform was set up to govern the project. About 70 000 GOs were issued from the four pilot production plants, several thousand of which were bought and used by entities such as Transport for London and H_2 MOBILITY Deutschland to prove the renewable nature of their hydrogen products to their customers.

153 https://ec.europa.eu/commission/presscorner/detail/en/FS_20_1296

154 https://www.etipbioenergy.eu/set4bio

155 https://artfuelsforum.eu

156 https://www.ctc-n.org/

157 https://www.certifhy.eu/

A new procurement procedure (see also Section 1.4) was launched in 2020 and a Framework Contract signed in order to pursue the following key objectives:

- Support further the establishment of an independent and self-sustainable community that will deal with all hydrogen certification issues (GOs and target compliance).
- 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.
- Engage in communication and outreach activities with hydrogen consumers, traders and policymakers with the aim of increasing the use of GOs, thereby adding to their market value.

In 2020, the study on '**Opportunities arising from the inclusion of Hydrogen Energy Technologies in the National Energy and Climate Plans (NECPs)**' was completed[158]. It was done by consultants Trinomics and LBST with close monitoring by the FCH 2 JU and DG ENER. The study produced 28 country files (one for each Member State and the UK) plus a full report presenting the methodology and the results for the EU-27+UK. The files were proactively distributed by the FCH 2 JU to Member State permanent representations in Brussels and by DG ENER to members of the HyENet group[159] of national hydrogen experts.

Last year also saw the public launch of the **Fuel Cells and Hydrogen Observatory**[160] (FCHO) which is aiming to become a reference point for all parties interested in knowing more about FCH technologies. The FCHO includes information on technology deployment, policies, training and education as well as financing. This portal will become a valuable tool for all policymakers and other stakeholders interested in the use of FCH technologies as a decarbonisation solution, primarily in the energy and transport sectors.

Throughout 2020, the FCH 2 JU supervised the implementation of the '**Study on European Business Cases for FCH Trucks and Technology Development Roadmap**'[161] which was published in December 2020 (see Section 1.4). The study was developed in cooperation with a large group of industry representatives organised on the Advisory Board. Companies from this grouping and several others also subscribed to the Coalition Statement, triggered by the study, in which they have committed to the deployment of up to 100 000 FC trucks and 1 500 HRS across the EU by 2030.

In the maritime sector, the absence of RCS for hydrogen as a maritime fuel has been the focus of regular exchanges and meetings between the FCH 2 JU, DG R&I, DG MOVE, EMSA[162], the JRC, CEN/CENELEC and HySafe (international association for hydrogen safety). In this respect, the FCH 2 JU placed one topic (FCH-04-2-2020: PNR on hydrogen-based fuels solutions for passenger ships) in the Call 2020 aiming at providing technical safety evidence to the maritime sector on the use of hydrogen as a maritime fuel. The planned participation of hydrogen stakeholders in the European Sustainable Shipping Forum and in the project on the topic 'Structuring R&I towards zero-emission waterborne transport' (H2020) is an additional contribution. Following the workshop on '**H2@Ports**'[163], co-organised with the US Department of Energy and in collaboration with DG ENER and Clean Energy the first ministerial discussions have started on forming a coalition of ports interested in hydrogen as a commodity for their clean operations (ship fleets or container machinery), to decarbonise industries located on their premises and as hubs for the import/export of hydrogen on a large scale.

FCH 2 JU support to EC policymakers goes beyond energy and transport. During 2020, it has continued working closely with DG GROW. Building on this good collaboration with DG GROW, it provided extensive evidence-based policy input that led to the selection of 'hydrogen technologies and systems' as an EC key strategic value chain for EU industrial policy. Activities in 2020 revolved around stimulating applications of Important Projects of Common European Interest (IPCEI) on hydrogen[164]. To this end, in January 2020, DG GROW and the FCH 2 JU co-organised the 'Hydrogen for IPCEI conference'[165] to inform participants about the IPCEI concept, process, opportunities and limitations, as well alternative sources of

158 https://www.fch.europa.eu/publications/opportunities-hydrogen-energy-technologies-considering-national-energy-climate-plans

159 https://ec.europa.eu/energy/topics/energy-system-integration/hydrogen/hydrogen-energy-network-meetings_en

160 https://www.fchobservatory.eu/

161 https://www.fch.europa.eu/publications/study-fuel-cells-hydrogen-trucks

162 European Maritime Safety Agency: http://www.emsa.europa.eu/

163 https://www.energy.gov/eere/fuelcells/h2ports-workshop

164 https://www.fch.europa.eu/news/hydrogen-ipcei-conference

165 https://www.fch.europa.eu/news/hydrogen-ipcei-conference

financing for large-scale industrial hydrogen development. The conference was the floor for presentations by a number of major large-scale hydrogen projects. It also organised and facilitated extensive matchmaking among participants in order to find the industrial partners required for the implementation of both existing and new project ideas.

With the creation of the European Clean Hydrogen Alliance[166], the collaboration with DG GROW extended to the organisation of the **European Hydrogen Forum**[167] – a two-day event during European Hydrogen Week. The set-up initiated in the first-ever European Hydrogen Week will be replicated annually.

In addition, in 2020, the FCH 2 JU initiated exchanges with DG DEVCO and the EU Global Technical Assistance Facility for Sustainable Energy (EU GTAF)[168] to explore potential synergies in Africa and generate highly impactful projects with benefits shared fairly between EU and African counterparts.

Collaborations with other agencies and joint undertakings

The FCH 2 JU has continued exchanges which include executive agencies managing other parts of H2020 in areas relevant to FCH technologies. For example, in the transport sector, it continues to work with the INEA on activities related to FCEVs, FC buses, maritime and HRS. Similarly, collaboration is ongoing in the energy sector. For the first time, a number of FCH-related INEA projects presented their progress in the 2020 edition of the FCH 2 JU PRD (during European Hydrogen Week in November 2020). In addition, FCH 2 JU has continued to work with EASME, in particular with those working with public authorities[169] to foster the implementation of hydrogen-based sustainable energy and transport solutions. For instance, the FCH 2 JU organised a session on 'H_2 mobility' as part of the 2020 edition of the Covenant of Mayors Investment Forum – Energy Efficiency Finance Market Place organised by EASME and the EC. Furthermore, it has supported colleagues at INEA in preparations for the first Call of the Innovation Fund for hydrogen-related issues.

Collaborations were also extended to other EC programmes. For instance, the FCH C 2 JU project EVERYWH2ERE has signed a memorandum of understanding in collaboration with the Connecting Europe Facility project Onshore Power Supply (OPS) Master Plan, to install a 100-kW hydrogen genset to provide OPS to ships berthed in the port of Tenerife, Spain.

The FCH 2 JU has also remained proactive in taking up opportunities for collaboration with other JUs, EU agencies, initiatives and actions with the potential for synergy with its research agenda. Examples include the common study with Clean Sky 2 on the potential for hydrogen use in aviation[170] which was finalised and presented during 2020. As a result of a similar collaboration with Shift2Rail, in its 2020 Call for proposals the FCH 2 JU included a topic on the development of FC-powered trains which has received a successful response. In addition, the FCH 2 JU has continued exchanges with the European Defence Agency[171] on transport and energy. As part of this, it took an active role in the first meeting of the Phase III of the Consultation Forum for Sustainable Energy in the Defence and Security Sectors, which brings together European ministries of defence. As a result, it has been invited to contribute specific project ideas that could be implemented for the decarbonisation of the defence sector by utilising FCH solutions.

Working with regions

As part of the FCH Regions initiative[172], the FCH 2 JU study on 'Fuel Cells and Hydrogen for Green Energy in European Cities and Regions', published in 2018, identified project implementation intentions in excess of EUR 1.8 billion over a 5-year period. Since then, the FCH 2 JU has been working closely with regions to realise this potential.

166 https://www.ech2a.eu/

167 https://www.fch.europa.eu/european-hydrogen-week

168 https://ec.europa.eu/international-partnerships/projects/eu-global-technical-assistance-facility-sustainable-energy-eu-gtaf_ro

169 https://ec.europa.eu/easme/en/section/horizon-2020-energy-efficiency/public-authorities

170 https://www.fch.europa.eu/publications/hydrogen-powered-aviation

171 https://eda.europa.eu/

172 More information at: https://www.fch.europa.eu/page/fch-regions-hub

Building partnerships with regions

Leveraging on the existing network and capacity-building generated under the FCH Regions initiative, the FCH 2 JU has facilitated and supported a group of four co-leading regions from the Netherlands, France (two) and Spain. The aim is to set up a new thematic interregional partnership on FCH within the Smart Specialisation (S3) Platform for Industrial Modernisation approved by DG GROW in 2019. The so-called **European Hydrogen Valleys Partnership (EHV-S3P)**[173] involves 35 European regions, as of July 2020, working together in 8 distinct working groups across the hydrogen value chain, aiming to enhance the role of green hydrogen in the European energy transition process. The partnership supports regions in their efforts to raise the technological and commercial readiness of FCH applications, facilitate matchmaking and co-investment among European regions whilst also leveraging EU funds' blending opportunities, and strengthen the value chain for FCH technologies via interregional cooperation. The partnership became an active stakeholder in EU policymaking on hydrogen, moving towards the decarbonisation of the EU economy with a bottom-up approach (from local regions to the EU), and publishing several position papers. In 2021, the FCH 2 JU will continue to bring forward the results and outcomes of this partnership's activities.

Project development assistance for regions

In addition, in 2019, the FCH 2 JU launched a pilot **PDA**[174] facility to help develop detailed project planning in regions and cities with a lower maturity level, with a special focus on Central and Eastern Europe. Since starting in June 2020, this one-year FCH PDA for regions is supporting 11 public regional and local authorities from across the EU to develop their concepts for regional FCH projects into detailed work plans. It is noteworthy that more than half of the projects selected are from regions with no specific track record in deploying hydrogen-related projects. These projects should help to accelerate the progress of hydrogen deployment in Europe by providing a blueprint for other regional hydrogen projects, namely to the other 24 regions participating in its Observer Network, as part of a drive towards carbon neutrality. Amongst other things, this network also benefits from dedicated monthly seminars on several topics of their preference, including technical issues and solutions, peer-to-peer reviews and financing opportunities for the deployment of FCH projects.

Additional opportunities for PDA for Regions were explored in 2020: in particular, the FCH 2 JU continued exchanges with EASME and INEA to better understand the opportunities that the Island[175] and City[176] Facilities managed by these two executive agencies could bring to the FCH community. These facilities are designed to support public bodies in the development of sustainable energy and transport projects as well as to mobilise the necessary investment to implement them. For instance, the FCH 2 JU organised several exchanges with the team implementing the Island Facility (NESOI) and contributed to its promotion among regions with an interest in FCH solutions.

Hydrogen valleys and ecosystems

A successful response to the topic in the AWP2015 on hydrogen territories resulted in the signature of BIG HIT. BIG HIT[177] is a project in a Scottish archipelago demonstrating an entire hydrogen ecosystem, from hydrogen production in an electrolyser fed by curtailed renewable electricity to its distribution in trucks and its final use for stationary and transport applications. Although the scale of this trial is limited (1MW electrolyser, two catalytic boilers, a 75kW stationary FC and 5 vans), it has provided some very valuable lessons learned and has illustrated the concept of hydrogen ecosystems. In addition, in 2020, the project launched the **Hydrogen Territories Platform**[178], which is aiming to be a replication tool providing a basis for calculation, information and a discussion forum for new islands or isolated territories that want to reproduce the hydrogen system experience. Following the positive reaction to this project, the FCH 2 JU decided to 'raise the bar' with the inclusion of a larger topic in the AWP2019 (topic FCH-03-1-2019) for a hydrogen valley, which led to support for the HEAVENN[179] project, which provides for a significant scale-up of this concept. Based in the northern regions of the Netherlands, the project aims to assess the business case for large-scale hydrogen production from renewable electricity, its distribution by pipeline and trucks, and its consumption as industry feedstock, for various transport applications (including a salt ship) and for domestic heating. Total investment in the project is close to EUR 100 million and it will also interface with other projects already running in the region. One of its objectives is to serve as a replication model for other regions in the future. In 2020, the FCH 2 JU started discussions with the representative of all these projects to facilitate the coordination of its hydrogen valley activities.

173 https://s3platform.jrc.ec.europa.eu/hydrogen-valleys

174 https://www.fch.europa.eu/news/project-development-assistance-kicks-selected-regions

175 https://www.nesoi.eu/

176 https://eucityfacility.eu/home.html

177 https://www.bighit.eu/

178 www.h2territory.eu

179 https://www.fch.europa.eu/page/energy#HEAVENN

To foster the adoption of FCH solutions on islands, in 2019 the FCH 2 JU presented the portfolio of FCH solutions to representatives of the '**Clean energy for EU islands initiative**'[180],[181]. This came at a time when the FCH 2 JU was exploring the inclusion of a 'hydrogen in islands' topic in the AWP2020. This topic was finally included and a successful proposal selected. In 2020, the GREEN HYSLAND[182] project was signed which will showcase the role of hydrogen in decarbonising EU islands by demonstrating a hydrogen ecosystem on an unprecedented scale on the island of Mallorca (ES).

Furthermore, following the significant interest generated in the hydrogen island topic, it was decided to strengthen activities in this area. In recent years, the FCH 2 JU has been facilitating the participation of FCH 2 JU-supported projects in the forums organised by the Clean Energy for EU Islands Secretariat. Together with the EC, the FCH 2 JU organised a 'hydrogen island' session as part of the EUSEW 2020[183]. This session gave examples of hydrogen projects on islands across Europe and its outermost regions. Since then, the FCH 2 JU has started an exchange with the **Island Commission of the Conference of Peripheral Maritime Regions (CPMR)**[184]. As a result, in 2020, the FCH 2 JU held a webinar for members of the CPMR Islands Commission to illustrate the opportunities FCH could bring to their territories in the context of a green economic recovery. This event was very successful and a number of concrete follow-ups have already been identified.

In 2020, the FCH 2 JU also developed a **Hydrogen Valley Platform**[185] under the umbrella of Mission Innovation's 'Renewable and Clean Hydrogen' Innovation Challenge. The platform was launched publically on 19 January 2021[186], gathering more than 1 000 participants from across the world. The platform presents and connects the existing regional clusters with 32 hydrogen valleys from 18 countries already featured. It is aimed primarily at project developers but is also raising awareness among policymakers and is intended to inspire others willing to replicate similar projects.

The FCH 2 JU Regions Hub

In 2020, building on the activities and experiences mentioned above, and in response to the expectations of the 35 regions involved in the FCH PDA for Regions, the FCH 2 JU launched the **FCH Regions Hub**[187], a subweb page to help regional and local authorities to develop and turn their concepts for regional FCH projects into detailed work plans. The aim is to accelerate the deployment of hydrogen in Europe, contributing to carbon neutrality and zero pollution. The Hub centralises the relevant information gathered within FCH 2 JU projects, studies and initiatives. It also offers links to specific external sources and complementary initiatives capable of helping them to deploy regional FCH plans and projects.

Funding and financial engineering

Despite the COVID-19 disruptions in face-to-face events and meetings that are essential for establishing trust between partners, in 2020, the FCH 2 JU activity on funding/financial engineering did not lose momentum. While the evolution of the EU strategy and policy framework gave further clarity and business certainty to investors and financiers alike, the various stimulus packages brought forward during the year, including the Innovation Fund, the Recovery and Resilience Facility and the IPCEIs, boosted the activity in terms of project development in Europe. The market introduction and acceleration of the deployment of technologies stemming from the FCH 2 JU projects is helping to further establish the JU in terms of a partner providing advice and support to prospective or past beneficiaries of FCH 2 JU projects. The goal is to support large project ideas, combine funding from various programmes, and optimise structured finance operations.

Furthermore, raising awareness among the banking and investor community has become a regular JU activity. This has taken place in various formats, namely in dedicated meetings and brainstorming with bank/investor/project developer teams in specific virtual presentations around the state of play of hydrogen-related activities and studies promoted by the FCH 2 JU. Likewise, specific events have played a role, such as the World Hydrogen Leaders' World Hydrogen Finance and Investment Conference (08/2020: 'Money talks: the facts and figures behind hydrogen investment numbers') and the JU chairing the financing panel of the World Hydrogen Congress (09/2020: 'Encouraging investment in the hydrogen economy: what business models will enable a long-term focus on energy transition? Locking in investors').

180 https://ec.europa.eu/energy/topics/markets-and-consumers/clean-energy-eu-islands_cs

181 https://euislands.eu/

182 https://www.fch.europa.eu/page/energy#GREEN%20HYSLAND

183 https://eusew.eu/hydrogen-green-recovery-european-islands

184 https://cpmr-islands.org/

185 https://www.h2v.eu/

186 https://www.fch.europa.eu/page/mission-innovation-hydrogen-valleys-platform

187 https://www.fch.europa.eu/page/fch-regions-hub

During the first European Hydrogen Week (November 2020), and in close cooperation with DG GROW, the FCH 2 JU organised the companies' and investors' (reversed) pitching sessions on the second day of the European Clean Hydrogen Alliance Forum. Within this Forum for Alliance members only, over 185 projects/companies, several of which are not yet direct beneficiaries of the FCH 2 JU, applied for pitching, from which 45 were selected. In terms of investors, with the assistance of Tech Tour, 14 distinct players were chosen covering a wide spectrum of financiers/investors (international financial institutions, European institutions, corporate venture capital, venture capital, private equity and commercial banking), as well as European-related institutions with a specific focus on bridging with this type of financier/investor. The online event, which provided an opportunity for virtual matchmaking among participants, proved very successful, paving the way for a more structured venture capital event in the future.

The FCH 2 JU has also collaborated with national funding programmes for the blending of funds. For instance, the HySHIP[188] project is working on a 3-MW FC-powered ferry and benefiting from around EUR 20 million from Enova, the Norwegian Innovation Fund, in addition to the EUR 8 million provided by the FCH 2 JU.

1.2.7 INTERNATIONAL COOPERATION

Given the importance of international cooperation in science and technology, explicitly recognised in the EU's Innovation Union flagship initiative[189] and the H2020 programme, and described in the Communication 'Enhancing and focusing EU international cooperation in research and innovation: a strategic approach'[190], the FCH 2 JU has continued to be active at the international level in order to align with, facilitate and accelerate the worldwide market introduction of FCH technologies.

As the deployment of FCH technology is carried out globally and key partners of the FCH 2 JU are involved in these developments, the JU has continued to develop links with the major deployment programmes globally. This has taken place mainly through the IPHE but also through bilateral periodic discussions with the US Department of Energy, Japan METI/NEDO (Ministry of Energy and Transport) and in particular the Mission Innovation's Innovation Challenge 8: Renewable and Clean Hydrogen[191] (MI-IC8) to harmonise standards and regulations and to accelerate market preparation.

In this respect, the FCH 2 JU collaborated closely with EC representatives on the MI-IC8 and, during 2020, developed a Hydrogen Valley Platform under the umbrella of Mission Innovation's Renewable and Clean Hydrogen Innovation Challenge. As mentioned in Section 1.2.6 under Hydrogen valleys and territories, the platform was publically launched on 19 January 2021[192] and gathered more than 1 000 participants from across the world. It presents and connects the existing regional clusters, with 32 hydrogen valleys from 18 countries already featured. It is aimed primarily at project developers but is also raising awareness among policymakers and is intended to inspire others willing to replicate similar projects.

In support of the JRC, the FCH 2 JU continued to contribute to the activities of the IEA Hydrogen Technology Collaboration Programme executive committee to optimise and share the effort. In particular, it focused on the IEA tasks related to Power-to-X (task 38), Maritime Applications (task 39), and Data and Modelling[193] (task 41).

As in previous years, the FCH 2 JU exchanged best practice with the US DoE among reviewers during both the US DoE Annual Merit Review and FCH 2 JU proposal evaluations.

Call 2020 topics were open to collaboration with the IPHE[194] and MI-IC8 countries. In this context, it is worth highlighting the e-SHyIPS project on standards for maritime/shipping applications, which aims to gather new knowledge based on regulatory framework review and experimental data on ship design, safety systems, material and components and bunkering procedures. The project will define a pre-standardisation plan for IGF code update for hydrogen-based-fuels passenger ships and a roadmap for boosting the hydrogen economy in the maritime sector. It foresees cooperation with the United States and other international partners, with the aim of using the project results to develop international standards for hydrogen on-board ships.

188 https://cordis.europa.eu/project/id/101007205/fr

189 https://ec.europa.eu/info/research-and-innovation/strategy/goals-research-and-innovation-policy/innovation-union_en

190 https://ec.europa.eu/research/iscp/pdf/policy/com_2012_497_communication_from_commission_to_inst_en.pdf

191 http://mission-innovation.net/our-work/innovation-challenges/renewable-and-clean-hydrogen/

192 https://www.fch.europa.eu/page/mission-innovation-hydrogen-valleys-platform

193 The FCH 2 JU hosted a Task 41 Definition Meeting (Data and Modelling) on 29 August 2019 in Brussels, Belgium. Topics of discussion included how to model hydrogen in the value chain and improve current methods, experiences from other tasks, and data consolidation of parameters describing hydrogen technologies.

194 https://www.iphe.net/

1.3 CALLS FOR PROPOSALS AND GRANT INFORMATION

1.3.1 PROPOSALS

2020 Call

The 2020 Call for proposals (H2020-JTI-FCH-2020-1) was published on 14 January 2020 and, in accordance with the AWP 2020, included 24 topics: 8 in the transport pillar, 9 in the energy pillar, 2 in overarching activities, and 5 in cross-cutting activities, with an indicative budget of EUR 93 million. The deadline for submission of proposals was 21/04/2020, extended to 29/04/2020 due to COVID-19.

On 27 January 2020, a public information day was organised in Brussels. The 2020 call received 71 proposals: the results of the evaluation of these proposals are presented below in paragraph 1.3.2. All consortia were informed of the evaluation results at the same time, 100 days (Time To Inform – TTI) after the closure of the call, well in advance of the TTI target fixed by the EC (153 days). Immediately after the information had been sent, preparation of the grant agreements (GAs) began: 22 of the 23 GAs were signed in 2020 within an average of 222 days and before the Time To Grant (TTG) target fixed by the EC, i.e. 245 days after the closure of the Call. The remaining GA requested an extension of the TTG deadline, due to exceptional circumstances.

TABLE 5: CALL 2020 - TIME TO SIGN AND GRANT

CALL	PROPOSAL NUMBER	ACRONYM	TTI	TTS	TTG
H2020-JTI-FCH-2020-1	101007216	BEST4Hy	100	119	219
H2020-JTI-FCH-2020-1	101006774	CoacHyfied	100	124	224
H2020-JTI-FCH-2020-1	101007173	COSMHYC DEMO	100	119	219
H2020-JTI-FCH-2020-1	101007219	E2P2	100	116	216
H2020-JTI-FCH-2020-1	101007166	eGHOST	100	124	224
H2020-JTI-FCH-2020-1	101007226	e-SHyIPS	100	116	216
H2020-JTI-FCH-2020-1	101006633	FCH2RAIL	100	125	225
H2020-JTI-FCH-2020-1	101007201	GREEN HYSLAND	100	125	225
H2020-JTI-FCH-2020-1	101006751	HYPSTER	100	119	219
H2020-JTI-FCH-2020-1	101007205	HyShip	100	119	219
H2020-JTI-FCH-2020-1	101007176	HyStorIES	100	120	220
H2020-JTI-FCH-2020-1	101006641	IMMORTAL	100	132	232
H2020-JTI-FCH-2020-1	101007108	MegaSyn	100	ongoing	ongoing
H2020-JTI-FCH-2020-1	101006794	MultHyFuel	100	125	225
H2020-JTI-FCH-2020-1	101007168	OYSTER	100	126	226
H2020-JTI-FCH-2020-1	101007194	PROMETEO	100	124	224
H2020-JTI-FCH-2020-1	101007175	REACTT	100	119	219
H2020-JTI-FCH-2020-1	101007182	SH2APED	100	132	232
H2020-JTI-FCH-2020-1	101007163	SH2E	100	124	224
H2020-JTI-FCH-2020-1	101007223	SHERLOHCK	100	119	219
H2020-JTI-FCH-2020-1	101006667	SO-FREE	100	130	230
H2020-JTI-FCH-2020-1	101005934	StaSHH	100	123	223
H2020-JTI-FCH-2020-1	101007165	WINNER	100	119	219

The 23 projects listed above include 226 participations for the total FCH 2 JU contribution of EUR 91.8 million.

The figures below indicate the distribution of the number of participants and the FCH 2 JU contribution by participant category.

FIGURE 23: BREAKDOWN OF CONTRIBUTION BY PARTICIPANT CATEGORY (IN EUR)

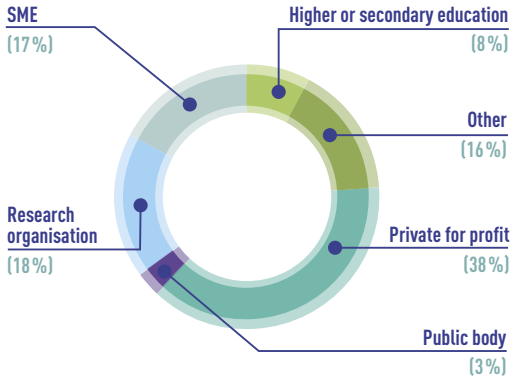
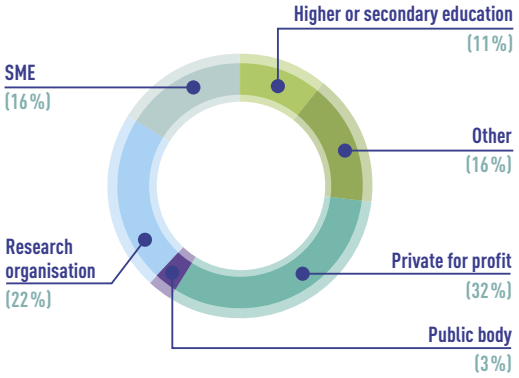


FIGURE 24: BREAKDOWN OF PARTICIPANT CATEGORY (BY LEGAL TYPE)



Beneficiaries from 23 EU Member States or Associated Countries are participating in the 17 projects and have received or will receive funding. In addition, entities from four third countries are participating in seven projects.

The figures below indicate the distribution of the participants and the FCH 2 JU contribution by country.

FIGURE 25: FCH CONTRIBUTION BY COUNTRY (IN EUR)

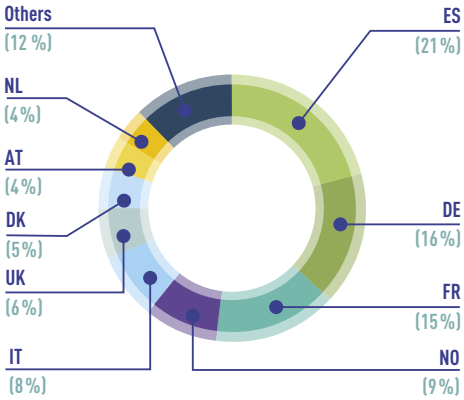
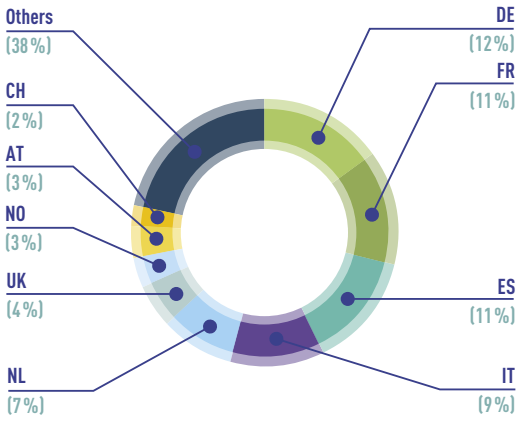


FIGURE 26: NUMBER OF PARTICIPANTS BY COUNTRY



1.3.2 EVALUATION: PROCEDURES AND GLOBAL EVALUATION OUTCOME, REDRESS, STATISTICS (NO. OF EVALUATORS, GENDER, AREA, ETC.)

Under the AWP 2020, approved by the GB on 16 December 2019, the FCH 2 JU published the H2020-JTI-FCH-2020-1 Call for proposals on 14 January 2020 (Official Journal C012). In accordance with the FCH 2 JU rules (vade mecum) on proposal submission and evaluation, adopted on 30 June 2014 by the GB, an evaluation report, including all annexes (main list, reserve list, ineligible list, evaluation summary reports, statistical information on proposals received, and experts' report, panel report and observer report) was submitted to the GB for approval. All the 71 proposals received met the eligibility criteria.

The distribution of the 71 proposals, according to pillar and Call topic, is provided below:

TABLE 6: NUMBER OF PROPOSALS EVALUATED

AREA	TOPIC	TOTAL
Transport	FCH-01-1-2020	6
	FCH-01-2-2020	5
	FCH-01-3-2020	1
	FCH-01-4-2020	1
	FCH-01-5-2020	2
	FCH-01-6-2020	4
	FCH-01-7-2020	2
	FCH-01-8-2020	2
Energy	FCH-02-1-2020	1
	FCH-02-2-2020	2
	FCH-02-3-2020	1
	FCH-02-4-2020	2
	FCH-02-5-2020	5
	FCH-02-6-2020	6
	FCH-02-7-2020	2
	FCH-02-8-2020	1
	FCH-02-9-2020	2
Overarching	FCH-03-1-2020	3
	FCH-03-2-2020	10
Cross-cutting	FCH-04-1-2020	1
	FCH-04-2-2020	4
	FCH-04-3-2020	1
	FCH-04-4-2020	4
	FCH-04-5-2020	3
	Grand total	**71**

The 71 proposals included 621 participations. They were evaluated by 53 independent experts with 3 chairs to assist with managing the entire evaluation process, including the quality control task and 1 observer for the evaluation procedure.

43 proposals (60 %) passed all the Call thresholds. The figures below provide statistics on the 56 experts (excluding the observer):

FIGURE 27: BREAKDOWN OF EXPERTS BY COUNTRY

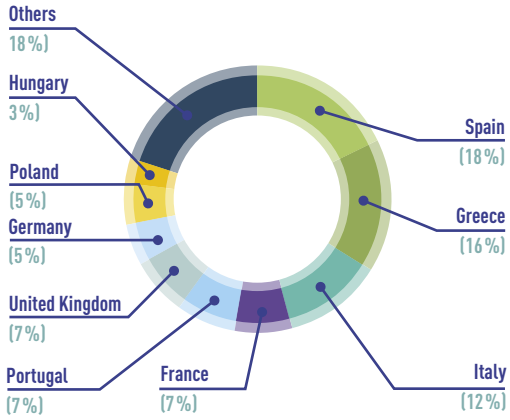
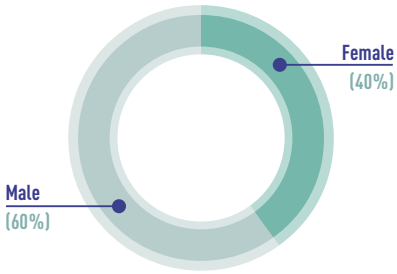


FIGURE 28: BREAKDOWN OF EXPERTS BY GENDER



The final ranking list for the Call provided by the FCH2 JU PO did not deviate from the experts' recommendations.

The distribution of the retained proposals and budget per panel is provided in the table below:

TABLE 7: BREAKDOWN OF PROPOSALS PER PILLAR AND ACTIVITY

	TOPIC/PANEL	NUMBER OF ELIGIBLE PROPOSALS RECEIVED	NUMBER OF PROPOSALS RETAINED (MAIN LISTS)	NUMBER OF PROPOSALS IN RESERVE LIST	CUMULATIVE REQUESTED EU CONTRIBUTION	AVAILABLE BUDGET IN TOPIC/PANEL (IN EUR)
Transport	FCH-01-1-2020	6	1	3	1 993 550.00	2 000 000.00
	FCH-01-2-2020	5	1	3	3 825 927.50	3 500 000.00
	FCH-01-3-2020	1	0	0	-	2 000 000.00
	FCH-01-4-2020	1	1	0	7 500 000.00	7 500 000.00
	FCH-01-5-2020	2	1	0	4 999 441.75	5 000 000.00
	FCH-01-6-2020	4	1	0	7 993 942.00	8 000 000.00
	FCH-01-7-2020	2	1	0	9 999 999.13	10 000 000.00
	FCH-01-8-2020	2	1	1	2 999 637.13	3 000 000.00
Energy	FCH-02-1-2020	1	1	0	2 563 328.75	2 500 000.00
	FCH-02-2-2020	2	1	1	2 499 531.25	2 500 000.00
	FCH-02-3-2020	1	1	0	2 712 322.50	2 500 000.00
	FCH-02-4-2020	2	1	0	2 739 094.00	2 500 000.00
	FCH-02-5-2020	5	1	2	2 499 911.75	2 500 000.00
	FCH-02-6-2020	6	1	3	4 999 843.00	5 000 000.00
	FCH-02-7-2020	2	1	0	4 999 999.00	5 000 000.00
	FCH-02-8-2020	1	1	0	4 999 449.39	5 000 000.00
	FCH-02-9-2020	2	1	0	2 499 715.50	2 500 000.00
Over-arching	FCH-03-1-2020	3	1	1	2 931 788.75	3 000 000.00
	FCH-03-2-2020	10	1	1	9 999 999.50	10 000 000.00
Cross-cutting	FCH-04-1-2020	1	1	0	1 997 406.25	2.000.000.00
	FCH-04-2-2020	4	1	1	2 500 000.00	2 500 000.00
	FCH-04-3-2020	1	1	0	998 991.25	1 000 000.00
	FCH-04-4-2020	4	1	2	1 586 015.00	1 500 000.00
	FCH-04-5-2020	3	1	2	1 997 616.25	2 000 000.00
	Total	**71**	**23**	**20**	**91 837 509.65**	**93 000 000.00**

FCH2 JU informed the applicants on the outcome of the evaluation. Two proposals requested a review (redress), neither of which led to re-evaluation or change in the ranked lists established in the evaluation process.

1.4 CALL FOR TENDERS

On the basis of AWP 2020, FCH 2 JU launched operational procurement (open procedure) on the following topic:

1. Study on use of hydrogen and fuel cells for aircraft propulsion (joint study with Clean Sky 2 JU)

Together, FCH 2 JU and the Clean Sky 2 JU have contracted the above-mentioned study through a joint procurement procedure led by Clean Sky JU.

The results of the study on the potential use of hydrogen in aviation were presented on 22 June through a digitally hosted event which featured the following keynote speakers: Adina-Ioana Vălean, European Commissioner for Transport; Patrick Child, Deputy Director-General of the EC's Directorate-General for Research and Innovation; plus leading industry representatives: Stéphane Cueille (CTO, Safran), Glenn Llewellyn (VP Zero Emissions Technology, Airbus), David Burns (VP Global Business Development, Linde), Per Ekdunge (Executive Vice-President, PowerCell) and Rolf Henke (Member of the Executive Board, German Aerospace Centre – DLR).

The study found that hydrogen – as a primary energy source for propulsion, either for FCs, direct burn 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. Costing less than EUR 18 [USD 20] extra per person on a short-range flight, and reducing climate impact by 50-90%, hydrogen could play a central role in the future mix of aircraft and propulsion technologies.

The full results of the study are available on the FCH 2 JU website[195].

2. Study on the impact of deployment of BEV and FCEV infrastructures (detailed analysis of the best mix between battery charging points and HRSs infrastructures, to avoid redundancies or not relevant allocations and allowing a massive electric vehicle for every type of usage)

The study has not been published yet and was consequently transferred to the public procurements to be carried out in 2021. Although the drafting of tender specifications for the study was initiated during 2019, because of modifications to policy, on the one hand, and new developments in the sector, on the other hand, the scope of the Call for tenders is being re-evaluated and is currently under discussion with the corresponding services at the EC.

3. Study on accelerating the deployment of GO schemes for hydrogen and for the design of a voluntary scheme for compliance with RED II targets

The study was foreseen in the AWP 2019; its publication and finalisation were postponed to 2020, as reported in the AAR 2019. Further to an open procurement procedure, the Framework Contract was signed on 9 October 2020 for a period of 36 months and a maximum total amount of EUR 1 499 000.00. The Framework Contract is being implemented via successive specific service contracts, the first of which was signed on 19 October 2020.

4. Previous procurement contracts for studies have been finalised and the reports are now publicly available:

a. The final study report on FCH trucks, foreseen in the FCH 2 JU AWP 2019 and awarded to contractor Roland Berger, was released on 15 December 2020. The study provides an in-depth analysis of the market potential of heavy-duty FCs underpinned with concrete case studies. The complete study results are available on the FCH 2 JU website[196].

b. The study analysing opportunities for hydrogen energy technologies considering the NECPs, foreseen in the FCH 2 JU AWP 2019 and awarded to a consortium led by Trinomics B.V., was finalised in 2020 and the final report made available on the FCH 2 JU website[197]. The study covered all EU Member States (including the UK) and focused on the period up to 2030 (i.e. the period covered by the NECPs). It analysed the role of hydrogen in the NECPs and identified opportunities for hydrogen technologies to contribute to effective and efficient achievement of the 2030 climate and energy targets of the EU and its Member States. The study focused on the potential of and opportunities for renewable hydrogen, produced by electrolysers using renewable electricity, and of low-carbon hydrogen, produced by

195 https://www.fch.europa.eu/publications/hydrogen-powered-aviation

196 https://www.fch.europa.eu/publications/study-fuel-cells-hydrogen-trucks

197 https://www.fch.europa.eu/publications/opportunities-hydrogen-energy-technologies-considering-national-energy-climate-plans

steam methane reforming combined with carbon capture and storage (CCS). The opportunities for and impacts of hydrogen deployment were assessed and summarised in individual files per Member State. The study concluded by determining the potential for CO_2 reduction beyond that foreseen in the NECPs through hydrogen energy technologies, estimating the reduction of fossil fuel imports and reliance, the prospective cost, the value added and jobs created.

1.5 DISSEMINATION AND INFORMATION OF PROJECT RESULTS

Closely aligned with the knowledge management objectives, the monitoring of FCH 2 JU project dissemination and exploitation activities continued during 2020, as did following closely the EC activities in preparation for the post-H2020 period and Horizon Europe.

D&E-Net: The FCH 2 JU has been part of the Horizon 2020 Dissemination and Exploitation Network established by the EC's DG R&I under the H2020 Strategy for the common dissemination and exploitation of research and innovation data and results for the period of 2018-2020. In this context, the D&E-Net principal working group launched the following six subgroups; this same structure continued during 2020:

(1) D&E practices across the R&I family and capacity building;

(2) Data sharing and visualisation;

(3) Activating multipliers and synergies;

(4) HRP & Go-to-Market guidance for POs;

(5) Strengthening policy feedback; and

(6) Exploitation and impact in Framework Programmes (FPs).

The FCH 2 JU has appointed representatives for each working group and has followed their activities closely, while contributing to the periodical meetings. The main objective was to prepare the existing and new D&E tools and activities towards an integrated Dissemination & Exploitation Ecosystem for Horizon Europe. Key outcomes of these working groups, supported by the FCH 2 JU, comprise: a) the new Collaborative Framework for Feedback to Policy (F2P Framework), based on the consulting engagement in the existing process of R&I policy feedback performed by the IAS[198], and the lessons learned from its piloting; b) the renewed (post-2020) D&E Strategy and its governance; c) the 2021-22 D&E Action Plan; d) the consultation on CORDIS orientations; e) the 'Go to Market' guidance for project officers; and f) input for the D&E sections of the proposal and reporting templates.

Horizon Results Platform[199]: The HRP is a D&E tool launched by DG R&I in 2019, a dedicated platform provided for projects to present their results to targeted audiences (e.g. business partners, angel investors, venture capital, policymakers, business development assistance and others) and to help the projects' beneficiaries to establish fruitful partnerships. During the pilot launch of this tool in 2019, FCH 2 JU participated with 10 projects. In 2020, a total of **24 project results** were uploaded on the platform, while all FCH 2 JU projects have been continuously reminded of this new tool and its benefits and encouraged to upload their results.

198 Consultation performed upon request of the CIC.

199 https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/horizon-results-platform

Support Services for Exploitation of Research Results (SSERR)[200]: These on-demand services launched in 2015 by the EC to help H2020 research projects to maximise the added value and impact of their results by receiving consultancy-type advice on exploitation aspects, ended in 2020. SSERR addressed completed and ongoing research projects under:

- FP7 – Thematic Priority number 5 'ENERGY' in the 'Co-operation' programme;
- 'Horizon 2020' – Societal Challenge 'Secure, clean and efficient energy'.

Under the energy pillar, out of 14 eligible FCH 2 JU projects which requested the SSERR services in the period 2015-2019, in total **12 services were distributed to 11 of the projects** (in particular, in 2019, when a contractor managed to deliver few services due to residual budget constraints). The service offered to the FCH 2 JU projects and horizontally included:

- Ad-hoc assistance – AHA – (to be agreed on a case-by-case basis);
- Exploitation strategy seminars – ESS – to brainstorm on key results and how to address the risks and obstacles associated with exploitation;
- Business plan development – BPD – service to help project partners better approach this crucial step towards the commercialisation of the products or services.

TABLE 8: SSERR AHA SERVICE TO THE FCH 2 JU

PROJECTS	EXPERT/S NAME	SEMINAR DATE	DELIVERY DATE OF FINAL REPORT	SEMINAR PLACE	CONTRACT
Pitching Training for PRD 2018	Natali	14/11/2018	14/11/2018	Brussels, BE	SC-19-SSERR-2018
Pitching Training for TechTour Energy Transition 2019	Di Anselmo Mazzella	26/11/2019	n.a.	Brussels, BE	SC-26-SSERR-2019

TABLE 9: SSERR SERVICES TO THE FCH 2 JU PROJECTS

PROJECTS	CALL	EXPERT/S NAME	SEMINAR DATE	DATE DELIVERY FINAL REPORT	SEMINAR PLACE	CONTRACT
AHA						
HyCARE	2018	Melasecche	20-21/01/2020	18/02/2020	Trento, IT	SC-27-SSERR-2019
ESS						
HYGRID	2015	Mogyorosi	18/05/2017	23/08/2017	San Sebastian, ES	SC-08-SSERR-2016
BIONICO	2014	Olesen	06/09/2017	08/12/2017	San Sebastian, ES	SC-11-SSERR-2017
DEMOSOFC	2014	Melasecche	21/11/2018	11/01/2019	Turin, IT	SC-17-SSERR-2018
INSiGHT	2016	Di Anselmo	30/01/2019	13/02/2019	Salerno, IT	SC-20-SSERR-2019
GRASSHOPER	2017	Di Anselmo	21/05/2019	19/06/2019	Duisburg, DE	SC-20-SSERR-2019
PECSYS	2016	Di Anselmo	23-24/01/2020	19/03/2020	Catania, IT	SC-27-SSERR-2019
HAEOLUS	2017	Melasecche	16/01/2020	07/02/2020	Benevento, IT	SC-27-SSERR-2019
BPD						
CISTEM	2012	Kallai	24/11/2016	02/12/2016	Brussels, BE	SC-06-SSERR-2016
HEALTHCODE	2014	Mazzella	21/09/2018	06/11/2018	Turin, IT	SC-16-SSERR-2018
Cell3ditor	2015	Melasecche	27/11/2018	21/12/2018	Nottingham, UK	SC-13-SSERR-2018
DEMOSOFC	2014	Melasecche	17/11/2019 12/03/2020 03/04/2020	18/05/2020	Espoo, SF Online Online	SC-27-SSERR-2019

200 http://sserr.meta-group.com/SitePages/default.aspx

As illustrated in the final report, almost **11 % of the total services in all FP7 and H2020 implementing bodies/JUs were distributed to FCH 2 JU projects**, reflecting FCH 2 JU's continuing efforts to guide the projects towards the exploitation of their results by actively supporting and participating in all relevant EC initiatives in the field of D&E.

Horizon Results Booster (HRB): The EC Horizon Results (Dissemination and Exploitation) Booster, successor to the SSERR, was launched during the last quarter of 2019, although the Framework Contract with the implementing consortium was only signed in May 2020. Despite this delay and the pandemic situation, **one project has already requested one of the services** provided (design and execute a portfolio dissemination plan) and **three others have already expressed their interest in applying**. The PO informed the projects' consortia via a number of different communications channels, such as events (Info Day, Coordinators' Day, Programme Review Days, dedicated emails, etc.) about the importance of these services and tools for enhancing project dissemination and exploitation plans. Dissemination and exploitation of project results awareness starts before signature of the GA, during its preparation and is closely monitored throughout its duration.

Innovation Radar (IR): This initiative aims to identify high-potential innovations and the key innovators in H2020 projects. The FCH 2 JU began to participate in the IR pilot in 2018 in project mid-term reviews when a dedicated expert is mandated to identify potential innovations and has to fill out a questionnaire to provide information in a structured manner. The purpose of the IR exercise is not only to identify promising actors with the potential to grow, but also to stimulate and propel them to 'make it happen' faster and more efficiently. With the help of the questionnaire, the IR expert provides concrete recommendations on the project's innovation aspects and for individual innovator organisations within the consortium. As the IR exercise is linked to the mid-term review, when applicable, these recommendations are also integrated into the formal review report.

To date, **innovations in 54 FCH 2 JU projects** in total have been analysed: **112 innovations** (63 % of are considered to be 'very innovative' or 'obviously innovative and easily appreciated advantages to customer') and **175 innovators** (almost 62 % of which have been acknowledged as medium to high capacity) have been identified and uploaded on the platform. In 2020, **25 more innovations and 33 innovators of 15 FCH 2 JU projects were identified**.

FIGURE 29: TOTAL NUMBER OF INNOVATIONS ANALYSED AND PRESENTED IN IR AND THE INNOVATORS RELATED TO FCH 2 JU PROJECTS

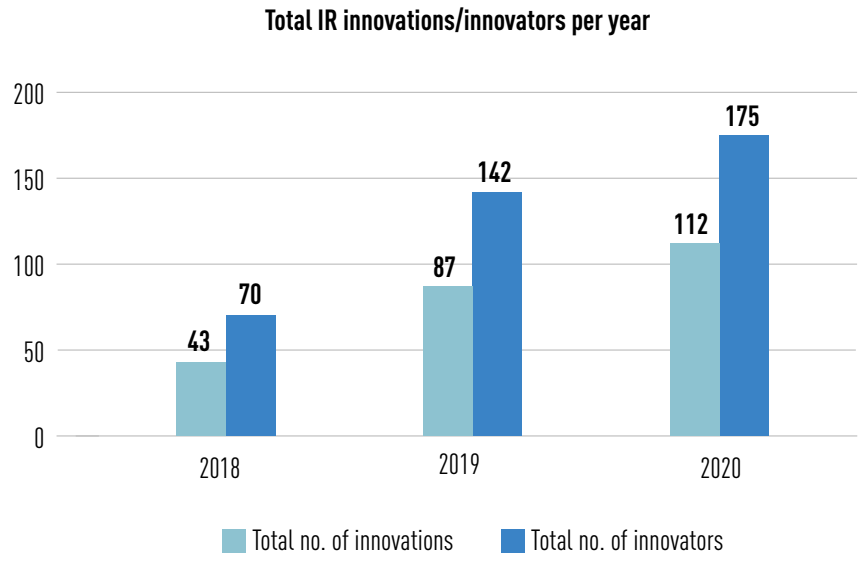
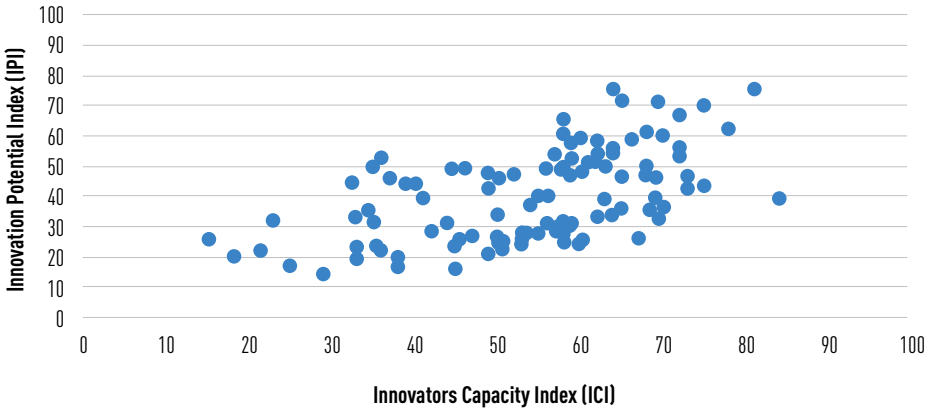
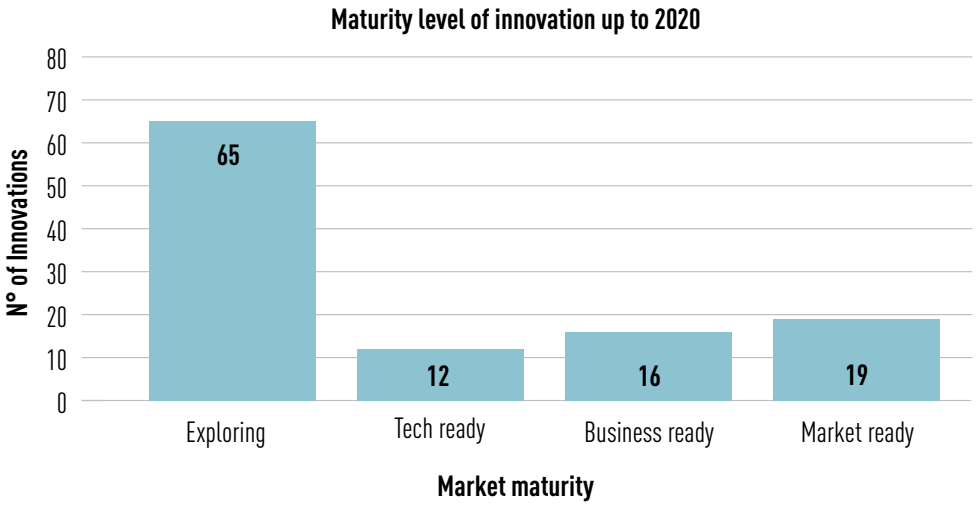


FIGURE 30: RANKINGS OF THE DIFFERENT INNOVATIONS BASED ON THEIR INNOVATOR CAPACITY SCORE AND INNOVATION POTENTIAL INDEX



These are displayed, and have been categorised, based on the IR methodology, as 'exploring', 'tech ready', 'market ready' or 'business ready'. These categories are meant to span the path between the most basic TRLs of 'exploration' to the most advanced and closest to a potential product of 'optimisation'. A very positive result has also been the identification of at least 37 innovations that score above 50 points in the IPI, making them ideal first candidates for follow-up actions for exploitation proposals for financing. In addition, FCH 2 JU beneficiaries of the Haeolus and HySTOC projects were shortlisted for the **Innovation Radar Prize 2020**, and HySTOC was the winner in the 'Tech for Society'[201] category.

FIGURE 31: CLUSTERING OF INNOVATIONS BASED ON THE MATURITY LEVEL



Since the pilot launch, the FCH 2 JU has been collecting valuable feedback to communicate to the EC (e.g. DG R&I, DG CONNECT, etc.) in a continuous effort to establish how IR can be further improved and exploring how the information collected can be further utilised by other EC services which support the commercial exploitation of research results (e.g. SSERR and Horizon Results Boosters, HRP, etc.). Furthermore, a new service called the Dealflow.eu[202] is aimed at the innovations/innovators identified to support them in the further exploitation of their results, especially in commercialising their innovations (Go-to-Market), by facilitating access to clients and investors and providing high-end coaching services (e.g. venture-building, preparations for fund-raising, networking, pitching to possible investors, etc.). Finally, the FCH 2 JU will monitor any FCH 2 JU project activity within these initiatives to provide dedicated assistance in either the exploitation or dissemination of results.

PRD 2020 – EU Survey: In the context of the PRD 2020, one of the pillars of the annual data-collection exercise is the EU Survey in the form of a questionnaire filled out by the FCH 2 JU projects. Its purpose is to collect the necessary information to help assess the progress made by the FCH 2 JU programme, identify its successes and make recommendations for improvement. According to the data provided by 78 active projects on their 2019 activities, as regards D&E activities and the **key exploitable results (KERs)**:

201 https://ec.europa.eu/futurium/en/innovation-radar-prize/tech-for-society-2020

202 https://dealflow.eu/

- 69 projects reported 402 dissemination activities;
- 53 projects reported 88 exploitation activities; and
- 35 projects reported 61 KERs.

In addition, 77 publications were reported and 1 patent (while 2 more are under examination).

As regards the projects' **dissemination activities** that were active in 2019, almost two-thirds of them were related to active participation in conferences, including presentations, posters, etc. (46 %) and scientific publications (17.7 %). The projects have also been performing other types of activities (organising conferences, education or clustering activities, etc.), depending on the content of their research. In more than half of the dissemination activities, the target audience are the research communities.

FIGURE 32: TYPE OF DISSEMINATION ACTIVITIES PERFORMED BY FCH 2 JU PROJECTS IN 2019

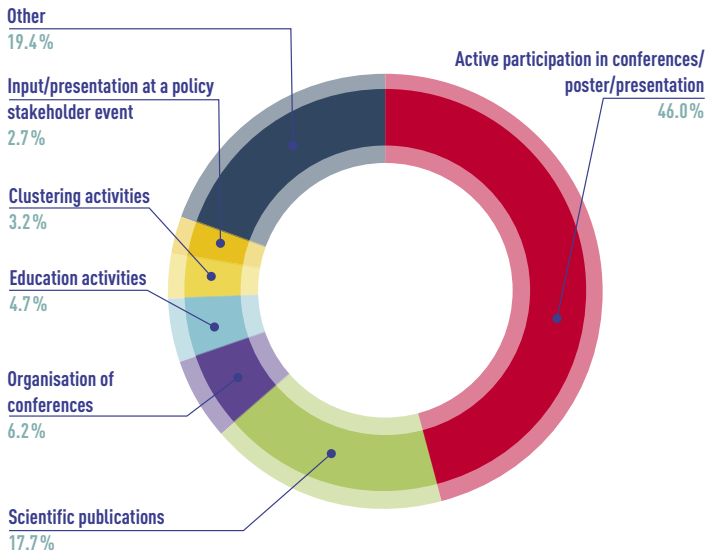
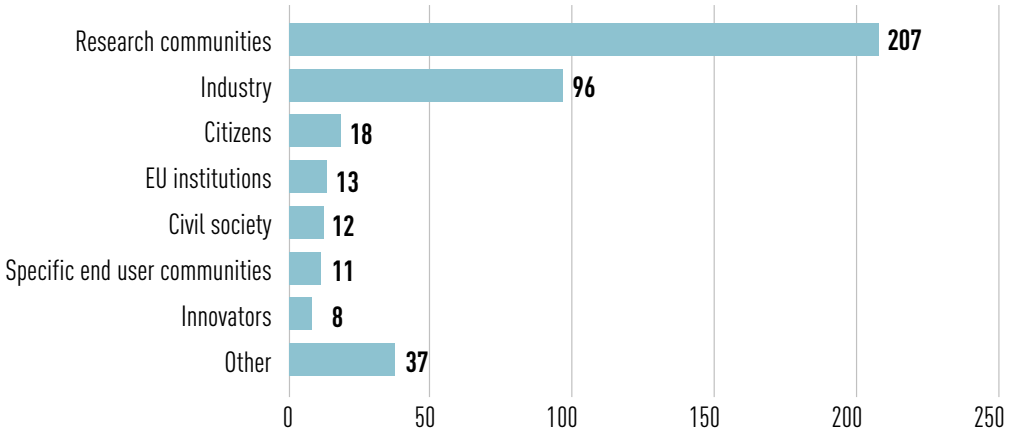


FIGURE 33: DISSEMINATION ACTIVITIES PER TARGET AUDIENCE PERFORMED BY FCH JU 2 IN 2019



The **exploitation activities** were more diverse: almost 25 % were related to meeting with user communities, whereas a further 30 % were related to IPR activities (17 %) and market surveys (13.6 %). Other exploitation activities included meetings with public authorities (10.2 %), and steps towards standardisation (9.3 %), etc. As regards the target audience for these activities, almost half aimed to reach the industry (Go-to-Market) while the rest were used mainly to support further use of the project outcomes or to reach legislative authorities (EU institutions, research communities, specific end-user communities, etc.). In addition, the projects benefited from EC support services (SSERR, IR, HRP, etc). in one-third of their exploitation activities.

FIGURE 34: TYPE OF THE EXPLOITATION ACTIVITIES PERFORMED BY FCH 2 JU PROJECTS IN 2019

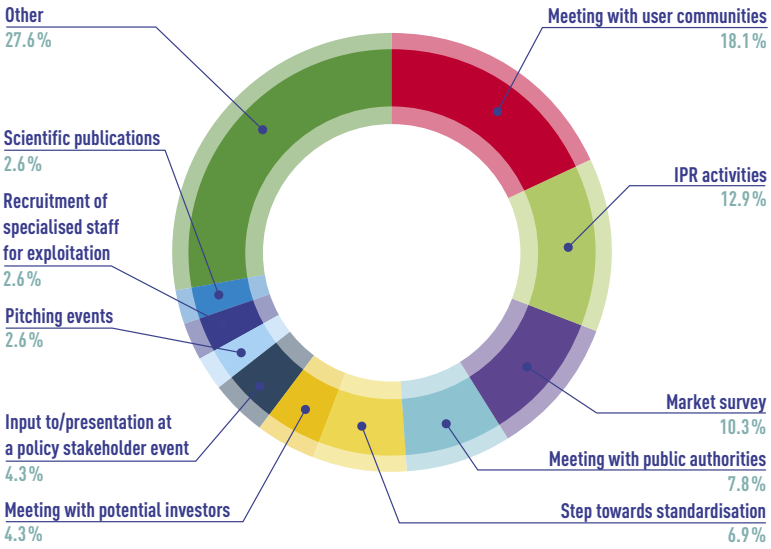


FIGURE 35: TARGET AUDIENCE FOR THE EXPLOITATION ACTIVITIES PERFORMED BY FCH 2 JU PROJECTS IN 2019

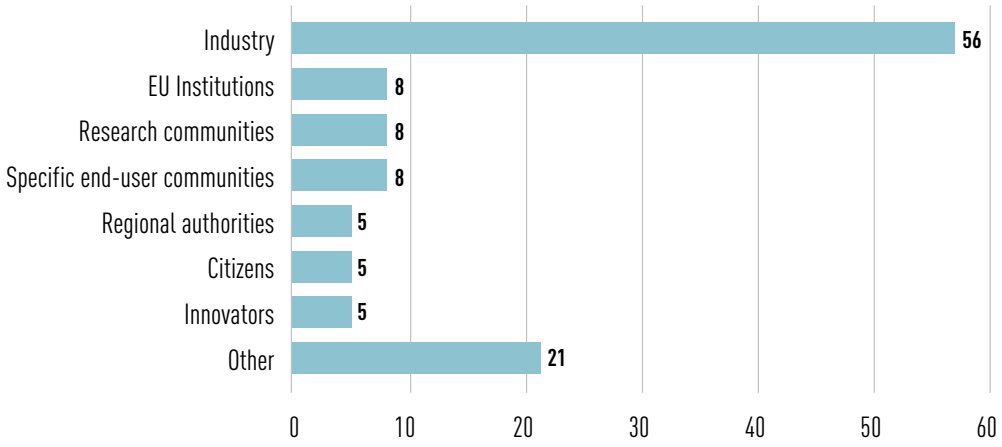
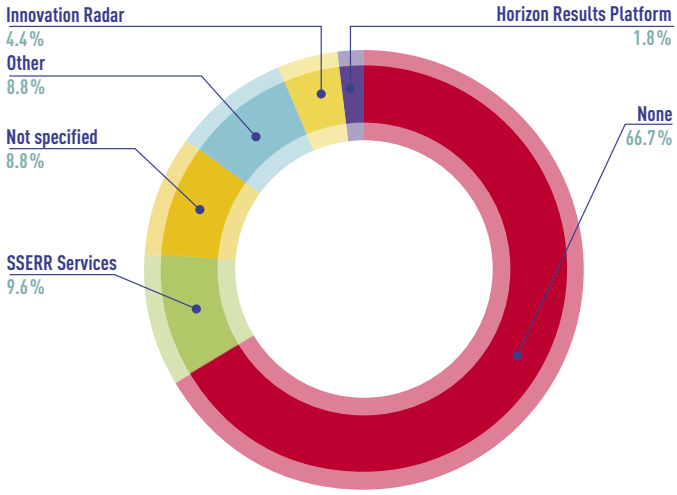


FIGURE 36: USE OF EC SUPPORT SERVICES BY FCH 2 JU PROJECTS IN 2019



As regards the **KERs**, 21.3 % have already been exploited while the majority (65.6 %) of them are under development and 13.1 % have been developed but not exploited yet. The exploitation path for the majority of KERs is commercial (72.1 %), while almost one in four (24.6 %) needs further research. Furthermore, the main bottlenecks/obstacles identified during the exploitation process were financing, a lack of standards, and the lack of experience and skills in the exploitation of results.

FIGURE 37: EXPLOITATION STATUS AND TYPES OF EXPLOITATION PATHS FOR KERS REPORTED BY FCH 2 JU PROJECTS IN 2019

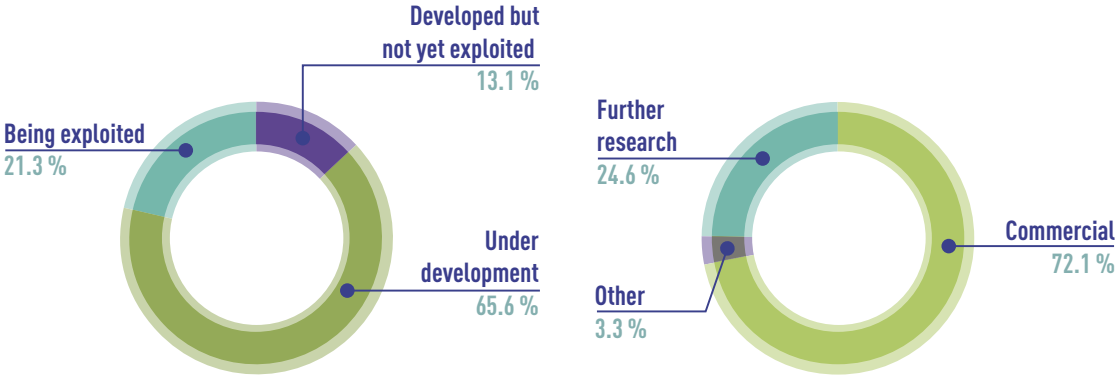
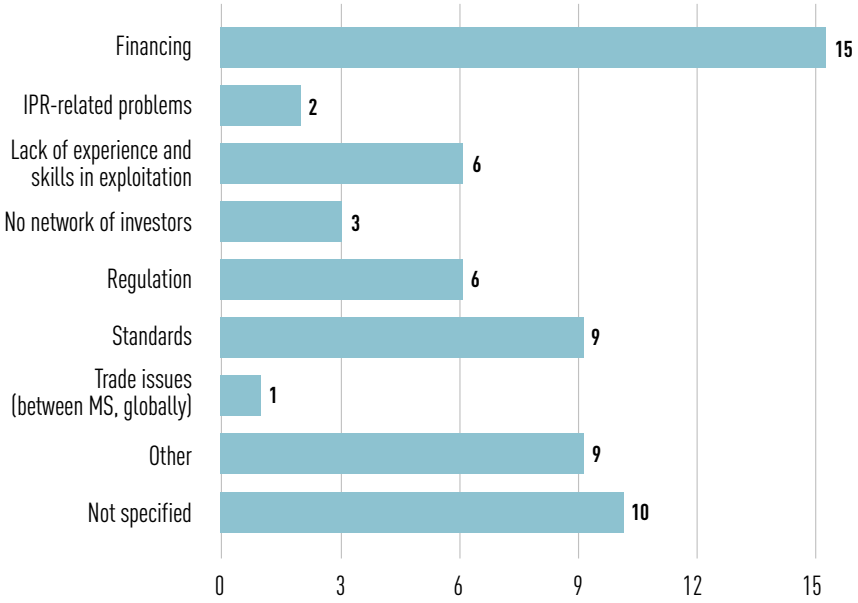


FIGURE 38: IDENTIFIED BOTTLENECKS/OBSTACLES DURING EXPLOITATION OF KERS BY FCH 2 JU PROJECTS IN 2019



1.6 OPERATIONAL BUDGET EXECUTION

The total budget available in 2020 (including internal assigned revenues) for operational expenses reached EUR 98 348 847 in terms of commitment appropriations and EUR 97 026 523 in terms of payment appropriations. Commitment utilisation rate reached 94.9 % (85.6 % in 2019) whereas payment execution rate reached 96.9 % (99.7 % in 2019), which marks the second-best execution rate in FCH JU history, only behind 2019.

In more detail:

- FP7 budget

In 2020, 4 periodic reports were assessed (2 interim and 2 final), with the total amount of payments reaching EUR 6.1 million. The budget execution (in terms of payment appropriations) reached 88.8 % (95.1 % in 2019) due to the fact that 1 project did not submit the final report as expected and another one had an underspend.

- H2020 budget

In 2020, 55 reports were assessed (36 interim and 19 final payments). In addition, H2020 operational payment appropriations were used for 22 pre-financing payments (from Call 2020), as well as for studies, the JRC's work, and the work of experts in the context of the EHSP.

Budget execution in terms of payment appropriations reached 97.5 % (100 % in 2019). Part of the decrease is due to the impact of COVID-19 on the payments scheduled for 2020. There were 6 amendments due to COVID-19 that shifted payments from 2020 to 2021 and 1 payment that was reduced due to delays. The total impact of these changes amounted to EUR 2 million or 2.2 % of the H2020 budget.

In terms of commitment appropriations, the execution rate reached 96.5 % (86.3 % in 2019), reflecting the successful outcome of Call 2020.

For further details on the budget, see Section 2.3.

1.7 IN-KIND CONTRIBUTIONS

In-kind contributions in H2020

The FCH 2 JU legal framework for in-kind contributions[203] is defined in Council Regulation (EU) No. 559/2014 of 6 May 2014 establishing the FCH 2 JU, in which Article 4 provides that:

'The Members of the FCH 2 Joint Undertaking other than the Union shall make or arrange for their constituent entities or their affiliated entities to make a total contribution of at least EUR 380 million over the period defined in Article 1.'

When assessing the level of contributions according to the above-mentioned Article, the FCH 2 JU distinguishes between different types of contributions:

- Financial (cash) contributions
- In-kind contributions in operational activities (IKOP)
- In-kind contributions in additional activities (IKAA)

Thus, the **overall minimum threshold of EUR 380 million for the H2020 programme** refers to the sum of all three types of contributions.

In 2020, FCH 2 JU members other than the EU were able to demonstrate an **overall figure close to EUR 900 million** of actual and certified contributions from private members, largely exceeding the minimum targets.

The table and graph below provide an overview of members' contributions under FCH 2 JU:

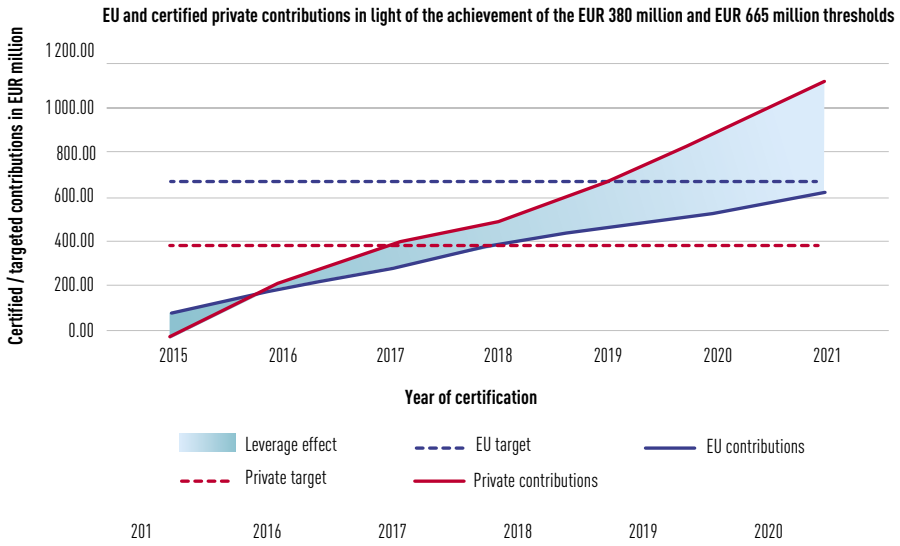
TABLE 10:FINANCIAL (CASH) AND CERTIFIED IN-KIND CONTRIBUTIONS FROM PRIVATE MEMBERS AS OF 31 DECEMBER 2020

CASH AND CERTIFIED IN-KIND CONTRIBUTIONS	EUR MILLION
Cash contributions to FCH 2 JU administrative costs	
Industry	7.49
Research	1.22
Total cash contribution	**8.71**
Indirect actions – in-kind contributions 'IKOP'	
Total certified IKOP as of 31 December 2020*	**11.92**
Additional activities – certified 'IKAA'	
Certified IKAA as of 31 December 2019	667.00
Newly certified IKAA in 2020	209.55
Total certified IKAA as of 31 December 2020	**876.55**
Total: as of 31 December 2020	**897.18**

** According to the IKOP methodology, the majority of the in-kind contributions are only certified at the end of the project (upon reception of the CFS certificate).*

203 This legal framework was complemented by a methodology for both IKOP and IKAA agreed by the FCH 2 JU GB on 18 November 2015 and 9 December 2016, respectively.

FIGURE 39: EU AND CERTIFIED PRIVATE CONTRIBUTIONS AS OF 31 DECEMBER 2020 WITH OUTLOOK FOR 2021



In-kind contributions in operational activities (IKOP)

IKOP are costs incurred in implementing indirect actions minus the contribution of the FCH 2 JU and any other EU contribution to those costs (Statutes, Article 13.3.b).

To be considered as IKOP, these costs must be incurred by members of Hydrogen Europe or Hydrogen Europe Research or their affiliates participating in FCH 2 JU indirect actions.

The regulation provides that IKOP should be valued according to members' usual accounting practices and applicable national and international accounting standards (Regulation, Article 4.4).

The Council Regulation allows the members to base their declaration of IKOP on the basis of their 'total costs' (according to their usual accounting practices) which may be slightly higher than their 'eligible costs' (according to H2020 rules). On a proposal from the Industry and Research Groupings, the GB decided to limit IKOP to eligible costs for cost-efficiency and simplification reasons.

As a result, the IKOP in H2020 projects for FCH 2 JU are limited to the amount of eligible costs as per H2020 rules, minus the EU contribution.

Calculation of the level of in-kind contributions is based on the methodology endorsed by the GB on 18 November 2015. *Ex-ante* controls for the IKOP under H2020 follow the harmonised practice in line with the common strategy of the rest of the R&I family, with the aim of simplifying and easing the controls performed when the payment is approved.

Ex-post certification of IKOP is provided by the *ex-ante* certificate of financial statements (CFS) which, compared to the FP7 programme, are only applicable for the final project period where the amount of FCH contribution to direct costs is higher than EUR 325 000.

Validation of the amount of IKOP is provided at ED level, upon receipt of the CFS certificate and/or based on the result of the *ex-post* audits.

The amount of IKOP reflected in the FCH 2 JU accounts is based on all signed running projects as of 31 December 2020, considering mainly the estimated costs (mostly pro rata) as well as cost claims which were received but had not been validated at the cut-off date.

As of 31 December 2020, the estimated in-kind contributions for the 131 projects signed for the H2020 programme (2014-2020 Calls) were as follows (in EUR):

TABLE 11: OVERVIEW OF IN-KIND CONTRIBUTIONS IN OPERATIONAL ACTIVITIES (IKOP)

H2020 IN 2020	ACCUMULATED VALIDATED IKOP AT 01/01/2020	VALIDATED IKOP FOR 2020	IKOP RECEIVED BUT NOT VALIDATED AT 31/12/2020	IKOP ESTIMATE (PRO RATA) AT 31/12/2020	IKOP ESTIMATE TO BE VALIDATED	FORECAST OF AGGREGATED LEVEL OF IKOP
Industry grouping	EUR 5.23 mil.	EUR 6.54 mil.	EUR 27.29 mil.	EUR 8.72 mil.	EUR 110.55 mil.	EUR 158.34 mil.
Research grouping	EUR 0.15 mil.	0	0	0	EUR 0.10 mil.	EUR 0.24 mil.
TOTAL	**EUR 5.38 mil.**	**EUR 6.54 mil.**	**EUR 27.29 mil.**	**EUR 8.72 mil.**	**EUR 110.65 mil**	**EUR 158.58 mil.**

Most of the IKOPs were not certified, as this will happen later during the H2020 programme at the final payment of the projects when the CFS are due.

In-kind contributions in additional activities (IKAA)

According to the FCH 2 JU regulation, additional activities are defined as those carried out by members of Hydrogen Europe and Hydrogen Europe Research and their affiliates contributing to the FCH 2 JU programme's objectives but undertaken outside of its work plan, which are not funded by the EU or the JU.

The regulation provides that determination of the costs taken into account for the valuation of the in-kind contributions shall be in accordance with the usual cost accounting practices of the entities concerned, the applicable accounting standards of the country where the entity is established, and the applicable international accounting standards and international financial reporting standards (Article 4.4).

The FCH 2 JU regulation establishes a minimum level of IKAA at EUR 285 million over the period defined in Article 1 of the regulation.

The planning, reporting and certification process of the additional activities in 2020 followed a formal FCH 2 JU IKAA methodology, describing a robust control process to ensure the planned, reported and certified IKAA figures are reasonable (the methodology was agreed by the FCH 2 JU GB on 9 December 2016).

In 2020, the following important activities took place (in chronological order):

1. (Preliminary) Reporting of the values of the IKAA contributions for 2019 by Hydrogen Europe and Hydrogen Europe Research members, as of 31 January 2020

As per the Council Regulation, members of the FCH 2 JU other than the EU shall report each year by 31 January to the FCH 2 JU GB on the value of the contributions in additional activities made in each of the previous financial years.

In accordance with the Regulation, the 2019 IKAA preliminary report was submitted on 31 January 2020 to the FCH 2 JU GB for information. An estimated IKAA of EUR 238.26 million was reported as achieved compared to the initial 2019 IKAA plan of EUR 198.49 million adopted by the FCH 2 JU GB on 9 April 2019.

The submission of IKAA 2019 revised figures in January 2020 was the first time in H2020 reporting that the members reported higher revised figures than those in the original plan. At the beginning of 2020, this signalled a clear statement that the industry and research activities in the sector were starting to boom at the end of 2019.

2. IKAA certifications for the 2019 period

As COVID-19 caused delays in certifications (as most certifications were scheduled for the months of March – May 2020), in June 2020, the members delivered certificates for the IKAA for a total amount of EUR 52.86 million.

To ensure strict continuity and compliance with the adopted Plan, no new activities (for the 2019 reporting period) compared to the adopted 2019 IKAA Plan, were included in that report.

3. Additional IKAA certifications for the 2019 period

Since most of the certifications were pending at the deadline for the first submission (Q2 in 2020), a new certification milestone for the activities in 2019 was set for October 2020.

Those activities only included the additional activities derived from the 2019 IKAA Plan which encapsulated planned activities declared by the members at the beginning of the period and which were pending certification in June 2020.

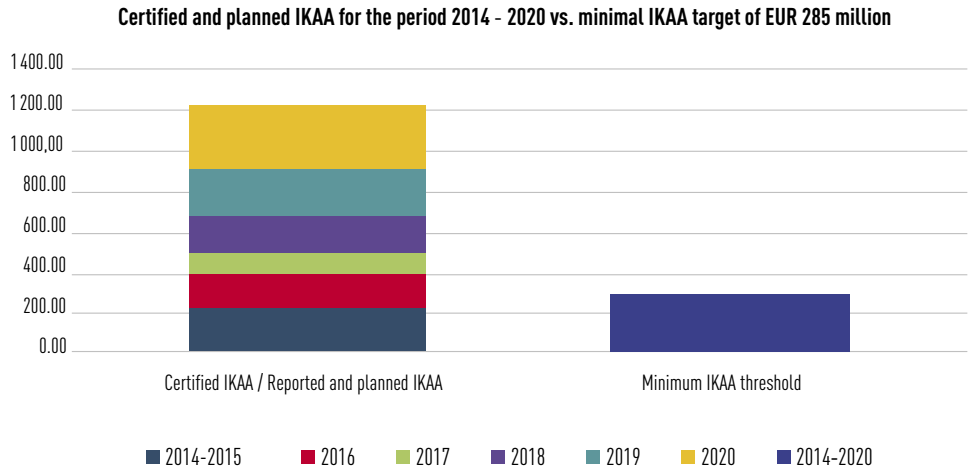
With newly certified activities for 2019, for an amount of EUR 156.69 million, the **total certified IKAA amount for 2014–2019 reached EUR 876.55 million.**

General overview of additional activities as of 31 December 2020

This section provides an overview of the cumulative amount of additional activities:

- Certified IKAA for the period 2014-2019 (based on the certificates received and validated at 31 December 2020, totalling EUR 876.55 million);
- Planned IKAA for the period 2020 (based on 2020 IKAA Preliminary Report submitted to FCH 2 JU GB in January 2021 for EUR 218.52 million).

FIGURE 40: CERTIFIED AND REPORTED IKAA FOR 2014-2020



The FCH 2 JU believes that the scope of investments reflected in the AA is a clear testimony of the FCH sector members' strong commitment, the continued progress of these technologies towards the market, and the strong leverage of FCH 2 JU investment. The JU believes that these investments in AA embody a robust contribution towards achieving joint objectives even beyond the FCH 2 JU regulation.

FP7

The FCH JU founding regulation (Council Regulation (EU) No. 521/2008 as amended by Regulation 1183/2011) states that the FCH JU operational costs shall be covered through the financial contribution of the EU and in-kind contributions from the legal entities participating in the activities.

Calculation of the level of in-kind contributions follows a methodology approved by the FCH JU GB on 10 February 2012. Verification of these costs includes: 1) *ex-ante* controls before validation of the cost claims submitted by the beneficiaries (either based on desk-review assessment by the PO and/or certificates on financial statements provided by independent auditors); and 2) *ex-post* audits after validation of the cost claims, carried out by independent auditors appointed by FCH JU, in line with the FCH JU *ex-post* audit strategy.

In addition, in accordance with the methodology, the aggregated level of in-kind contributions is assessed every year by an independent external auditor.

In February 2020, KPMG carried out the assessment and confirmed the amount of the aggregated level of in-kind contributions certified by the FCH 2 JU ED (cut-off date 31 December 2019).

The full publishable report can be found at: http://www.fch.europa.eu/page/annual-activity-reports

As of 31 December 2020, details of the aggregated level of in-kind contributions are as follows in EUR mil:

TABLE 12: AGGREGATED LEVEL OF IN-KIND CONTRIBUTIONS

FP7 YEAR 2020	ACCUMULATED VALIDATED IKC CONTRIBUTIONS AT 01/01/2020	VALIDATED IKC CONTRIBUTIONS IN YEAR 2020	IKC CONTRIBUTION ESTIMATE (PRO-RATA) AT 31/12/2020	IKC CONTRIBUTION ESTIMATE TO BE VALIDATED AS FROM 01/01/2021	FORECAST OF AGGREGATED LEVEL OF IN-KIND CONTRIBUTIONS
Industry grouping	EUR 286.47 mil.	EUR 6.38 mil.	EUR 4.70 mil.	EUR 9.35 mil.	EUR 306.90 mil.
Research grouping	EUR 143.15 mil.	EUR 4.38 mil.	EUR 2.25 mil.	EUR 4.82 mil.	EUR 154.60 mil.
TOTAL	**EUR 429.62 mil**	**EUR 10.76 mil.**	**EUR 6.95 mil.**	**EUR 14.17 mil.**	**EUR 461.50 mil.**

02
SUPPORT TO OPERATIONS

2.1 COMMUNICATION ACTIVITIES

2.1.1 COMMUNICATION OBJECTIVES 2020

Throughout 2020, the communication activities intensified significantly to respond to the evolution of hydrogen as a main topic on the European policy agenda. Beginning with the launch of the European Green Deal and continuing with the Hydrogen Strategy and the setting-up of the European Clean Hydrogen Alliance, hydrogen has benefited from greater attention from policymakers and the media alike, which culminated in the organisation of the first edition of the European Hydrogen Week (EHW), including the European Hydrogen Forum. Since public awareness remains a critical issue for the deployment of FCH technologies, several communication activities aimed to raise awareness and to reach out to a more diverse audience.

To respond to this specific context, as well as to the challenges created by the COVID-19 pandemic, the FCH 2 JU adapted its communication objectives and tools accordingly during the year, with a focus on media outreach and online communication.

More specifically, it enhanced its media efforts, turned to organising online events and made several upgrades to its website. In addition, it continued to build on the programme's success stories to demonstrate the benefits of the technology as well as its results.

The key communication themes across the year included:

- Hydrogen is a priority area for the Green Deal and ultimately for a clean and circular economy
- There is a growing political momentum for FCH technology
- FCH 2 JU is a successful partnership between the EU, research and industry, which has achieved breakthroughs for European R&I
- Programme success stories: concrete benefits for European citizens, socio-economic benefits, benefits to and involvement of SMEs, etc.
- Hydrogen for aviation (hydrogen is 'taking off')
- International cooperation under Mission Innovation
- The launch of the MI Hydrogen Valley Platform, the first comprehensive information-sharing platform on hydrogen valleys around the globe
- The development of hydrogen valleys and hydrogen islands
- 2020 Call for proposals
- The development of Project development assistance for regions (PDA)[204]

204 https://www.fch.europa.eu/page/going-fch-ju-pda-regions

Target audiences

The audiences targeted by the FCH 2 JU communication strategy in 2020 were:

- Policymakers: EU institutions (European Commission, European Parliament, Committee of the Regions, Council of the EU), individual Member States (relevant representatives of governments and permanent representations), municipalities and regional authorities
- FCH stakeholders (governance: European Commission, Hydrogen Europe, Hydrogen Europe Research, National Contact Points, technical experts, associations, etc.)
- Current FCH beneficiaries
- Potential FCH beneficiaries
- Research community
- Decision supporters/multipliers (civil society, associations, NGOs)
- General public.

The FCH 2 JU continued to reach out to key actors from the **European institutions** to keep them informed about its activities and results. This translated into the organisation of several joint events in cooperation with various EC DGs: participation in the EU Sustainable Energy Week (**EUSEW**) in cooperation with DG ENER and organisation of the European Hydrogen Forum (with DG GROW).

The programme communications also targeted **potential (new) participants** in the FCH 2 JU's Calls for proposals, through up-to-date, relevant information provided via online channels (website, news updates, social media) and during events, such as the annual Info Day organised around the launch of the Call for proposals and the Coordinators' Day, leading to the signature of the GAs.

The participation of a wider public was stimulated by intensifying activity on social media channels.

Cooperation with other JUs (Clean Sky in particular) enabled the FCH 2 JU to reach out to stakeholders from the aviation sector.

2.1.2 PUBLIC OUTREACH ACTIVITIES – EVENTS

The FCH 2 JU turned to the organisation of online events throughout 2020. Many provided opportunities to reach out to a wider audience as well as employing a full range of communication activities, including webstreaming, social media promotion, and media engagement. Events also served as an anchor point to double the newsletter subscribers' database – consequently, FCH 2 JU news items and newsletters now reach over 10 000 people. The Joint Undertaking's flagship events – the European Hydrogen Forum (previously known as the Stakeholders Forum) and the FCH JU Awards – were once again at the centre of both policy and communication efforts.

First edition of European Hydrogen Week – November 2020

From 23 to 27 November 2020, an entire week of events was dedicated to the essential role of hydrogen in reaching the EU's commitment to achieve carbon neutrality by 2050. Highlights included the **European Hydrogen Forum**, a policy conference entitled '**PrioritHy**', under the German Presidency, the **FCH JU Awards**, as well as the **PRD**, which provided an excellent visibility platform for more than 100 projects currently ongoing under FCH 2 JU.

Over 5 000 delegates from industry, research, academia, the EU, and national and local authorities attended the **European Hydrogen Forum**[205] with the theme '**Kick-starting the EU hydrogen industry to achieve the EU climate goals**'. They participated in panel discussions, smart talks and hundreds of matchmaking opportunities on the deployment of clean hydrogen, building links between EU funding and financing instruments, and driving innovation through dedicated research projects.

205 https://www.fch.europa.eu/news/european-hydrogen-forum-europe-must-work-keep-its-lead-hydrogen-energy

In addition, the **PrioritHy policy conference**[206] was organised together with Germany's National Organisation Hydrogen and Fuel Cell Technology (NOW) GmbH on the occasion of the German Presidency of the Council of the European Union. Discussions covered European and national strategies – notably in the host country Germany – along with examples of experimental hydrogen regions, city and regional partnerships for hydrogen, national and EU funding, FCH and EU initiatives, and the role of international cooperation, with contributions from ministers in Chile, Morocco and Portugal as well as partners in Norway, the USA and Australia.

In addition, the **FCH JU Awards**[207] took place for the third time in 2020. Different projects were awarded in the three award categories (best outreach, best success story and best innovation) and their outstanding achievements were celebrated.

During the week, we welcomed attendees from over 60 countries, more than 100 speakers, over 260 project results, convening an overall online audience of over 15 000 participants.

FCH 2 JU Info Day – 27 January 2020

The Info Day[208] was an opportunity for potential participants to receive further insights into the description of the topics and rules for participation in the 2020 Call for proposals, and to benefit from networking opportunities. The event, which was organised in the White Atrium premises in Brussels, included a brokerage session. It was broadcast live and around 100 participants joined on-site.

Coordinators' Day – 10 September 2020

Following the evaluation of the proposals received in the 2020 Call, the FCH 2 JU invited the coordinators of the successful projects for a day of presentations (online event)[209] covering all the necessary details on the preparation and signature of a GA.

Webinar on hydrogen for aviation – 22 June 2020

A new independent study, commissioned by Clean Sky 2 and Fuel Cells and Hydrogen 2 Joint Undertakings on hydrogen's potential for use in aviation, was presented at an online event on 22 June. It featured Adina-Ioana Vălean, European Commissioner for Transport, and Patrick Child, Deputy Director-General of the Directorate-General for Research and Innovation at the EC as keynote speakers, in addition to leading industry representatives.

206 https://www.fch.europa.eu/press-releases/hydrogen-green-recovery-growth-and-jobs

207 https://www.fch.europa.eu/news/innovators-accelerate-european-fuel-cell-success

208 https://www.fch.europa.eu/news/info-day-2020-%E2%80%93-presentations-and-videos-day

209 https://www.fch.europa.eu/news/coordinators-day-2020-preparations-grant-agreements-have-commenced

Public launch of the Fuel Cell Hydrogen Observatory (FCHO) – 15 September 2020

Within the framework of the launch of the portal, an event was organised to bring together the relevant stakeholders, provide information on the FCHO and enable the first feedback on the project. The project consortium presented the key analytical results to give users an insight into the functionalities of the portal and the information that can be retrieved.

Webinar on moving electrolysers to the gigawatt scale – 29 October 2020

In cooperation with ISPT, a Dutch clean-energy think-tank, the FCH 2 JU organised a half-day webinar[210] focusing on the scale-up of green hydrogen production. ISPT launched and presented their baseline study design of a gigawatt electrolyser plant for green hydrogen production, which was followed by a discussion with representatives from global leading countries in the sector.

Events under the umbrella of the European Commission

EUSEW 2020

On 20 June 2020, as part of the EU Sustainable Energy Week (EUSEW), FCH 2 JU hosted a session on '**Hydrogen islands and the role of hydrogen in the economic recovery**'. Participants discussed the elements needed to develop and implement an integrated approach to ramping up the use of hydrogen in different European island regions. They looked at policy, finance/investments, business models, local (regional) contexts and technology, among other issues, to see how the development of hydrogen valleys can foster economic growth on European islands while responding to local energy needs and reducing pollution.

18th EU Regions Week

As part of the annual European Week of Regions and Cities, organised by DG REGIO and the European Committee of the Regions, FCH 2 JU organised a session on '**Green hydrogen mobility for regions**', together with Energie Burgenland and the State of Burgenland. The event gave the floor to several European regions which have developed an integrated approach to decarbonise their transport systems by deploying green hydrogen technology. During the discussion, the regions' representatives shared their plans and experiences and addressed questions from the audience regarding challenges and opportunities on implementing a hydrogen economy at a regional and communal level.

2.1.2 PUBLIC OUTREACH ACTIVITIES – MEDIA

For the FCH 2 JU, 2020 marked a milestone in terms of outreach and brand recognition through a comprehensive media plan. As a result, the FCH 2 JU expanded its media and social media presence through a proactive approach and targeted partnerships.

The objectives of the media plan were to:

- Increase FCH 2 JU's brand awareness
- Promote FCH utilisation as Europe's best available option to store clean energy on a large scale
- Raise awareness on the benefits of clean hydrogen for the economy and the environment and as a clean fuel for clean mobility

210 https://www.fch.europa.eu/news/invitation-webinar-moving-electrolysers-gigawatt-scale

- Highlight the FCH 2 JU's mission and achievements among EU influencers in Brussels and beyond.

- Several opportunities were pursued throughout the year, illustrating greater media interest in topics covering green sustainable energy and transport. A mix of specialist, local and national media covered the partnership, and additional exposure was generated through the FCH 2 JU-funded projects. Media coverage was generated mainly through earned media, with paid partnerships set up with Politico and EurActiv.

The FCH 2 JU has been supporting the hydrogen section in EurActiv's Energy and Environment hub, as well as the Hydrogène and Wasserstoff sections on euractiv.fr and euractiv.de, respectively. The sections have included ongoing editorial coverage of relevant issues, based on direct contact with EurActiv journalists. This section also gave the FCH 2 JU more visibility with the inclusion of its logo and branded banners among other elements displayed on the web page. These were visible on the section page and on all the articles uploaded in it. Between May and December 2020, the section generated 92 148 page views from 69 576 unique visitors.

In the context of the first edition of the EHW, which took place from 23-27 November 2020, **Politico** ran promotional banners to promote the event, boost registrations and views while reaching out to a large target audience, comprising European policymakers, industry, the scientific community, as well as the general public. The campaign was divided into two waves:

1) The first waves were aimed at redirecting the reader to the event registration page ('register here' spots) in the weeks leading up to the event – using banners and a homepage takeover.

2) The second wave was intended to boost participation using banners during the event with a call-to-action to redirect readers to the FCH 2 JU online streaming portal of the event.

- The online banners also helped increase FCH 2 JU brand awareness:

Politico also ran the joint campaign with Clean Sky JU achieving excellent results around the launch of the study on hydrogen in aviation: https://www.politico.eu/sponsored-content/hydrogen-powered-aviation-is-ready-for-take-off/.

In addition, the launch event of the FCHO benefited from organic outreach through Politico's dedicated newsletter **Morning Energy and Climate**.

The **partnership with H2 View**, a new platform to support and promote the growing hydrogen economy, aimed to promote the FCH 2 JU projects and success stories within a new section entitled 'Pillars of Progress', as well as with monthly opinion columns from the FCH 2 JU ED.

According to the statistics received, throughout 2020, the Pillars of Progress series has been one of the FCH 2 JU's most popular ones, showing positive statistics across the board – and it looks set to continue receiving positive attention in 2021.

Throughout 2020, FCH 2 JU articles showed a strong number of impressions[211], with an average of 4 819 per article. Engagement with the articles across our social platforms has also been high – registering an average engagement per story of 110 and an engagement rate of 2.29 % (well above the media industry average of 0.01 % – 0.95 %).

The first edition of the EHW allowed us to test other media partners – the **Brussels Times**, a local publication read by a heterogeneous English-speaking community in Brussels. It reaches around 3 million readers/month. Previous to the EHW, the publication's home page featured a sponsored article promoting the event.

Other media

Below is a non-exhaustive list of articles published by European, technical and national media, in which FCH 2 JU was specifically mentioned:

- **Euronews:** https://www.euronews.com/2020/01/24/europe-s-hydrogen-revolution-the-promise-of-power-without-pollution; https://www.euronews.com/2020/07/10/explainer-why-is-the-eu-commission-betting-on-hydrogen-for-a-cleaner-future
- **H2-international:** promotional banner campaign prior to the EHW editorial signed by Bart Biebuyck
- Sustainable Bus Magazine
- EuroPost
- Gas Transition Magazine
- FuelCellsWorks

Additional exposure was achieved through FCH 2 JU-funded projects. Flagship projects, such as REMOTE, H2ME, REFHYNE, BIG HIT, MULTIPLHY, H2Ports, REVIVE, JIVE, DEMOSOFC, H2FUTURE, etc. benefited from visibility both on the international and national level. Some of the media outlets in which these projects were featured included H2 View, H2-international, PetrolPlaza, FuelCellsWorks, Sustainable Bus, EurActiv, H2IT, Valencia Plaza, Renewable Energy Magazine, Electrive, Rinnovabili, Renewables Now, Frontiers in Energy Research, Railway Gazette, Corresponsables, El Economista, Nexotrans, Informationsdienst Wissenschaft, IEA, etc.

Social media

Campaigns in the media and online events have been driving website and social-media traffic throughout the year.

211 An impression refers to each time a person sees an article on a social platform – this high level shows great brand recognition.

In 2020, social media accounts (Twitter and LinkedIn) recorded a constant rise in the number of followers – an average of 140 new followers for Twitter and approximately 860 new followers on LinkedIn[212]). Other KPIs also show that events and studies tend to increase the engagement rate of FCH 2 JU posts (e.g. the most commented posts on LinkedIn in 2020 were those referring to the hydrogen-powered aviation and the EHW social media campaign). The social media schedule enabled FCH 2 JU not only to boost visibility on social media but also to keep track of its projects' communication efforts.

FCH 2 JU ran a dedicated social media campaign for the EHW in November. The event itself was broadcast live on Twitter where the posts generated a total of 189 448 organic impressions. The specific hashtag created #EUHydrogenWeek was very successful in reaching 4 360 453 people during the event. On LinkedIn, the content generated 3.2 times more impressions (54 410) than last year with a total of 2 229 engagements. As a bonus, through the event's social media campaign alone, the FCH 2 JU gained 440 new followers on LinkedIn in a single week.

2.1.3 COMMUNICATION ON PROJECT RESULTS

FCH JU Awards

The 2020 FCH JU Awards were presented online on 24 November 2020 during the first European Hydrogen Week, with more than 1 000 attendees signed up to applaud the strength and diversity of European FC innovation. The first two awards — the best success story and best innovation — were chosen by public vote from 21 nominees.

The best success story of the year was 'Advanced tools for better-performing stationary fuel-cell systems'[213], which received over 60 % of the vote in its category. A series of projects (D-CODE[214], DESIGN[215], DIAMOND[216], GENIUS[217], HEALTH-CODE[218], INSIGHT[219] and now RUBY[220]) have developed IT-based tools that quickly detect faults in FC stacks. The technology boosts the reliability of stationary FC systems, facilitates their maintenance and reduces associated costs, increasing the already strong case for on-site clean power generation. The award was presented by Valérie Bouillon-Delporte, President of Hydrogen Europe and Chair of the FCH 2 JU GB.

The MAMA-MEA[221] project, led by Johnson Matthey Fuel Cells Limited, received the most votes for best innovation for its revolutionary approach to producing FC membrane electrode assemblies. An additive manufacturing process replaces assembly from individual layers to meet demand from manufacturers for reliable low-waste production. This helps them to compete on cost and quality in the booming PEMFC market.

On-site generation features in the best outreach award, which went to EVERYWH2ERE[222]. The project has designed mobile FC generators that can power festivals, events and construction sites safely without the noise and pollution of diesel generators. Eight of the plug-and-play generators, built entirely from European components, are being trialled across Europe at events such as the Berlinale (DE) and Cannes Film Festival (FR) before commercialisation in 2025.

Synergies with project communications

Overall, the FCH 2 JU's **communication with project partners** set out to increase synergies and amplify the outcome of its communication activities. This is why, in 2020, the FCH launched a comprehensive exercise with the aim of gathering and analysing project communication plans.

212 LinkedIn included the 'New followers' feature on their Analytics platform, starting from October 2020.

213 https://www.fch.europa.eu/sites/default/files/FCH%20Docs/EG0220766ENN_002%20%28ID%209876559%29.pdf

214 https://www.d-code.unisa.it/

215 https://cordis.europa.eu/project/id/256693

216 https://cordis.europa.eu/project/id/621208

217 https://www.fch.europa.eu/page/stationary-power-production-and-combined-heat-and-power#GENIUS

218 https://pemfc.health-code.eu/

219 http://insight-project.eu/

220 https://www.rubyproject.eu/

221 https://www.mama-mea.eu/

222 https://www.everywh2ere.eu/

Collaboration with the CORDIS website

Collaboration with CORDIS continued in 2020, with the following projects featured in CORDIS news throughout the year:

ELY4OFF: https://cordis.europa.eu/article/id/418019-water-electrolysis-a-promising-remedy-for-the-off-grid-solar-energy-storage-problem

HEATSTACK: https://cordis.europa.eu/article/id/415405-a-giant-leap-to-commercialisation-for-residential-fuel-cell-combined-heat-and-power?WT.mc_id=exp

GIANTLEAP: https://cordis.europa.eu/article/id/415405-a-giant-leap-to-commercialisation-for-residential-fuel-cell-combined-heat-and-power

HySTOC: https://cordis.europa.eu/article/id/421415-safe-and-reliable-hystoc-s-promise-for-the-future-of-hydrogen-supply

Projects in the media[223]

Djewels:

- https://www.spglobal.com/platts/en/market-insights/latest-news/electric-power/012420-dutch-20-mw-green-hydrogen-electrolyzer-project-secures-eu-funding
- https://www.rechargenews.com/transition/europes-largest-green-hydrogen-project-awarded-11m-grant-by-eu-body/2-1-743199

Hypster: https://www.lavoixdelain.fr/actualite-42666-etrez-va-stocker-le-nouvel-or-vert-l-hydrogene-renouvelable

H2ME: https://www.petrolplaza.com/news/24694

Hydrogen Valley South Tyrol: https://www.s3vanguardinitiative.eu/news/vanguard-member-south-tyrol-selected-lighthouse-project-mission-innovation

Giantleap: https://www.sustainable-bus.com/news/vdl-hydrogen-bus-connexxion/

CertifHy: https://www.h2-international.com/tag/primary-energy/

ZEFER: https://fuelcellsworks.com/news/toyota-mirai-fleet-keeps-key-workers-safe-during-lockdown/

Waste-to-Wheels: https://www.lavenir.net/cnt/dmf20200529_01478987/feu-vert-de-l-executif-regional-pour-une-station-d-hydrogene

H2PORTS:

- https://valenciaplaza.com/la-estacion-movil-de-hidrogeno-llegara-en-2021-al-puerto-de-valencia;
- https://www.hellenicshippingnews.com/futuristic-ports-pilot-schemes-explore-use-of-5g-and-hydrogen-fuel-to-develop-ports-of-tomorrow/
- http://www.nexotrans.com/noticia/100186/NEXOLOG/Pedro-Sanchez-destaca-el-proyecto-H2Ports-de-Valenciaport.html

HEAVENN and BIG HIT:

- https://www.euractiv.com/section/energy/news/dutch-pin-hopes-on-hydrogen-valley-to-revive-declining-gas-region,
- https://www.euractiv.com/section/energy/news/from-hydrogen-islands-to-hydrogen-valleys/

JIVE:

- https://www.7sur7.be/ecologie/des-bus-du-tec-charleroi-vont-rouler-a-l-hydrogene~aacd0a8a/?referrer=https://www.fch.europa.eu/page/newsletter-archive/3105;
- https://www.sustainable-bus.com/fuel-cell/caetanobus-tmb-barcelona-hydrogen-buses/

JIVE 2: https://www.electrive.com/2020/06/17/barcelona-releases-tender-for-8-hydrogen-buses/

REVIVE: https://www.renewableenergymagazine.com/miscellaneous/powercell-participates-in-eu-project-which-will-20200709

DEMOSOFC: https://www.rinnovabili.it/energia/efficienza-energetica/demosofc-energia-alta-efficienza-zero-emissioni/

223 Please note that the list below is indicative, based on the feedback received from projects during the data collection exercise, rather than exhaustive.

HyCoRA: https://www.frontiersin.org/articles/10.3389/fenrg.2020.585334/full?&utm_source=Email_to_authors_&utm_medium=Email&utm_content=T1_11.5e1_author&utm_campaign=Email_publication&field=&journalName=Frontiers_in_Energy_Research&id=585334

COSMHYC: https://idw-online.de/de/news758725

H2FUTURE: https://www.iea.org/articles/decarbonising-industry-with-green-hydrogen

2.1.4 PUBLICATIONS

The first issues of the **FCH JU newsletter** were released in 2020 and sent out to a database of newsletter subscribers. The newsletter, based on the European Media Monitoring tool, provided by the JRC, includes news about the programme, the projects and policy updates and relevant news from across the world. It is sent to a database of currently[224] more than 10 000 subscribers and complements the 'news updates' the FCH 2 JU sends out on a case-by-case basis to announce milestones and events.

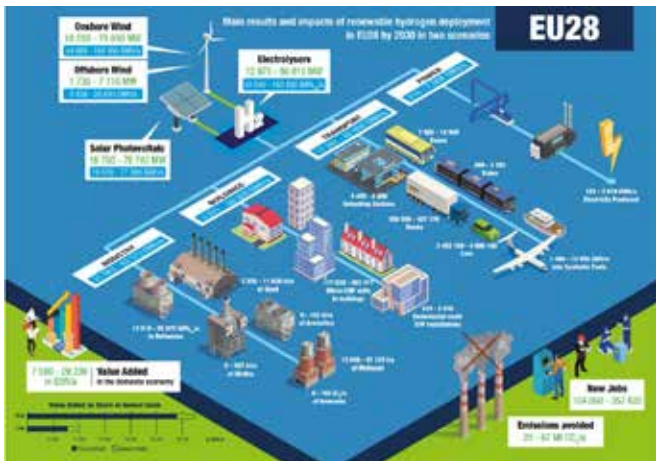
In addition, the FCH 2 JU produced and promoted the following publications (available on the FCH 2 JU website) through its newsletter and social media channels:

An updated edition of the Success Stories Brochure[225] was released ahead of the PRD/European Hydrogen Forum. Individual projects are presented in a new, easy-to-read format enabling the clear presentation of results plus the impact of each project on the clean energy transition.

The **Study on Hydrogen for Aviation**[226] was published in June 2020 during a joint webinar organised with the Clean Sky Joint Undertaking. A joint press release was sent out to promote the study results to the specialised media.

The **Study on Fuel Cells Hydrogen Trucks**[227] was launched with a dedicated session during the European Hydrogen Week, which featured the European Commissioner for Transport and a number of high-level industry representatives. The full study was published on 15 December 2020.

The study on **Opportunities for Hydrogen Energy Technologies Considering the National Energy & Climate Plans**[228] was published on 31 August 2020. The study analyses the role of hydrogen in the NECPs and identifies and highlights opportunities for hydrogen technologies to contribute to the effective and efficient achievement of the 2030 climate and energy targets of the EU and its Member States.



224 January 2021

225 https://www.fch.europa.eu/success-story/2020-success-stories

226 https://www.fch.europa.eu/publications/hydrogen-powered-aviation

227 https://www.fch.europa.eu/publications/study-fuel-cells-hydrogen-trucks

228 https://www.fch.europa.eu/publications/opportunities-hydrogen-energy-technologies-considering-national-energy-climate-plans

2.2 LEGAL AND FINANCIAL FRAMEWORK

During 2020, the following procedures were drafted or updated and adopted:

- **Decision of the Governing Board of the Fuel Cells and Hydrogen 2 Joint Undertaking (FCH 2 JU) no. FCH-GB-2020-04 laying down internal rules concerning restrictions of certain rights of data subjects in relation to processing of personal data in the framework of the functioning of the FCH 2 JU**

In accordance with Article 25(1) of Regulation (EU) 2018/1725, restrictions of the application of Articles 14 to 22, 35 and 36, as well as Article 4 of that Regulation, insofar as those provisions correspond to the rights and obligations provided for in Articles 14 to 22, should be based on internal rules to be adopted by the JU, where these are not based on legal acts adopted on the basis of the Treaties. In order to comply with this legal obligation, internal implemented rules have been adopted by the Governing Board, further to the prior consultation of the European Data Protection Supervisor (EDPS).

The Rules were published in the EU Official Journal on 17 July 2020 as well as on the FCH 2 JU website (under the section 'Your rights'). The internal rules entered into force on the twentieth day following publication.

Data protection

As an EU body applying Regulation (EU) 2018/1725[229], in the course of 2020, the following measures have been taken:

- In accordance with Article 31 (5) of Regulation (EU) 2018/1725, the FCH 2 JU has migrated its register of processing operations into a fully digital tool and has made the register publicly available. The 'GDPR Register' is available for consultation on the FCH 2 JU website[230].

- Further to audit activities monitoring compliance efforts by EU bodies, the EDPS declared in 2020 the FCH 2 JU as fully compliant with regard to its obligations under Article 31 (5) of Regulation (EU) 2018/1725.

- Within the same efforts of ensuring data protection is thoroughly embedded in the everyday work of the PO, a dedicated training on GDPR Central was given to staff members to ensure the register is kept up to date and in line with the JUs' activities. Furthermore, the section on data protection on the intranet has been revised and a different approach is currently under way for displaying all information under Article 15 to staff members in the form of a compendium. The compendium is expected to be finalised in the course of 2021.

- The dedicated tool for cookies and consent management (provided further to a public procurement procedure by OneTrust) entered into production during the second quarter of 2020. The FCH 2 JU website has a cookies banner and a preference centre, allowing for additional information and options for visitors to the website to be able to exert their rights in accordance with the applicable rules. Furthermore, a dedicated section on the cookies has been set up[231] under the 'Privacy Policy' web page[232], informing visitors on the data the FCH 2 JU collects via its analytics tool – Europa Analytics. The Europa Analytics tool produced the first traffic and usage statistics for the FCH 2 JU website during the summer.

- Jointly with Shift2Rail JU, ECSEL JU, IMI 2 JU, BBI JU, and Clean Sky 2 JU, a data protection impact assessment has been carried out for Microsoft Office 365 services, Azure AD, Windows 10 and Office 2016, with the aim, on the one hand, of assessing the compliance of the current ICT set up with data-protection guidelines and rules and, on the other hand, in view of the possible implementation of Microsoft Office 365. Further to the conclusions of the data-protection impact assessment, an action plan has been set up providing a set of necessary mitigation measures. Implementation of the identified mitigation measures is under way and is expected to be finalised for four selected Microsoft Office 365 assets in the course of 2021.

229 Regulation (EU) 2018/1725 of the European Parliament and of the Council of 23 October 2018 on the protection of natural persons with regard to the processing of personal data by the Union institutions, bodies, offices and agencies and on the free movement of such data, and repealing Regulation (EC) No. 45/2001 and Decision No. 1247/2002/EC (Text with EEA relevance.); OJ L 295, 21.11.2018, pp. 39-98.

230 https://www.fch.europa.eu/page/fch-2-ju-data-protection-line-central-register

231 https://www.fch.europa.eu/sites/default/files/Cookies%20Webpage%20version%20april%202020.pdf

232 https://www.fch.europa.eu/node/514

2.3 BUDGETARY AND FINANCIAL MANAGEMENT

2.3.1 BUDGET

The FCH 2 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 as well as the costs associated with the recruitment procedure and representational costs;
- Title 2 covers the costs associated with the functioning of the PO, such as renting premises, IT needs, expenses related to external communications, experts' fees and the cost of *ex-post* audits;
- Title 3 covers the operational activities of FCH 2 JU for both the FP7 and H2020 programmes.

Compared to 2019, the 2020 commitment appropriations increased by 14 % whereas payment appropriations were reduced by 9 %.

There were four budget transfers and one amendment in 2020. The amendment, which was adopted by the FCH 2 JU GB on 20 April 2020, introduced unused administrative and operational payment appropriations carried over from 2019.

An overview of the initial budget, the amendments and transfers is presented below:

TABLE 13: BUDGET EVOLUTION

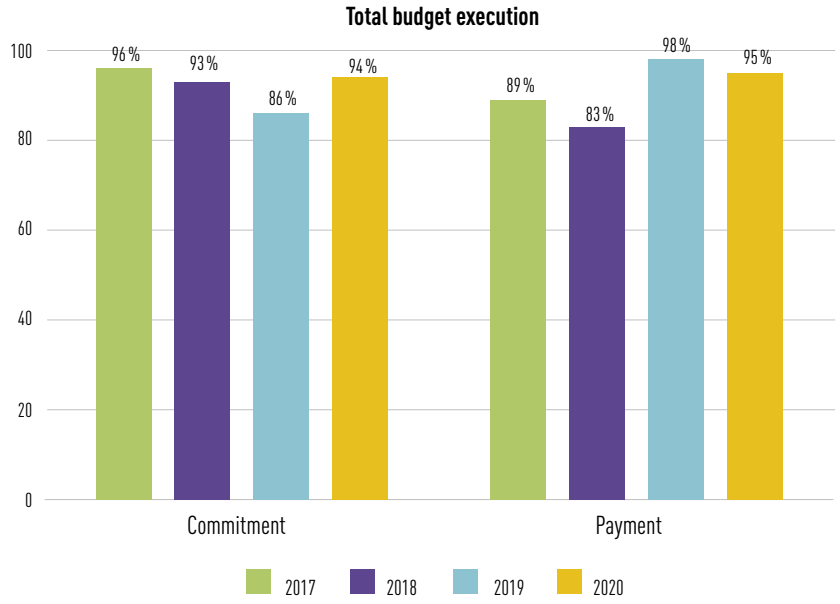
BUDGET 2020 (IN EUR)									
	VOTED BUDGET		AMENDMENTS		TRANSFERS		ASSIGNED REVENUES	FINAL BUDGET	
	CA	PA	CA	PA	CA	PA	CA+PA	CA	PA
EU operational FP7		3 935 268		586 054				0	4 521 322
EU administrative	2 381 733	2 381 733						2 381 733	2 381 733
Hydrogen Europe	2 048 290	2 048 290						2 048 290	2 048 290
Hydrogen Europe Research	333 443	333 443						333 443	333 443
EU operational H2020	81 510 246	76 127 865						81 510 246	76 127 865
Reactivations from previous years	14 004 311	11 796 696	130 394	2 746 431				14 134 705	14 543 127
JTI revenues							3 823 225	3 823 225	3 823 225
Total revenue	**100 278 023**	**96 623 295**	**130 394**	**3 332 485**	**0**	**0**	**3 823 225**	**104 231 642**	**103 779 005**

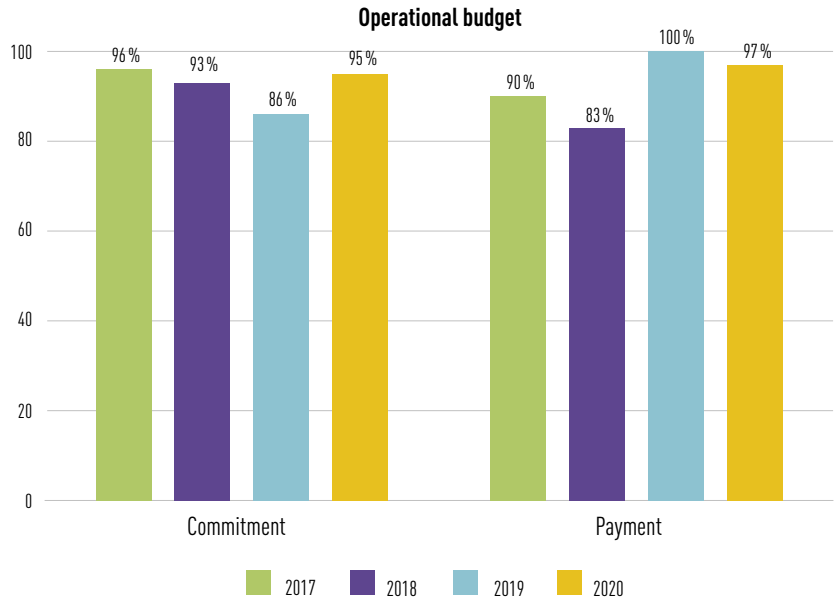
BUDGET 2020 (IN EUR)									
	VOTED BUDGET		AMENDMENTS		TRANSFERS		ASSIGNED REVENUES	FINAL BUDGET	
	CA	PA	CA	PA	CA	PA	CA+PA	CA	PA
Expenditure									
Title 1	3 786 100	3 786 100		125 965			111	3 786 211	3 912 176
Title 2	1 944 400	1 944 400	119 756	863 477			32 429	2 096 584	2 840 306
Title 3 – FP7		4 337 752		886 054		-15 184	1 660 820	1 660 820	6 869 441
Title 3 – H2020	94 547 523	86 555 043	10 639	1 456 989		15 184	2 129 865	96 688 027	90 157 082
Total expenditure	**100 278 023**	**96 623 295**	**130 394**	**3 332 485**	**0**	**0**	**3 823 225**	**104 231 642**	**103 779 005**

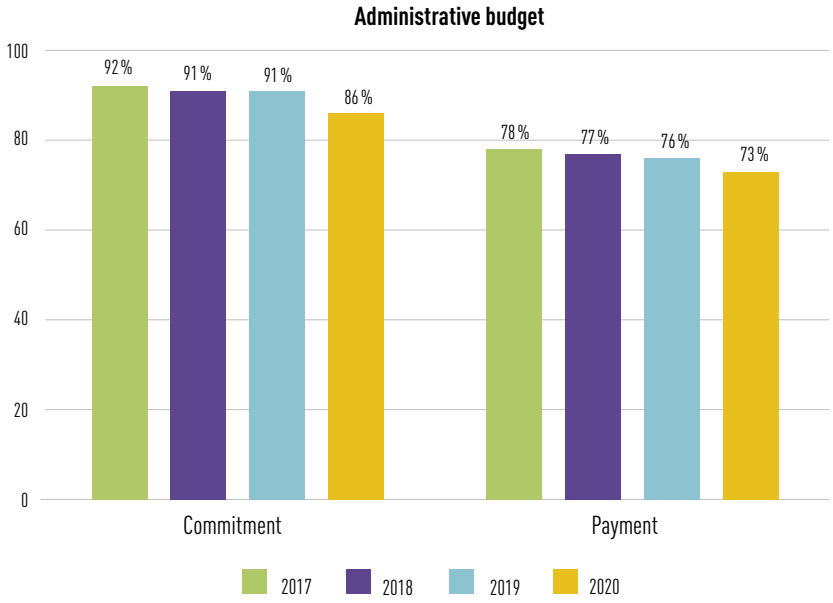
2.3.2 BUDGET EXECUTION

In 2020, the level of executed payments recorded the second-best performance in FCH history (95.3 %). This reveals the accuracy of the budget forecast and is the outcome of closely monitoring project spending and Time to Pay (TTP). The commitment execution rate increased by 8 percentage points compared to 2019 as a result of the successful Call 2020.

FIGURE 41: BUDGET EXECUTION







The execution rates for the operational budget reached 94.9 % and 96.9 % for commitments and payments, respectively, as shown in figure. The utilisation rates for administrative commitments and payments decreased compared to previous years because of COVID-19 restrictions and the change in working mode.

Further details on budget execution:

Revenues

FCH 2 JU revenue for 2020:

TABLE 14: IMPLEMENTATION OF REVENUES

REVENUE (IN EUR)	
HEADING	CASHED IN 2020
Operational expenditure, Union	80 649 187
Administrative expenditure, Union	2 381 733
Administrative expenditure, Hydrogen Europe	2 048 290
Administrative expenditure, Hydrogen Europe Research	333 443
Recoveries	3 863 870
Total	**89 276 523**

The amount shown above as cashed refers to revenue cashed and recorded in the budget.

Expenditure

TABLE 15: IMPLEMENTATION OF EXPENDITURE

Title Chapter Article Item	Heading	Commitment				Payment			
		Commitment appropriations (CA) (1)	Commitments (2)	Non-used appropriations (3)=(1)-(2)	% committed (4)=(2)/(1)	Payment appropriations (PA) (5)	Payments (6)	Non-used payment appropriations (7)=(5)-(6)	% paid (8)=(6)/(5)
1	STAFF EXPENDITURE								
1 1 0 0	Staff costs	3 556 111	3 281 888	274 222	92.3 %	3 652 654	3 256 817	395 838	89.2 %
1 2 0 0	Expenditure related to recruitment	5 000	576	4 424	11.5 %	5 000	576	4 424	11.5 %
1 3 0 0	Mission expenses	175 000	21 522	153 478	12.3 %	198 916	31 038	167 879	15.6 %
1 4 0 0	Socio-medical infrastructure and training	44 500	22 710	21 790	51.0 %	50 005	25 219	24 786	50.4 %
1 5 0 0	Entertainment and representation expenses	5 600	4 532	1 068	80.9 %	5 600	3 481	2 119	62.2 %
TOTAL TITLE 1		**3 786 211**	**3 331 228**	**454 983**	**88.0 %**	**3 912 176**	**3 317 130**	**595 046**	**84.8 %**
2	INFRASTRUCTURE								
2 0 0 0	Rentals	371 817	345 462	26 355	92.9 %	383 065	341 859	41 205	89.2 %
2 1 0 0	IT costs operational	426 275	411 491	14 785	96.5 %	663 679	382 205	281 474	57.6 %
2 2 0 0	Movable property and associated office equipment costs	5 000	0	5 000	0.00 %	5 000	0	5 000	0.00 %
2 3 0 0	Current administrative expenditure	11 000	7 937	3 063	72.2 %	11 859	5 622	6 237	47.4 %
2 4 0 0	Correspondence, postage and telecommunications	22 100	22 038	62	99.7 %	30 836	12 082	18 754	39.2 %
2 5 0 0	Meetings in general	60 000	14 962	45 038	24.9 %	63 721	18 227	45 494	28.6 %
2 6 0 0	Communication costs	576 753	524 705	52 048	91.0 %	848 458	371 568	476 890	43.8 %
2 7 0 0	Service contracts	262 239	148 087	114 152	56.5 %	454 734	209 952	244 782	46.2 %
2 8 0 0	Expert contracts and meetings	361 400	246 927	114 473	68.3 %	378 953	252 867	126 086	66.7 %
TOTAL TITLE 2		**2 096 584**	**1 721 607**	**374 977**	**82.1 %**	**2 840 306**	**1 594 383**	**1 245 923**	**56.1 %**
TOTAL TITLE 1+2		**5 882 795**	**5 052 835**	**829 960**	**85.9 %**	**6 752 481**	**4 911 513**	**1 840 969**	**72.7 %**
3	OPERATIONAL EXPENDITURE								
3 0 0 1	**FP7**	1 660 820	0	1 660 820	0.00 %	6 869 441	6 101 482	767 960	88.8 %
3 0 0 2	**H2020**	96 688 026	93 347 310	3 340 716	96.5 %	90 157 081	87 889 956	2 267 125	97.5 %
TOTAL TITLE 3		**98 348 846**	**93 347 310**	**5 001 537**	**94.9 %**	**97 026 523**	**93 991 438**	**3 035 085**	**96.9 %**
TOTAL		**104 231 641**	**98 400 145**	**5 831 497**	**94.4 %**	**103 779 004**	**98 902 951**	**4 876 053**	**95.3 %**

Administrative expenditure

The FCH 2 JU's administrative budget execution decreased to 85.9 % (90.8 % in 2019). Unused appropriations coming from the 2020 budget as well as those becoming available in 2020 from decommitments of previous years totalled EUR 920 065, of which EUR 43 500 had already been reactivated in the 2021 budget. The remaining EUR 876 565 can be reactivated in the 2021 or 2022 budget in accordance with FCH 2 JU financial rules.

Compared to 2019, the administrative expenses decreased by 2.0 % (EUR -101 474)

Staff expenditure (title 1) decreased by 1.3 % (EUR -42 649).

In particular, staff costs increased by 4.6 % (EUR +144 725), which was attributed to the effect of step advancements, reclassifications, indexation and additional interim staff required due to the departure of three staff members.

On the other hand, compared to 2019, there was a significant decrease in:

- Missions, by EUR 158 478 (decrease of 88.0 %), as a direct impact of travel restrictions.
- Socio-medical infrastructure and training by EUR 16 823 (decrease of 42.6 %), as a consequence of teleworking (reduced mobility costs), the closure of EC medical centres and overall restrictions preventing the organisation of away days.

Infrastructure expenses (under title 2) also fell by 3.3 % compared to 2019 (EUR -58 825).

Specifically, IT costs increased by 16.1 % (EUR +57 018) and telecommunication nearly doubled (EUR +11 378), the latter being attributed to the new mode of working and the extensive need for online meetings. Service contracts also increased by 24.2 % (EUR +28 837), mainly as a result of an increase in the costs of the Service Level Agreement (SLA) with DG BUDG.

On the other hand, compared to 2019, there was a decrease in:

- Catering costs (booked under meetings in general budget line) by 68.9 % (EUR -48 184), as the lockdown only permitted a few on-site meetings in the first 2 months of the year.
- Communication costs by 7.9 % (EUR -45 015) which is also attributed to the cancellation of many events and others going online with no cost involvement for FCH 2 JU.
- Expert contracts and meetings by 23.1 % (EUR -74 332) mainly due to the reduction in the number of mid-terms and final reviews (38 contracts with experts signed in 2020 compared to 54 in 2019) as well as the fact that, since most meetings were held online, limited travel and subsistence allowances were paid to reviewers in 2020. The impact of the latter is calculated at EUR 27 000.

To summarise, the COVID-19 impact on administration costs is calculated at EUR 284 000 or 4.8 % of the administrative budget. This is also the difference in the implementation rate between 2019 and 2020.

Operational expenditure

As regards **FP7 operational costs**, the execution rate on the payment appropriations reached 88.8 %, recording a decrease compared to 2019 (95.1 %). This is due to the non-submission of one final report and an underspend by one project that closed in 2020.

As regards the **H2020 operational costs** (call, studies, JRC and EHSP), the commitment execution rate reached 96.5 %, an improvement on 2019 (86.3 %), as a direct effect of the success of Call 2020.

In terms of payments, the implementation rate reached 97.5 %, marking the second-best performance for H2020.

Overview of programme implementation

The following tables give an overview of FP7 and H2020 implementation:

TABLE 16: IMPLEMENTATION OF FP7 PROGRAMME

FP7 (IN EUR)			
TYPE	EXECUTION UNTIL 31/12/2020	SUBSEQUENT YEARS	TOTAL
Commitments (operational costs)	428 477 494		428 477 494
Payments (operational costs)	421 414 747	4 367 997	425 782 744
Cumulative execution (operational costs)	**98.4 %**	**99.4 %**	**99.4 %**
Commitments (administrative costs)	30 658 610		30 658 610
Payments (administrative costs)	30 658 610		30 658 610
Cumulative execution (administrative costs)	**100.0 %**	**100.0 %**	**100.0 %**
Overall FP7 execution	**98.5 %**	**99.4 %**	**99.4 %**

As regards **operational costs:**

For FP7, the execution rate had reached 98.5 % at the end of 2020, based on the ratio payments to commitments. The commitments under operational costs refer to individual commitments for grants and studies. In total, there were 155 grant commitments and 13 operational commitments referring to procurement activities. Until 31 December 2020, from the 155 grant agreements signed, 1 project was cancelled, final payments were made for 151 projects, and 3 projects remain open. The amount shown under 'subsequent years' refers to the interim and final payments for these three projects.

TABLE 17: IMPLEMENTATION OF H2020 PROGRAMME

H2020 (IN EUR)			
TYPE	EXECUTION UNTIL 31/12/2020	SUBSEQUENT YEARS	TOTAL
Commitments (operational costs)	643 671 318	2 328 682	646 000 000
Payments (operational costs)	490 340 826	155 659 174	646 000 000
Cumulative execution (operational costs)	**76.2 %**	**100.0 %**	**100.0 %**
Commitments (administrative costs)	16 304 084	21 695 916	38 000 000
Payments (administrative costs)	15 383 181	22 616 819	38 000 000
Cumulative execution (administrative costs)	**94.4 %**	**100.0 %**	**100.0 %**
Overall H2020 execution	**76.6 %**	**100.0 %**	**100.0 %**

For **H2020**, the amount committed until the end of 2020 refers to the 131 individual commitments for H2020 projects and the balance from the global commitment of Call 2020 for one project not signed by the end of the year. In addition, it includes 21 studies contracted, 3 annual commitments for the European Hydrogen Safety Panel, 5 commitments for the JRC's annual work as well as 1 commitment for acquisition of the registry for certificates.

As regards the **administrative costs**, EUR 920 903 was committed in 2019 and 2020 but not paid (as services are ongoing and/or invoices pending); therefore, this will be carried forward to 2021 to respect remaining obligations.

Amendments signed in 2020

Besides assessing the periodic reports, FCH financial management also includes the processing of project amendments.

In 2020, the ED signed 52 H2020 amendments.

2.3.3 TIME TO PAY

Operational payments

In 2020, 4 FP7 and 55 H2020 reports (interim and final) were assessed (61 in 2019). The overall TTP for FP7 and H2020 combined slightly improved compared to 2019, from 71 to 67 days. The gross TTP (including any suspensions due to requests for clarifications and amendments) reached 117 days.

In more detail:

FP7

Four reports were assessed in 2020 (nine in 2019), of which two were final and two were interim.

The average TTP of these reports was 78 days (67 days in 2018). The gross TTP (235 days) increased from 2019 (162 days) as a result of a lengthy clarification process for an interim report.

H2020

The average Time To Grant (TTG) for the 22 signed projects from Call 2020 was 223, slightly quicker than for Call 2019 (230 days).

In 2020, 36 interim and 19 final reports were assessed with an average TTP of 66 days (71 in 2019). The gross time to assess was 98 days (101 in 2019).

Administrative payments

The average TTP for administrative payments (invoices from suppliers of goods, service providers and cost claims from experts/staff) was 15.8 days (16.3 in 2019). The number of late payments (1.8 %) marked the best performance in FCH records, improving the 2019 performance by 47 %. Strong monitoring measures on the open invoices contributed to this record.

2.4 PROCUREMENT AND CONTRACTS

The tender and contract management has been simplified as far as possible by following the inter-institutional procurement procedures launched by the EC and using the resulting multi-annual Framework Contracts. FCH 2 JU also cooperates with other Joint Undertakings on tendering needs in order to minimise the administrative effort.

As in previous years, most of FCH 2 JU's contracting was carried out under existing multi-annual Framework Contracts, except for operational procurement activities (see procurement studies under Section 1.4 Call for tenders). In terms of volume, procurement of studies and the managed IT services were the most significant procedures launched.

Launching and publishing a call for tender as well as receiving and opening tenders has been simplified by using eTendering, eNotices and eSubmission modules. The last of these was updated in 2020 to enable the automatic registration of tenders with the EC Document Management IT System (ARES). The FCH 2 JU is using the latest version of eSubmission and thus the publication, submission and reception of offers, opening and evaluation stages are now fully digital.

In addition, in 2020, the FCH 2 JU migrated to EU Sign, a software solution provided by the EC's DG DIGIT which allows a qualified electronic signature to be applied to documents. The FCH 2 JU now applies a QES on its contracts, which facilitates business processes by significantly reducing the time and cost of signing a contract in blue ink. In addition, QES – as applied via EU Sign – is legally binding as it is compliant with EU Regulation No. 910/2014 (eIDAS Regulation) for electronic transactions within the internal European market and provides a higher level of technical security.

The table below gives an overview of the contracts awarded in 2020, including the procedure used in each case and the name of the contractor(s). Only those contracts with a value exceeding EUR 15 000 are listed. It is noted that, at the end of 2020, the call for tender with reference FCH/Contract No. 282 for the operation and maintenance of the European HRS availability system (E-HRS) was under evaluation, with the Framework Contract expected to be signed in January 2021.

TABLE 18: CONTRACTS AWARDED IN 2020 (CONTRACTS OF > EUR 15 000)

TYPE OF CONTRACT	CONTRACT TITLE	CONTRACT REFERENCE	SELECTION PROCEDURE (IF APPLICABLE FOR CONTRACT AWARDS)	NAME OF CONTRACTOR	AMOUNT (IN EUR)
Framework Contract for services	Study on accelerating the deployment of Guarantees of Origin Schemes for Hydrogen and for the design of a Voluntary Scheme for compliance with REDII targets	FCH / OP /Contract No. 278	Open procedure	Hinicio SA	1 499 000
Specific	Study on accelerating the deployment of Guarantees of Origin Schemes for Hydrogen and for the design of a Voluntary Scheme for compliance with REDII targets	Specific contract No. 1	Specific contract under framework	Hinicio SA	1 011 000
Direct	Trucks study	FCH/OP/260	Open procedure	Roland Berger GmbH	299 000
Specific	Organisation of Hydrogen Week 2020	FWC/PCO/Lot3-20/017	Specific contract under framework	VO Communication SA	222 762
Specific	Managed IT services 2021	Specific contract No. 5	Specific contract under framework	RealDolmen NV	78 865
Specific	TRUST ITGM	Specific contract No. ITGM-000199	Specific contract under framework	Everis Spain SLU	51 343
Direct	Lease of hydrogen powered fuel cell car	FCH/CONTRACT 279	Negotiated procedure with three tenderers	MERCEDES-BENZ AG	49 920
Specific	Audits on annual accounts for financial years 2020 and 2021	SPECIFIC CONTRACT NO 04_01	Specific contract under framework	ERNST ET YOUNG REVISEURS D'ENTREPRISES	47 335
Specific	Editorial work 2020	FCH/Contract 227-2	Specific contract under framework	EUROPEAN SERVICE NETWORK SA	46 323
Specific	Interim services	FCH JU 2020 PO46	Specific contract under framework	RANDSTAD BELGIUM	37 723
Specific	Interim services	FCH JU 2020 PO76	Specific contract under framework	RANDSTAD BELGIUM	37 118
Specific	Interim services	FCH JU 2020 PO45	Specific contract under framework	RANDSTAD BELGIUM	31 621
Specific	Interim services	FCH JU 2020 PO44	Specific contract under framework	RANDSTAD BELGIUM	31 621
Specific	Interim services	FCH JU 2020 PO110	Specific contract under framework	RANDSTAD BELGIUM	31 359
Specific	Interim services	FCH JU 2020 PO79	Specific contract under framework	RANDSTAD BELGIUM	31 117
Specific	Interim services	FCH JU 2020 PO80	Specific contract under framework	RANDSTAD BELGIUM	31 039
Specific	Interim services	FCH JU 2020 PO60	Specific contract under framework	RANDSTAD BELGIUM	28 028
Specific	Ongoing services Eurodomain	Testa-ng II Ext – SC51	Specific contract under framework	DEUTSCHE TELEKOM BUSINESS SOLUTIONS	27 094
Specific	Production of a 40'' video, a 6'' bumper and editing for 3 pre-recorded video messages	AV0118 -FCH JU	Specific contract under framework	EUROPEAN SERVICE NETWORK SA	26 773
Specific	3x Logitech Meet-up + Barco CX-50 for Mngt touchscreens	Specific contract No. 2	Specific contract under framework	TELMACO SOCIETE ANONYME PRODUCTION	26 637
Specific	Visual identity and digital posters 2020	AV0104-FCH JU	Specific contract under framework	EUROPEAN SERVICE NETWORK SA	24 175

TYPE OF CONTRACT	CONTRACT TITLE	CONTRACT REFERENCE	SELECTION PROCEDURE (IF APPLICABLE FOR CONTRACT AWARDS)	NAME OF CONTRACTOR	AMOUNT (IN EUR)
Direct	Media buying services	FCH/Contract/274	Negotiated procedure with 1 tenderer	EURACTIV MEDIA NETWORK	22 500
Specific	FP7 audit 13th batch	2020-13-LB	Specific contract under framework	LUBBOCK FINE LIMITED	19 200
Specific	Media awareness campaign	FCH-1	Specific contract under framework	EUROPEAN SERVICE NETWORK SA	15 444
Specific	Teleconference costs WACS 08/05/2020-01/05/2021	Specific contract 2020 – SC61	Specific contract under framework	BT Global Services Belgium	15 000

2.5 IT AND LOGISTICS

The year 2020 was driven by the monitoring and continuous improvement of the IT Managed Services provided by RealDolmen for support services and CANCOM for hosting services. FCH 2 JU also finalised the transfer of the secured data communication line (Testa line) to Hamburg to secure access to the EC applications. The year was also marked by the delivery of the DPIA report on the deployment of Microsoft Office 365 delivered by Deloitte – see also Section 2.2. The last quarter was marked by the organisation and success of the first European Hydrogen Week as a hybrid virtual web conference with the largest audience ever.

Support to FCH core business

As in previous years, FCH 2 JU staff were assured adequate access to the complete set of EC applications for grant management. The roles of the Single Point of Contact for COMPASS and Local Authorisations Manager for ABAC again proved useful in dealing with workload and blocking situations in workflows. Close contacts were maintained with the CIC to ensure the successful implementation of H2020 Call 2020.

The urgent deployment of the Teams pilot project during the second quarter, due to the COVID-19 situation, was very helpful in enabling the FCH 2 JU to continue its normal business activities without interruption.

A close follow-up of the infrastructure-as-a-service (IaaS) solution and IT Managed Services contracts available to the JU has been performed and the following indicators supporting the new internal control framework can be mentioned:

- The business continuity was tested at several levels in 2020:

  - Infrastructure: telework resilience and efficiency during COVID-19 circumstances

  - Lost data: the last recovery from back-up occurred on 21 December

  - Lost server: the last recovery from snapshots occurred on 15 December.

- The quality and performance indicators of the IT Managed Services, and the downtime of the key systems are reported on a quarterly basis in the inter-JUs IT Governance Report.

- There are several sources of monitoring depending on the type of service: performance metrics of EC tools, ScienceLogic portal for the IT Infrastructure and end support, a specific portal for the IaaS cloud services, and Splunk from CERT-EU for the log files and security analysis.

Business support tools

The FCH 2 JU continued to adopt more common EU systems. Amongst them, the e-tendering provided by DG DIGIT was used for the first time in November enabling a smoother process, simplified interactions, and efficiency gains for the evaluation process.

The FCH 2 JU continued to use the shared Innovative Medicines Initiative Joint Undertaking (IMI JU) cloud application platform for time-management and selection procedures while, in parallel, preparing for SYSPER (the EC IT tool for human resources) implementation in February 2021.

The FCH 2 JU website is hosted by DG DIGIT under the NextEuropa services to ensure the stability and continuity of this essential tool for the external communication and visibility of the FCH programme. In this context, the website structure has been improved with:

- New social media links and better control of the cookies according to the EUDPR
- Improved media gallery
- The newsletter subscription process aligned with the EUDPR requirement for consent management
- News and newsletter templates and publications revisited.

As regards EUDPR implementation and its implications for the website, please refer to Section 2.2 (Legal and financial framework).

FCH internal support

The specific contract under the EC Framework Contract TESTA NG II for the provision of secured telecommunications was signed to enable the continuation of services in all Joint Undertakings. This contract has been adapted to support access as the main link from the data centre operated by CANCOM in Hamburg to the EC's IT services (Testa@Cancom). The obsolete equipment in the White Atrium building has been decommissioned. This technical option has been fully validated supporting, without any problems, the huge use of teleworking during the confinement. Its relevance has been confirmed with the European Labour Agency and European Railway Agency joining in November in addition to the six Joint Undertakings and the BEREC Office which also share this solution. This is highlighted by DG DIGIT as a good example of synergy, since the associated costs are minimised and shared amongst a wider community while the operational aspects have been simplified for the various actors.

FCH 2 JU will proceed with the deployment of Microsoft Office 365 (O365) as Software-as-a-service solution (SaaS). Deloitte carried out a data-protection impact assessment during the second quarter of 2020 and a list of mitigation measures were defined to secure the Microsoft product. The efforts are shared by the data protection, IT, document management and human resources officers of the six Joint Undertakings hosted in the White Atrium. Technical measures have been assessed by the IT officers since October and the implementation supported by the IT Managed Services provider while the other measures will be supported by a specific procurement (see section on procurement and contracts). Teams with Unified communications and collaboration features, SharePoint, OneDrive and Exchange Online were identified as priority assets to deploy in 2021.

The FCH 2 JU is the leading authority for the Framework Contract for the IT Managed Services provided for the six JUs hosted in the White Atrium building. The third specific contract for the associated services entered into force on 1 January 2021. The necessary specific contracts for the migration towards Microsoft Office 365 cloud solutions and support services were signed in December 2020, paving the way for the new IT landscape for 2021 (unified communication, collaboration platform, mobile device management).

The evolutive maintenance and support contract on the internally developed data-collection platform TRUST was signed in December. It was supported by the e-request platform provided by DG DIGIT and DG R&I's ITGM Framework Contract. This contract will cover the technical, security improvements, helpdesk and service requests support for a robust application as well as the evolutive maintenance to develop the functionalities of the platform.

As an enhancement of the applications regarding performance, usability and user interface, the Windows VPN solution available with Windows 10 is also being deployed to improve the end-user experience. It will gradually be deployed from January 2021 as an essential IT support for teleworking.

FCH 2 JU will also use the SYSTAL tool for recruitment which has been adopted by a number of EU agencies. The tool will be shared by five Joint Undertakings. A SLA was signed in October with BBI JU which leads the project. The tool is expected to go live before summer 2021 (see also Section 2.6).

Support was also provided at events using video broadcasting. The use of the web conference as a communication method increased significantly in 2020, with events in hybrid or complete virtual mode. As a result, there was a shift in the costs from missions to telecommunications. The technical coordination of Hydrogen Week, with the PRD as a full virtual web conference and the rest of the programme as a hybrid event was a great success. It demonstrated the need for well-equipped audio-visual studio(s), which turned into a project to convert at least one existing meeting room in December.

Logistics

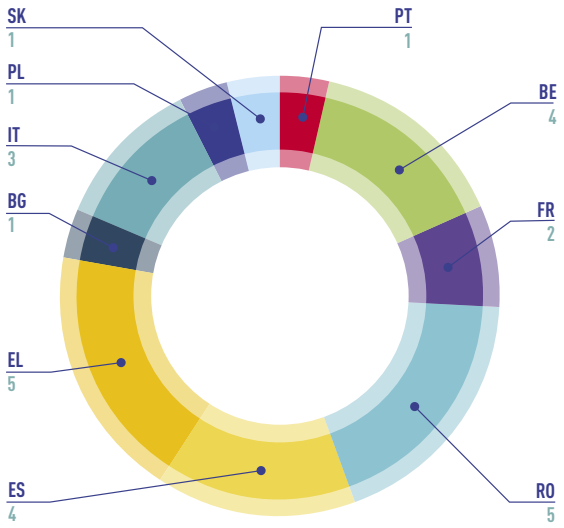
In addition, logistical support has been provided in the context of general administration. This encompasses the management of supply and maintenance of equipment, namely stationery, goods and services for administration, and includes the monitoring of services provided in particular through the Office des Infrastructures de Bruxelles (OIB), the translation centre and the Publications Office (OPOCE).

In 2020, one special achievement concerned implementation of the new internal telecommunication network equipment in the White Atrium, installed in collaboration with the other JUs. The IT service provider carried out the installation and configuration from the second quarter of 2020 until December, always taking into consideration the changing conditions due to COVID-19. A special focus was given to the Wi-Fi capacity to allow for any future office set-up arrangements (wireless/mobile offices, future/digital workplace, etc.).

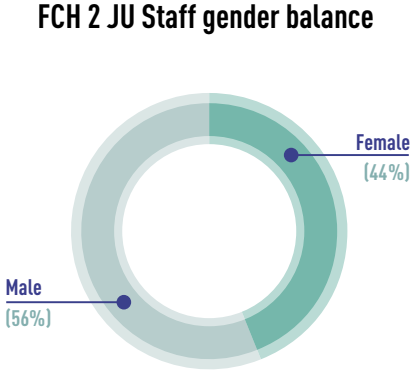
2.6 HUMAN RESOURCES

By the end of 2020, the FCH 2 JU PO comprised 27 statutory staff (24 temporary agents and 3 contract agents) and 2 seconded national experts (SNEs) representing 10 different EU Member States.

FIGURE 42: FCH 2 JU STAFF BY NATIONALITIES



In terms of gender distribution, 56 % are men and 44 % are women, with ages ranging from 35 to 63 years (average 49).



Details of the Staff Establishment Plan are shown in Annex 2.

The **COVID-19 situation** and the measures adopted by the Belgian authorities resulted in all staff **teleworking** from mid-March. The sudden change went smoothly as all staff are equipped with laptops and remote connection. Measures were taken to ensure the thorough cleaning of the office space, information on social distancing and other protection measures was displayed, and personnel protective equipment (face masks, gel dispensers) were put at the disposal of staff in case of the need to work at the office. With the temporary release of measures in the summer, a limited number of staff went to the office on a voluntary basis until telework became compulsory yet again from October. Staff was regularly informed of the situation by the ED.

Staff adapted well to the situation and attention was paid to maintaining good communication and to ensure staff well-being. In October 2020, together with the staff from six other Joint Undertakings' (SESAR, CS2, ECSEL, IMI2, BBI and S2R), FCH 2 JU staff participated in resilience training, facilitated by a professional certified coach. In addition, the training included breakout sessions to allow staff from all participating JUs to exchange views on working conditions. The success of the training led to the preparation of a follow-up programme shared by the seven JUs to be launched In February 2021.

Recruitment

An open-end call for an SNE was published in December 2019; the position was filled in July 2020 for an initial period of two years.

Three selection procedures were launched and completed in 2020 to replace staff who left the PO in the first quarter of the year. New staff (project officer, knowledge management officer, communication officer) took up their duties in July and September, respectively.

To provide support to the PO in communication and knowledge management and to cover the communication officer's maternity leave, short-term contracts for interim services were used in 2020. The PO also benefited from the contribution of one paid trainee who spent six months in the office supporting the work in the operations and communications unit.

Learning and development

The PO depends on the expertise and motivation of its staff to achieve its goals. In 2020, in accordance with the FCH 2 JU framework for **learning and development**, adopted by the GB in January 2018, and with the learning and development policy adopted by the ED in December 2018, emphasis on learning and development was pursued by identifying training needs and promoting professional development through training opportunities. Individual training needs were identified during the annual appraisal exercise in order to manage skills and ensure consistency in the professional and personal development of all staff in line with the PO's mission and tasks. This included both classroom and online training in languages, general soft skills and H2020 training, as well as on specific topics related to individual staff member's current jobs.

Due to COVID-19, the scheduled classroom courses where initially cancelled. Some were rescheduled and could be followed online. Internal trainings of shared interest were organised, mainly on COMPASS workflows (COPA – complementary payments), update on REPA (reporting and payment) and FINA (finalisation) workflows, as well as on ARES, data protection and the data protection register and on MS Teams. Special attention was also paid to fraud prevention: the anti-plagiarism tool became functional for the FCH 2 JU in July and a training session was organised internally to train all project officers and financial officers on its use. Furthermore 'Working together against corruption', a session organised by the European Anti-Fraud Office (OLAF) in December, saw many participants from FCH 2 JU.

Given the measures imposed due to COVID-19, it was not possible to have an away day. A virtual Christmas breakfast was arranged in December in which all staff members participated and it was appreciated by all.

Staff survey

A staff survey was launched and completed. The outcome was presented in June. Follow-up workshops were organised with the support of an HR professional to discuss further the needs at FCH 2 JU to improve the office dynamics and address the areas that need change and improvement. The work is expected to be completed in the first quarter of 2021.

Digitalisation of HR

As part of the 'second wave' of agencies preparing for the adoption of SYSPER, initiated in 2019, preparatory work was pursued with the aim of going live in February 2021. Further digitalisation of HR processes is expected in 2021 with the adoption of SYSTAL, a tool for recruitment procedures already in use in several EU agencies, for which the preparatory work started in 2020 (see also Section 2.5).

Other HR-related activities

The **Reclassification Exercise** 2020 was carried out and the decision on staff reclassified (five temporary agents and two contract agents) was adopted with reclassifications taking effect retroactively on 1 January 2020.

In accordance with the rules, the following **implementing rules** on staff regulations entered into force:

- Commission Decision C(2020) 4818 of 20/07/2020 amending the Commission Decision C(2011)1278 of 3 March 2011 on the general implementing provisions for Articles 11 and 12 of Annex VIII to the Staff Regulations on the transfer of pension rights, applies by analogy by FCH 2 JU GB decision FCH-GB-2020-10 of 15/10/2020

- Commission Decision C(2020) 1559 of 16 March 2020 amending Decision C(2013) 9051 of 16 December 2013 on leave, applies by analogy from 19/12/2020 (9 months after notification received from the Commission on 19/03/2020)

- Commission Decision C(2019)7822 of 30/10/2019 amending Commission Decision C(2004) 1318 of 7 April 2004 on the duties of Commission drivers, applies by analogy from 12/08/2020 (9 months after notification received from the Commission on 12/11/2019)

- Commission Decision C(2019)4231 of 12 June 2019 on conduct of administrative inquiries and disciplinary proceedings, applies by analogy from 19/03/2020 (9 months after notification received from the Commission on 17/06/2019)

As a member of the **European Union Network of Agencies**, the FCH 2 JU took part in the meetings and participated in various surveys and consultations on HR matters (including the 'back to the office' working group now renamed 'new ways of working').

03
GOVERNANCE

3.1 GOVERNING BOARD

The FCH 2 JU GB comprises three representatives from the EC representing the EU, six representatives from Hydrogen Europe and one from Hydrogen Europe Research. The GB chair is Valérie Bouillon-Delporte, president of Hydrogen Europe. The vice-chair was Patrick Child, Deputy Director-General of DG R&I, until 1 December 2020, when he was replaced by Rosalinde van der Vlies, Director of Clean Planet in DG Research and Innovation. In the last quarter of 2020, two representatives from Hydrogen Europe left and were replaced by two new representatives: Marco Liccardo (CNH Industrial) and Hege Rognø (Equinor).

During the year, the FCH 2 JU GB held three meetings: 2 April, 30 June and 28 October. Due to the COVID-19 situation all meetings were virtual.

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

- The first meeting was mainly dedicated to discussions on preparations for the Clean Hydrogen Partnership, the Green Deal, and on synergies between CHP and other initiatives.

- The June meeting included an update on progress in the preparations for the future Clean Hydrogen Partnership and a presentation of the revised Strategic Research and Innovation Agenda by Hydrogen Europe. The PO also made a proposal for the process and timeline for the preparation of the MAWP 2021-2027. The outcome of Call 2020 evaluations, which were subject to a written procedure for adoption of the Call results by the FCH 2 JU GB, was also presented.

- In October, the main topics included the latest developments on the Commission proposal for a Clean Hydrogen Partnership, the state of play of the MAWP 2021-2027, the use of operational budget 2020-2021, and the FCH 2 JU AWP and budget for 2021. It also included a presentation by the JRC of its work for the FCH 2 JU in 2020 and its plan for 2021.

The FCH 2 JU GB also adopted major decisions by written procedure, including:

- FCH-GB-2020-01 Approval of 20 April 2020 of the 1st amendment to the 'FCH 2 JU 2020 annual work plan and budget'

- FCH-GB-2020-02 Approval of 15 May 2020 of the independent assessment of the level of in-kind contributions (related to FP7 activities), as of 31 December 2019

- FCH-GB-2020-03 Approval of 9 June 2020 of the minutes of the FCH 2 JU GB meeting of 2 April 2020

- FCH-GB-2020-04 Approval of 26 May 2020 of the internal rules implementing Article 25 restrictions of certain rights of data subjects in relation to the processing of personal data in the framework of the functioning of the FCH 2 JU

- FCH-GB-2020-05 Approval of 5 June 2020 of FCH 2 JU AAR 2019 and its assessment by the GB

- FCH-GB-2020-06 Opinion of 1 July 2020 on the FCH 2 JU final accounts for 2019

- FCH-GB-2020-07 Approval of 30 July 2020 of Call 2020 evaluation results

- FCH-GB-2020-08 Approval of 11 September 2020 of the minutes of the FCH 2 JU GB meeting of 30 June 2020

- FCH-GB-2020-09 Approval of 15 October 2020 of the IAS Mission Charter
- FCH-GB-2020-10 Approval of 15 October 2020 of the application by analogy of the EC Decision on the transfer of pension rights
- FCH-GB-2020-11 Approval of 16 December 2020 of FCH 2 JU AWP and budget for 2021.

More information on the role and composition of the GB is available at: http://www.fch.europa.eu/page/governing-board

3.2. EXECUTIVE DIRECTOR

According to Article 9 of the FCH 2 JU statutes, the ED is the legal representative and the chief executive responsible for the day-to-day management of the FCH 2 JU, in accordance with the decisions of the GB.

Bart Biebuyck was appointed as ED by the FCH 2 JU GB and took up his duties on 16 May 2016. In 2019, his contract was extended until May 2023.

3.3. STATES REPRESENTATIVES GROUP

During 2020, the States Representatives Group (SRG) met on 2 June, 25 September and 27 November. Among other things, its activities focused on monitoring FCH 2 JU's achievements and results as well as on preparations for a future partnership, including the following:

- In the June meeting, the main topics included an update on Horizon Europe and the 'Clean Hydrogen Partnership', as well as on Hydrogen Europe activities related in particular to the Clean Hydrogen Alliance, the Green Deal and 'Post COVID-19 and the hydrogen sector'. FCH 2 JU presented the status of Call 2020.
- During the September meeting, the SRG members were updated on the status of Call 2020 and on progress on MAWP 2021-2027 preparations. A presentation was given by the EC on the progress of the preparatory work on future partnerships under Horizon Europe and on the Clean Hydrogen Alliance.
- In the November meeting, the EC presented the status of preparations for the proposal for a Clean Hydrogen Partnership, including on collaboration and synergies. The SRG members were also updated on the progress of MAWP 2021-2027 which was shared with them for comments. In addition, three studies commissioned by the FCH 2 JU were presented: the role of hydrogen in the NECPs[233], the FCHO[234], CertifHy, the hydrogen GO scheme[235].

The mandate of the chair and the two vice-chairs was extended until the establishment of the future partnership.

The SRG chair and/or vice-chair participated in the FCH 2 JU GB meetings. The SRG sent a letter to the FCH 2 JU GB in July 2020 highlighting a number of points it deemed essential to take into consideration for the future partnership. The EC representative (vice-chair of the GB) responded in August explaining the EC's approach on the points raised by the SRG. In December, several SRG members provided comments in response to the consultation on the first draft of the MAWP 2021-2027.

233 https://www.fch.europa.eu/node/3136

234 https://www.fchobservatory.eu/

235 https://www.certifhy.eu/

3.4. SCIENTIFIC COMMITTEE

The Scientific Committee (SC) is an advisory body to the GB and comprises a maximum of nine members reflecting a balanced representation of globally renowned expertise from academia, industry and regulatory bodies. The role of the SC is to provide: (a) advice on scientific priorities to be addressed in the annual work plans; and (b) advice on scientific achievements described in the annual activity reports. The SC was consulted on the latter. It did not meet in 2020 in the absence of a new call for proposals under H2020.

3.5. STAKEHOLDERS FORUM

The Stakeholders Forum is one of the FCH 2 JU key governance bodies, which ensures the transparency and openness of the FCH 2 JU programme for all stakeholders, including the public. It also provides opportunities to enhance FCH 2 JU communication activities as it brings together a large number of policymakers and EU stakeholders.

The 2020 edition of the Stakeholder Forum was renamed European Hydrogen Forum to reflect the updated format of the event, which was co-organised with DG GROW in their leading role in the European Clean Hydrogen Alliance (ECHA). The event was extended to two days and held on 26 and 27 November 2020 in a fully virtual format.

It brought together the European FCH community and facilitated an open discussion on the impact, achievements and strategic direction of the FCH JU programme and the ECHA, as well as on the latest developments in the sector.

For more information on the European Hydrogen Forum (including the FCH Awards), please see Section 2.1.2.

04
INTERNAL CONTROL FRAMEWORK

In August 2018, the GB adopted the revised FCH 2 JU ICF. The new framework is based on the revised EC framework and consists of five internal control components and 17 principles based on the COSO 2013 Internal Control-Integrated Framework.

The internal control components[236] underpin the structure of the ICF and support the FCH 2 JU in its efforts to achieve its objectives.

To facilitate the implementation of the ICF and management's assessment of whether each component is present and functioning, and whether the components function well together, each component consists of a set of principles. Assessments based on these principles help to provide reasonable assurance that the FCH 2 JU's objectives are being met. The principles specify the actions required for internal control to be effective. The characteristics of each principle are defined to assist the management in implementing internal control procedures and in assessing whether the principles are present and functioning.

In addition, the FCH 2 JU ICF provides for handover reports, briefings, monthly reporting on specific topics (such as budget execution, financial management, and monitoring KPIs) and reporting at weekly management meetings. A yearly review and declaration of assurance by each head of unit are included in their input for the AAR.

4.1 FINANCIAL PROCEDURES

The financial procedures guide FCH 2 JU operations and set out how it uses and manages its funds and resources.

Effective implementation of COMPASS workflows adds efficiency in managing grants.

Publication of calls for tenders, managing the calls (in particular questions and publishing answers), submission of offers and opening of tenders is based on IT solutions that significantly reduce the resources expended.

The financial circuits were updated in September 2020 with a view to further reinforcing the checks performed, in particular for financial initiators.

4.2. *EX-ANTE* CONTROLS ON OPERATIONAL EXPENDITURE

Ex-ante controls are essential to prevent errors and avoid the need for *ex-post* corrective action. In 2020, the FCH 2 JU continued to apply the provisions of Article 74 of the Financial Regulation and Article 21 of FCH 2 JU Financial Rules: *'each operation shall be subject at least to an ex-ante control relating to the operational and financial aspects of the operation, on the basis of a multiannual control strategy which takes risk into account'*.

Therefore, the main objective of *ex-ante* controls is to ascertain that the principles of sound financial management have been applied.

The FCH 2 JU has developed and continues to apply well-developed 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 the IT accounting system (ABAC) are performed via the corporate Horizon 2020 IT tools (SYGMA/COMPASS) for H2020 grants and experts, which ensures a high degree of automation and the controls are embedded in each workflow.

236 Control environment, risk assessment, control activities, information and communication, and monitoring activities.

Ex-ante control activities in 2020 included:

- Assessing 59 periodic reports
- Checks during the Grant Agreement Preparation (GAP) phase for the 23 projects under Call 2020
- Participation of project and finance officers in H2020 project kick-off meetings to clearly communicate the financial reporting requirements
- Targeted webinars focused on the specificities of each project
- Based on a detailed analysis of the most common audit findings and financial claims, a list of selected beneficiaries was drawn up and a financial questionnaire sent to them with the purpose of enhancing knowledge of FCH beneficiaries and strengthening their sound financial management and understanding of the H2020 rules
- 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 CSC Steering Board on 18 December 2020.

In addition, FCH 2 JU actively contributes to the development of the Horizon Europe control strategy (*ex-ante*, audit and fraud prevention) by participating in the dedicated working groups set up by the CIC and providing input. The work started in 2020 and is ongoing in 2021.

In 2020, to complement *ex-ante* control activities, as described above, additional resources and efforts were dedicated to a **pilot project on early identification and correction of the potential errors** via an identification of major risks among FCH 2 JU top beneficiaries.

In order to efficiently identify the beneficiaries with potential risks and significant budget exposure, the **populations of all FCH 2 JU beneficiaries were screened** for those who:

- Were among the top FCH 2 JU beneficiaries in terms of committed FCH 2 JU contribution from Call 2014-2019 actions (90 % of the committed FCH 2 JU contribution)
- Have already reported or were about to report the costs to FCH 2 JU in the financial statements submitted in the year 2020
- Have never been audited before in H2020 (either by FCH 2 JU or other H2020 stakeholders).

By applying this filter, the FCH 2 JU has selected 35 beneficiaries for a further **risk assessment**.

Based on a detailed analysis of the most common audit findings and financial claims, FCH 2 JU has prepared **a self-assessment financial questionnaire** which was sent to those selected beneficiaries. Based on the responses received, 22 beneficiaries were chosen for a follow-up action in the form of **a bilateral targeted financial webinar** with the purpose of enhancing knowledge of FCH beneficiaries and strengthening their sound financial management and understanding of the H2020 rules.

Thanks to positive responses to this initiative gathered from the beneficiaries, FCH 2 JU decided to continue with this iterative screening and targeted webinars in 2021.

Among other positive outcomes, this pilot project was also acclaimed in the recent IAS report as one of the strengths of FCH 2 JU's internal control contributing to effective grant implementation under Horizon 2020.

4.3 *EX-POST* CONTROL OF OPERATIONAL EXPENDITURE AND ERROR RATES IDENTIFIED

The main objectives of the *ex-post* controls are to ensure that legality, regularity and sound financial management (economy, efficiency and effectiveness) have been respected and to provide the basis for corrective and recovery activities, if necessary.

H2020 programme – *ex-post* controls, H2020 audit strategy and cooperation with the CIC

Ex-post controls of operational expenditure for H2020 are designed and implemented in line with the Horizon 2020 *Ex-Post* Audit Strategy[237]. For Horizon 2020, CIC (formerly known as Common Support Centre) developed this audit strategy in cooperation with all of its clients (i.e. the entities that implement the H2020 budget: EC services, executive agencies and joint undertakings).

Unit B2 of the CIC, the CAS ensures harmonised implementation of the H2020 *Ex-Post* Audit Strategy for the EU's R&I expenditure, serving all 20 H2020 stakeholders. The CAS uses the IT tool AUDEX for audit process management. Its mission is to deliver a corporate approach for the audit cycle: audit selection, planning, application of rules, relations with beneficiaries, and management information on the audit process.

The main objective of the audit strategy is to provide the individual authorising officers with the necessary assurance in a timely manner, thereby allowing them to report on the budget expenditure for which they are responsible. *Ex-post* controls on operational expenditure contribute in particular to:

- Assessing the legality and regularity of expenditure on a multiannual basis
- Providing an indication of the effectiveness of the related *ex-ante* controls
- Providing the basis for corrective and recovery mechanisms, if necessary.

The FCH 2 JU is effectively integrated in this control chain: it participates in the audit process definition and in the monitoring of its implementation in close cooperation with the CAS and its clients. The main objectives of this cooperation are to align operations and exploit synergies in the common audit effort. The efficiency gains will reduce audit costs and the administrative burden on auditees, always in line with the specific objectives explained above for *ex-post* controls.

237 Ref. Ares(2016)981660 - 25/02/2016, endorsed by the CSC Steering Board.

The implementation of all *ex-post* audit results remains the responsibility of the FCH 2 JU.

The FCH 2 JU also ensures the implementation of the research community's common anti-fraud strategy. The main actions derived from the strategy include the organisation of awareness-raising sessions within the JU and cooperation with OLAF (in the case of risk-based audits conducted by the CAS or outsourced contractors). Implementation of the action plan derived from the strategy is monitored by the Fraud and Irregularity Committee (FAIR) – see also Section 4.6.

In 2020, the following main achievements were reached:

- Selection of 26 new corrective and representative H2020 *ex-post* audits in cooperation between FCH 2 JU and CAS (CIC, B2 unit) for execution of the audits in 2020-2021 with the expected results (Letter of Conclusion sent) by 31 December 2021
- By continuous application of the JUs' sampling methodology (endorsed by the CIC Executive Committee on 19 July 2019), FCH 2 JU reached a **significant indirect audit coverage (45 %)** of the overall H2020 expenditure, forming a strong pillar for the declaration of assurance in 2020
- Closure of the 31 representative audits by 31 December 2020 allowing for more precise calculation of the FCH 2 JU specific representative error rate at the rate of -2.16 % on the total FCH 2 JU contribution of EUR 264.30 million, validated by 31 December 2020
- Participation of the FCH 2 JU in the extension of the audit findings exercise, common for all H2020 stakeholders, enabling further cleaning of the representative error rate down to **-1.34 % of the residual error rate**.

H2020 *ex-post* audit methodology and error rates – corporate approach

The Common Representative Sample (CRaS) provides an estimate, via a representative sample of cost claims across the R&I family, of the **overall level of error** in the research FPs, across all services involved in its management. All of these grants follow the same homogeneous overall control system set out in this report.

The H2020 *ex-post* audit strategy builds upon different layers of audits:

- A corporate layer consisting of a CRaS[238] complemented by risk-based samples
- An additional sample for entities with specific GAs or a separate discharge procedure and Article 10 audits on the demand of the JUs

In H2020, all 20 implementing entities are expected to follow the same homogeneous overall *ex-ante* control system[239].

The Horizon 2020 audit campaign started in 2016. At this stage, three common representative samples with a total of 467 expected results have been selected. By the end of 2020, cost claims amounting to EUR 24.3 billion had been submitted by the beneficiaries to the services.

The error rates at 31 December 2020 were:

- Representative detected error rate: 2.95 %[240]
- Cumulative residual error rate for the R&I family DGs: 2.16 % (2.24 % for DG R&I).

238 Taken biannually for 162 participations; Monetary Unit Sampling is applied; population is determined by the costs declared and paid by the beneficiaries through financial statements which form the basis for calculating the EU contribution.

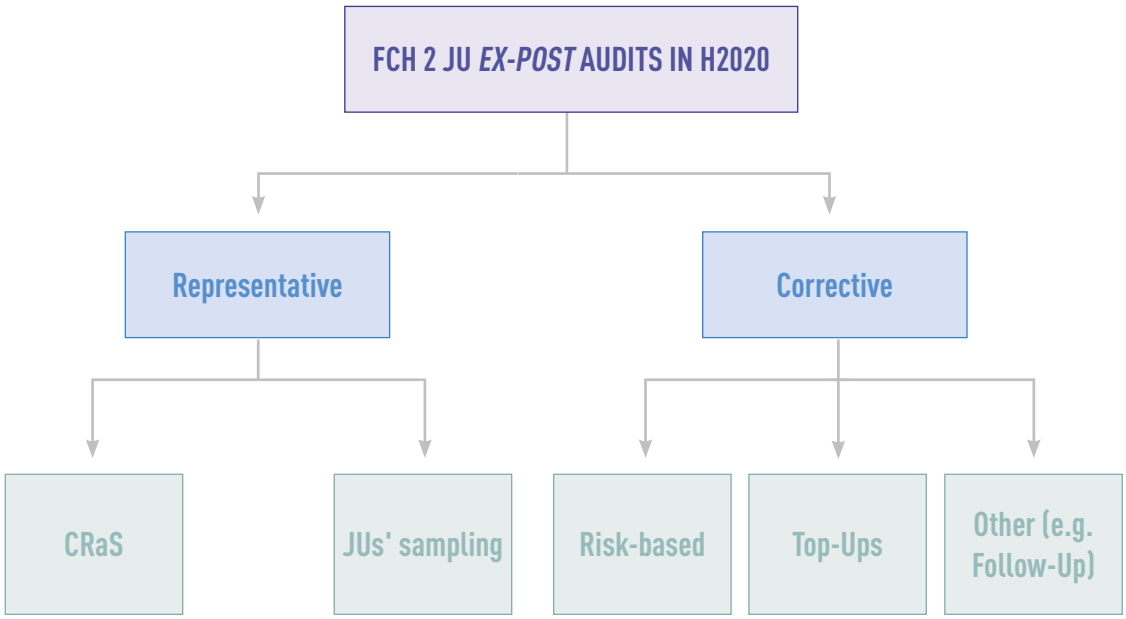
239 Guidance H2020 *ex-ante* controls on interim and final payments, version 1.0.

240 Based on 334 representative results of the 467 expected in the three common representative samples.

H2020 *ex-post* audit methodology and error rates – FCH 2 JU approach

For classification, reporting and error-rate calculation purposes, FCH 2 JU distinguishes between representative and corrective audits. Corrective FCH 2 JU audits are defined as all audits which were not selected by statistically representative sampling.

FIGURE 43: H2020 **EX-POST** AUDIT STRATEGY AT FCH 2 JU – CLASSIFICATION OF *EX-POST* AUDITS



Given the relatively small share of the FCH 2 JU's budget (target H2020 overall FCH 2 JU contribution of EUR 665 million: 1 %) compared to the overall H2020 target budget (EUR 63 584 million[241]: 100 %), the number of participations selected for *ex-post* audit by the CAS via the CRaS is very limited.

This observation was further confirmed by the fact that in the three rounds of CRaS, there were only three FCH 2 JU participations directly targeted by the monetary unit sampling. The items targeted by CRaS are considered as representative for calculation of the FCH 2 JU specific error rates.

By 31 December 2020, two results were available and had been incorporated into the FCH 2 JU specific error rate calculation.

Selection of the fourth round of CRaS is expected in Q2 of 2021.

In addition to CRaS samples and in line with Annex 1 to the H2020 *ex-post* audit strategy, the FCH 2 JU planned for additional audit sampling (i.e. JUs' specific sample) in order to ensure sufficient *ex-post* audit coverage and enable a representative error rate on FCH 2 JU expenditure to be calculated over time. This is necessary to provide reasonable assurance to the JU ED in view of his declaration of assurance and the separate discharge procedure for the JU.

By 31 December 2020, 120 participations were selected for *ex-post* audits (compared to the estimated target of 295 participations audited for the whole H2020 programme).

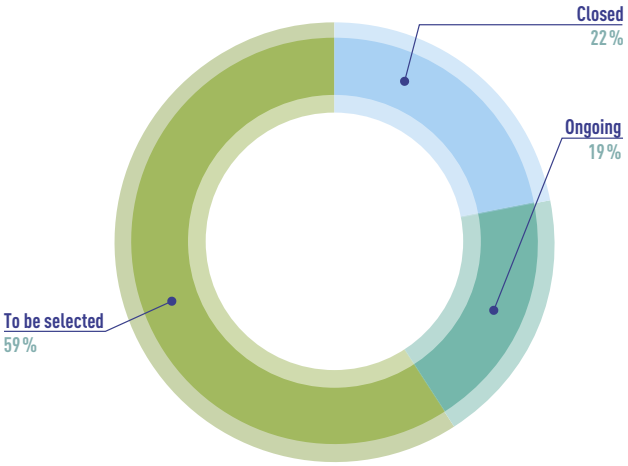
241 H2020 operational budget of EUR 70.280 million minus EUR 6.696 million related to the EIT financial instruments and others.

TABLE 19: *EX-POST* AUDITS IN PROGRESS AT 31 DECEMBER 2020 - COMPLETENESS STATUS

H2020 AUDITS WITH FCH 2 JU PARTICIPATIONS	NUMBER OF PARTICIPATIONS			
	CLOSED	ONGOING	TO BE SELECTED	H2020 OVERALL TARGET
Total up to 31 December 2020	65	55	175	295

In 2020, the FCH 2 JU validated cost claims totalling EUR 88.14 million (EUR 102.58 million in 2019), of which EUR 70.03 million represented the EU contribution (EUR 98.53 million in 2019).

FIGURE 44: FCH JU H2020 EX-POST AUDITS - COMPLETENESS STATUS (PARTICIPATIONS)



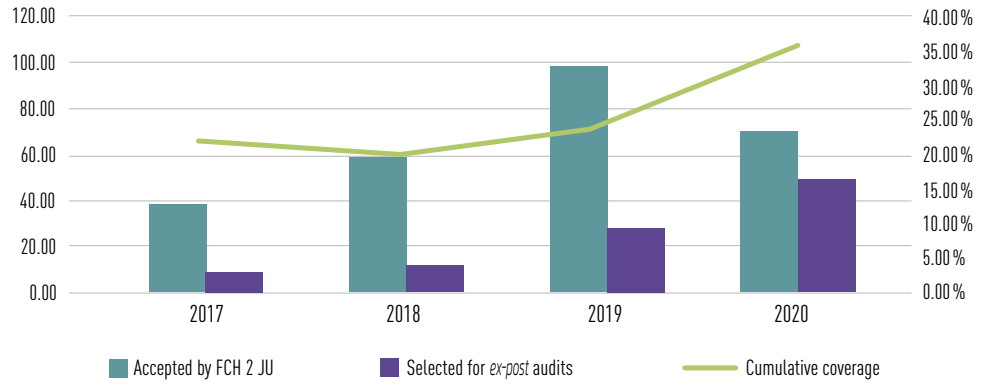
Of this EUR 70.03 million, throughout the year corrective and representative audits* were selected to target overall audit coverage of around 20 % of H2020 expenditure, as per the table below.

** Representative audits were selected by CAS, whereas corrective audits were identified either by FCH 2 JU or by CAS and subsequently agreed with FCH 2 JU.*

TABLE 20: *EX-POST* AUDITS IN PROGRESS AS OF 31 DECEMBER 2020 – DIRECT AUDIT COVERAGE

	FCH 2 JU CONTRIBUTION IN EUR MILLION				
YEAR	ACCEPTED BY FCH 2 JU	SELECTED FOR *EX-POST* AUDITS	CUMULATIVE COVERAGE	AUDITS CLOSED	CUMULATIVE COVERAGE
2017	37.09	8.14	21.96 %	8.14	21.96 %
2018	58.65	10.80	19.78 %	10.80	19.78 %
2019	98.53	27.29	23.80 %	22.49	21.32 %
2020	70.03	48.95	36.01 %	0.00	15.67 %
Total up to 31 December 2020	**264.30**	**95.17**	**36.01 %**	**41.43**	**15.67 %**

FIGURE 45: COVERAGE OF FCH 2 JU CONTRIBUTION BY H2020 EX-POST AUDITS SELECTED



Representative audits were selected following the 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) 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 in the FCH 2 JU programme
- Ensuring representability of the results, as per the International Standards on Auditing.

Risk-based audits in 2020 were selected by applying an analytical approach of reviewing the inherent risk and exposure profiles of FCH 2 JU beneficiaries (first step). In the second step, the selected beneficiaries were assessed internally by the project and financial officers to validate a rationale and the specific risks involved in projects signed with those beneficiaries.

As a result of this approach, nine beneficiaries were selected for the risk-based audits, following a discussion with the operational services.

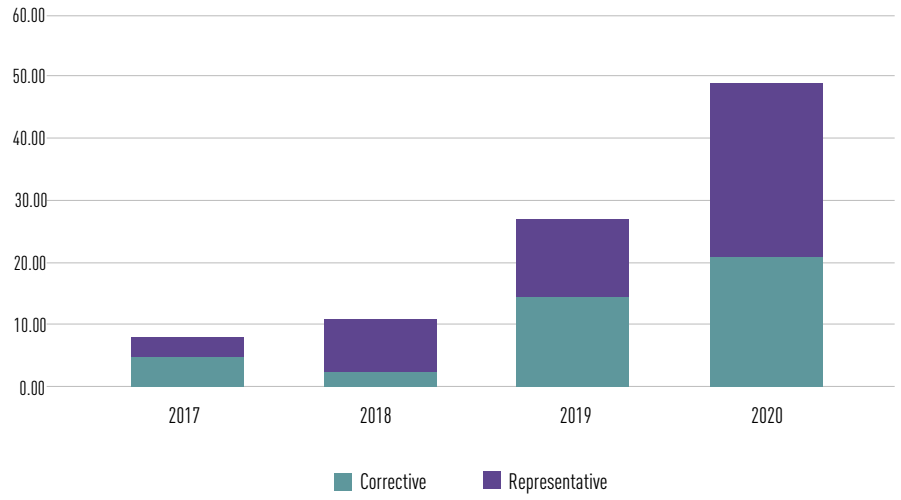
For efficiency purposes, all available cost claims validated by the FCH 2 JU until the audit was launched, if available, were added to the selection.

Distribution of the coverage of two main audit streams is captured in the table and figure below.

TABLE 21: *EX-POST* AUDITS IN PROGRESS AS OF 31 DECEMBER 2020 – CLASSIFICATION OF PARTICIPATIONS SELECTED FOR *EX-POST* AUDITS

	FCH 2 JU CONTRIBUTION IN EUR MILLION		
YEAR	CORRECTIVE	REPRESENTATIVE	TOTAL
2017	4.98	3.16	8.14
2018	2.38	8.42	10.80
2019	14.68	12.61	27.29
2020	21.01	27.94	48.95
Total up to 31 December 2020	**43.05**	**52.13**	**95.17**

FIGURE 46: FCH 2 JU CONTRIBUTIONS UP TO 31 DECEMBER 2020 COVERED BY EX-POST CONTROLS



FCH 2 JU specific error rates for H2020

For the calculation of the FCH 2 JU's representative error rate, only results coming from the items either directly hit by JU sampling or by MUS sampling of the CRaS are taken into consideration.

Results of 31 representative items were used to calculate an indicative cumulative representative error rate on H2020 expenditure specific to the FCH 2 JU, as of 31 December 2020:

Representative error rate on FCH 2 JU contribution: -2.16 %

Residual error rate on FCH 2 JU contribution: -1.34 %

H2020 audit implementation

Out of 65 closed participations (see Table 20), 32 led to negative adjustments out of which 27 are implemented and 5 in process of implementation.

ECA audits

In 2020, the ECA started to perform additional systems testing at the relevant JU.

This additional testing, based on a MUS sample of 30 transactions, should provide the additional assurance required to assess the implementation of H2020 and FP7 projects, and ensure the quality of the audit opinion, in line with auditing standards. In view of the COVID-19 situation, and to ensure the efficient use of audit resources, the ECA has requested that the necessary supporting documents be provided by the JU or final beneficiary, to perform desk reviews rather than on-site visits.

In respect of the individual discharge for each of the 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 JU individual error rate of the *ex-post* audits;
- the common error rate based on the results of our substantive testing;
- the error rate related to the transactions of a specific JU within our substantive testing; and
- the correctness of the calculation of the residual error rate reported by the JUs, based on the *ex-post* audit results for their grant payments.

In 2020, the ECA selected and reviewed 4 transactions (out of 30) from FCH 2 JU participations for the Discharge 2019. As a result, all of the reviews were concluded as free from errors and no observations were raised.

In the course of 2020 and early 2021, four new transactions were selected with the results expected in 2021.

COVID-19 considerations in H2020 *ex-post* audits

As a result of the COVID-19 crisis and related travel restrictions during 2020, the CAS – in line with EC instructions – had to postpone on-the-spot missions until further notice. To minimise the impact of the pandemic on the implementation of the audit campaign, the CAS converted traditional in-house audit assignments into desk reviews, in line with international best practice and auditing standards. Regarding outsourced audits, the CAS instructed the audit firms to perform remotely the maximum possible number of audit tests while complementing them with on-the-spot audit missions once travel restrictions were eased.

Despite travel restrictions, and other objective challenges due to the pandemic, the CAS was able to finalise 88 % of the targets for 2020 for FCH 2 JU.

FP7 programme

The FCH 2 JU *ex-post* controls of FCH FP7 grants included financial audits carried out by external audit firms.

In 2020, no new audits were launched on FP7 projects. The last batch of FP7 audits launched in November 2019 was completed and finalised in 2020.

Ex-post audits – coverage

The following table gives an overview of the number of *ex-post* audits and their audit coverage:

TABLE 22: NUMBER OF AUDITS AND AUDIT COVERAGE, CUMULATIVE

BATCH	YEAR	TO BE LAUNCHED	ON-GOING	FINALISED	TOTAL	OF WHICH	
						REPRESENTATIVE	RISK-BASED
1 to 12	2011-2019	0	0	145	145	120	25
Total (audits)		**0**	**0**	**145**	**145**	**120**	**25**
Total (cost claims)					**574**		
Total costs accepted by FCH JU (cumulative) (in EUR) **(A)**					841 577 080		
Total costs of audits launched (cumulative) (in EUR) **(B)**					189 657 854		
Total costs of audits finalised (cumulative) (in EUR) **(C)**					189 657 854		
Direct audit coverage of total audits (in %) **(B/A)**					23 %		
Direct audit coverage of finalised audits (in %) **(C/A)**					23 %		
Total FCH 2 JU beneficiaries **(D)**					561		
FCH 2 JU beneficiaries audited **(E)**					143		
Audit coverage (number of benef.) of total audits (in %) **(E/D)**					25 %		

In conclusion, for the entire FP7, 145 *ex-post* audits were launched of which 120 were representative and 25 risk-based, covering in total EUR 189.66 million of accepted costs declared by the beneficiaries, with an average sum of EUR 1.31 million of accepted costs per individual audit.

This resulted in direct audit coverage of 25 % from all costs claims validated by the FCH 2 JU for all 155 projects totalling EUR 841.58 million since the beginning of the FP7 Programme (at 31 December 2020).

Negative errors in FP7 affected mostly personnel costs (47 %), indirect costs (26 %) and other direct costs (34 %).

Ex-post audits – error rates

The error rates resulting from the 145 finalised audits are as follows:

Representative error rate on the FCH 2 JU contribution: 1.97 %
Residual error rate on the FCH 2 JU contribution: -1.01 %

Implementation of audit results

The FCH 2 JU has implemented the necessary controls and monitoring mechanisms to ensure that all errors detected in favour of the JU are corrected in due course (either through a recovery order or by offsetting a future payment).

Since the last FP7 audits were finalised at the end of 2020, implementation of the audit results will be finalised in the first quarters of 2021, in line with the implementation rules and legal deadlines for FP7.

As of 31 December 2020, the FCH 2 JU has cumulatively implemented negative adjustments on its contribution to the sum of EUR 2.02 million (of which 0.08 % of the last closed audit is in the process of implementation), stemming from the results of 145 FP7 *ex-post* audits.

Implementation of extrapolation/'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 FCH 2 JU claims from the same audited beneficiary. The timely implementation of extension of audit findings relies on beneficiaries preparing and submitting revised cost claims from which the effect of any systematic error(s) detected in audits has been eradicated.

The overall situation on the implementation of the extension of audit findings in FP7 is as follows:

- From 145 finalised FP7 audits, 44 audits (81 projects) were concerned by extrapolation (30 %); in other words, one out of 3 audits included findings of a potentially systemic nature;
- As part of the FP7 audit engagements with the external audit firms, all the cost claims potentially impacted by the extrapolation were assessed by the audit firm and the results were presented to the FCH 2 JU for implementation.

As of 31 December 2020, all implementations were finalised, with the last open files to be finalised in the first two quarters of 2021, for those audits which were closed at the end of 2020.

Conclusions for FP7 and H2020 *ex-post* controls

Because of the very limited number of projects still ongoing, 2019 was the last year FCH 2 JU launched FP7 *ex-post* audits. All audits were closed as of 31 December 2020 and the final cumulative FP7 error rates (both representative and residual) are well below 2 %, providing a robust indicator of the legality and regularity of the underlying transactions.

For the H2020 programme, sufficient audit coverage was ensured via the selection of the *ex-post* audits in the period 2017-2020, and the reliability of the error rate calculation base was confirmed with the closure of a statistically representative number of H2020 audits for FCH 2 JU.

A positive trend in the error rates (residual error rate on the FCH 2 JU contribution well below 2 %) in H2020 can only be confirmed when more audit results are made available.

Based on the experience and results from the FP7 *ex-post* audits, the FCH 2 JU observed that most errors originated in the incorrect implementation of the indirect costs methodology. This source of error was entirely removed in H2020, introducing a flat-rate of 25 % for indirect costs.

The second most error-prone cost category was personnel costs, with audit adjustments towards time-recording and hourly rate calculation. These errors tend to be repeated under H2020.

As part of an internal control, all lessons learnt and observations from the *ex-post* audits (applicable for both FP7 and H2020) feed back into the system of *ex-ante* checks in order to improve their effectiveness and efficiency.

This is an ongoing process whereby the close cooperation between FCH 2 JU operational units is facilitating the achievement of synergies between technical and financial knowledge, applied in practice.

Ex-post audit resources

The lean structure of the FCH 2 JU does not allow for the setting up of an internal *ex-post* audit section. Therefore, all *ex-post* audits are performed by the CAS or outsourced to external audit firms (all FP7 audits were outsourced to external audit firms).

Whereas the execution of the audit work is externalised, some of the JU's staff (*ex-post* audit team and an audit liaison officer in particular) are responsible for managing *ex-post* audits, mainly via the following three processes:

- Planning (i.e. selection of representative and risk-based audits, coordination with EC audits and preparation of audit input files)
- Monitoring (i.e. regular follow-up of audit status, interaction with the CAS on technical questions and, more importantly, quality checks of audit reports)
- Evaluation/implementation of audit results (i.e. inferring conclusions on the basis of identified error rates, extension of audit findings and initiation of recovery orders/offsetting with future payments to correct errors detected) with the use of the corresponding workflows in COMPASS.

The following table gives an overview of the resources devoted to *ex-post* audits:

TABLE 23: RESOURCES DEVOTED TO *EX-POST* AUDITS

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Internal resources *ex- post* audits	1 FTE	1.5 FTE	2 FTE	2 FTE	1.5 FTE	2 FTE	2 FTE	1 FTE	1 FTE	1.5 FTE
Cost of externalised audits (commitments, in EUR – FP7 audits only)	77 820	208 665	161 082	245 081	315 716	206 762	194 949	75 600	37 800	19 200

4.4 AUDIT OF THE EUROPEAN COURT OF AUDITORS

In 2020, the FCH 2 JU:

- Continued its cooperation with an independent auditor to audit FCH 2 JU accounts, as required by the FCH 2 JU financial rules.
- Provided support for the ECA auditors in the framework of their audit on the 2019 accounts.
- Liaised with ECA in their review of 30 transactions selected for Discharge 2019 (see Section 4.3 above).
- Followed up and implemented the recommendations made in the ECA's reports on the FCH 2 JU annual accounts.

4.5 INTERNAL AUDIT

The internal audit is carried out according to Article 20 of the FCH 2 JU financial rules.

Based on Council Regulation (EU) No 559/2014 of 6 May 2014 establishing the FCH 2 JU, the internal audit operation is under the authority and responsibility of the EC's IAS, succeeding the previous role taken on by the FCH JU's IAC.

Within the FCH 2 JU, the new role of internal control and audit manager was established in 2015 to act as a main contact point for the IAS and coordinate the execution and follow-up of the annual internal audits carried out by the IAS.

In 2020, in line with the strategic internal audit plan for 2019-2021, IAS launched an audit on H2020 grant implementation in the FCH 2 JU. Due to the COVID-19 situation, the audit fieldwork, and all the meetings, preparations and follow-up were conducted remotely.

Thanks to timely and **effective business continuity arrangements**, the FCH 2 JU and IAS teams ensured the smooth conduct and follow-up of the audit using the online tools readily available.

The objective of this audit was to assess the adequacy of the design and the efficiency and effectiveness of the internal control system in place in the FCH 2 JU for the implementation of GAs under H 2020 programme.

The fieldwork was finalised on 29 July 2020.

The auditors identified **two main strengths in the FCH 2 JU** that contribute to effective grant implementation under H2020, namely, the **re-enforced *ex-ante* controls** and FCH 2 JU **initiatives to boost dissemination and exploitation**.

The IAS concluded that the **FCH 2 JU has set up an efficient and effective internal control system for the implementation and closing of GAs under the H2020 programme**.

The monitoring of grant implementation, *ex-ante* controls on H2020 grant payments and management of amendments were supported by adequate IT systems and processes (e.g. automated controls, checklists embedded in the IT tools, systematic documentation) as well as by specific guidance designed by the CIC.

In line with the requirement of the H2020 legal base, *ex-ante* controls on payments have been simplified and are based on trust. Sufficient and adequate checks were made to support the 'certified correct' endorsement of the payments sampled.

The audit did not identify any critical or very important issue.

Recommendations to further document FCH 2 JU practices in grant implementation and risk-based controls in writing are part of the action plan which will be agreed with the IAS and implemented in 2021.

4.6 RISK MANAGEMENT AND CONFLICT OF INTEREST

Risk management

During the annual risk-assessment workshop, held in October 2020, the FCH 2 JU team focused on critical risks affecting the achievement of FCH 2 JU objectives as well as action plans that had been identified in the previous year, and assessed their adequacy and relevance for both 2020 and 2021.

In addition, consolidated input was gathered and discussed in order to establish a list of new significant risks for 2020, and the respective action plans were drawn up.

The full list of important risks and related action plans identified can be found in the AWP 2021.

The risk management policy was under preparation until 31 December 2020 and was expected to be adopted in Q1 2021. It includes guidance on how to conduct the annual risk-identification and risk-assessment exercise.

A complete risk matrix for 2020 (including lower-priority risks) is regularly assessed and discussed by management as part of an ongoing risk-assessment process to reflect on any changes in the organisation's internal and external environment. This exercise, which is part of the internal control system, is designed to capture, in a timely way, any new or emerging risks that could potentially influence achieving the FCH 2 JU objectives, and to provide timely reflection on the rating and relevance of the existing risks to ensure that appropriate actions and mitigating measures are put in place.

Managing potential conflict of interest

The PO has developed a comprehensive set of rules and procedures that are being implemented effectively across its entire governance structure, as follows:

- When joining the PO team, each staff member agrees to application of the staff regulations and signs a declaration of honour on the management of conflicts of interest.

- With ED Decision of 27/09/2019[242], FCH 2 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 are in place for the members of both the FCH 2 JU GB and the advisory bodies.
- Specific measures have been 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.

In addition, the FCH 2 JU implements the common Research Anti-Fraud Strategy. In March 2019, the CIC adopted the revised Strategy (RAFS 2019) and the associated action plan. The implementation of the action plan is monitored through regular meetings of FAIR in which the FCH 2 JU participates.

In 2020, internal training sessions were organised on the Early Detection and Exclusion System (EDES) and on the anti-plagiarism tool (see also Section 2.6)

Furthermore, for areas of expenditure other than grants, the FCH 2 JU applies *mutatis mutandis* by analogy DG R&I's anti-fraud strategy. This is relevant in particular for expert management, procurement and internal fraud; the risk analysis leads to the conclusion that the residual risks (after mitigating actions) are low.

4.7 COMPLIANCE AND EFFECTIVENESS OF INTERNAL CONTROL

The FCH 2 JU 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.

In line with the objectives and priorities described in the AWP 2020, the robustness of the internal control system was monitored throughout the year. Internal control matters, such as *ex-ante* and *ex-post* controls, segregation of duties, documented processes and procedures and sound financial management, were discussed at least on a weekly basis during unit meetings and on an ad-hoc basis when preparing new processes or revising existing operating procedures. Risks identified through the annual risk assessment exercise (see Sections 1.1 and 4.6), which might threaten achieving the FCH 2 JU's mission and objectives, were also systematically assessed and managed through appropriate controlling and mitigating actions. Throughout the year, particular efforts were made to monitor the KPIs, which led to further improvements in financial management, as indicated by the TTP.

Register of exceptions, analysis of internal control weakness or control failures recorded during 2020

The PO keeps a register of all exceptions and non-compliance events; reports are entered into the register through a dedicated procedure using predefined templates. The central register is reviewed regularly by the Head of Finance and Administration, the IAS and, in the course of the Declaration of Assurance procedure, by the ECA. The reasons behind the events reported in 2020 have been analysed by FCH 2 JU management in order to further strengthen the internal control system and ensure compliance with rules and procedures. Related risks and financial impacts have been assessed and monitored when material, corrective measures were introduced (e.g. internal instructions). Other deviations considered of limited relevance after management assessment were controlled and documented in appropriate notes to the file.

Reliability of financial reporting and accounting

In addition, DG BUDG carried out its annual evaluation of the Undertaking's local financial evaluation of local financial systems by reviewing the information on changes in the local systems and/or in the control environment. The DG BUDG team also verified a sample of transactions for operations authorised by the FCH 2 JU during the 2019 financial year. The evaluation did not identify any weaknesses in the internal control systems which would materially affect the accuracy, completeness and timeliness of the information required to draft the annual accounts and produce reliable reporting.

242 Ares(2019)6087752.

The self-assessment of the effectiveness of the ICF in 2020 was based on:

- an objective examination of reports and assessments carried out by management and by internal (IAS) and external auditors (independent auditors on the annual accounts and the ECA);
- management's overview of progress made on implementation of the corresponding action plans.

The latter was implemented in the following ways:

1) The Common Business Continuity Plan was tested and activated during the COVID-19 pandemic;

2) Training was organised on anti-plagiarism for project and financial officers in September 2020.

3) An internal session on EDES was held in February 2020.

4) Particular measures to raise awareness on phishing, specifically in light of teleworking, were implemented through CERT-EU and regular messages were sent to the staff.

5) A joint-JU DPIA was contracted for Microsoft Systems, the Office 365 IT Security Plan, the IT Security Risk Management Methodology and the project action plan.

6) The procedure on website access rights and uploading information was adopted in October 2020.

Assessment of the functioning of the internal control system

In conclusion, it can be confirmed that the FCH 2 JU is in compliance with all the principles, the controls in place are working as intended, and the internal control system is providing an effective framework for managing any risks to the JU's ability to achieve its objectives.

05
MANAGEMENT ASSURANCE

5.1 ASSESSMENT OF THE ANNUAL ACTIVITY REPORT BY THE GB

This section will be provided separately.

5.2. ELEMENTS SUPPORTING ASSURANCE

Reasonable assurance is the personal judgement of the JU's ED – as the JU's authorising officer at the date of signature of this Annual Activity Report – based on all the information at his disposal.

The main elements supporting the assurance are based on the JU's management assessment of the robustness of its ICF, the results of audits from the ECA and the IAS, the reporting from the internal control and audit manager, and the reporting from the heads of unit.

No significant weaknesses were identified or reported under Section 2 ('Support to Operations') and Section 4 ('Internal Control Framework'). Furthermore, based on their review, the heads of unit consider that, given the scope of the statement of assurance and taking into account the controls and monitoring system in place, there are no weaknesses that could call into question reasonable assurance as to the use of resources for their intended purpose, in accordance with the principles of sound financial management, and the fact that the implemented control procedures provide the necessary guarantees on the legality and regularity of the underlying transactions.

5.3. RESERVATIONS

H2020 programme

The indicative **representative error rate** resulting from the 31 representative audits finalised is **2.16 %** (2019: -0.94 %) at the FCH 2 JU contribution level.

The **residual error rate** (i.e. error remaining in the population after corrections and recoveries) calculated at this point is **–1.34 %** (2019: -0.70 %) at the FCH 2 JU contribution level. This rate should develop as more audits are closed and more corrections and recoveries undertaken.

Taking into consideration:

- the residual error rates below 2 % at this point in time;
- the adequate audit coverage, comprising a representative number of finalised audits;
- the experience gained by JU staff in the *ex-ante* validation of cost claims;
- the JU's strong *ex-ante* controls (financial webinars, etc.);

no reservation is necessary. In the opinion of the ED, considering the aspects above and with the information available at this stage, it is possible to state with reasonable assurance that by the end of the programme the residual error rate will be below the materiality threshold (i.e. 2 %) established in Annex 9 ('Materiality criteria').

FP7 programme

The **representative error rate** resulting from the 114 representative audits finalised is **–1.97 %** (2019: -2.08 %) at the FCH JU contribution level.

The **residual error rate** (i.e. error remaining in the population after corrections and recoveries) is **–1.01 %** (2019: -1.08 %) at the FCH JU contribution level. This rate is final as all FP7 audits were closed.

FCH 2 JU actions towards an acceptable level of residual error rate

The declaration of assurance in 2019 did not include a reservation, as is the case in 2020. This is the result of the FCH 2 JU's firm commitment to maintain a robust internal control system where *ex-post* audits play a significant role. The residual error rate is a key indicator of the legality and regularity of the JU's transactions. In this context, in 2012, the FCH JU set out an action plan for FP7, later complemented for H2020, with the aim of achieving an acceptable level of residual error rate. This should give the ED sufficient assurances while, at the same time, respecting cost-benefit principles (i.e. the cost of controls must be measured against the benefits that those additional controls can bring to the organisation – auditing 100 % of the cost claims is not cost-efficient).

The FCH 2 JU action plan includes a combination of **preventive, detective and corrective measures** and is closely monitored. The measures/actions can be grouped around three main axes, as follows:

- Organisation of financial webinars to explain key aspects of the financial provisions of the H2020 Model Grant Agreement and of financial reporting with a focus on specificities and business models pertinent to the FCH 2 JU and aiming to prevent errors. Since 2016, for all new signed grants, specific targeted financial webinars have been organised within the first year following the start of the action – these are available to all members of the consortia (see also Section 4.2).
- Greater involvement by the financial officers during GA preparations and in project kick-off meetings in order to check the financial aspects and clarify financial reporting requirements.
- Ad-hoc financial webinars for individual projects, depending on the complexity of the project and needs of the beneficiaries.
- Bilateral targeted webinars with beneficiaries selected based on risk-assessment.
- *Ex-ante* controls consistent with the guidelines on *ex-ante* controls in H2020, adopted by the CIC, which are predominantly risk-based and/or justified by deviations from the budget.
- *Ex-post* audits: as indicated in the sections on H2020 *ex-post* audits above, the FCH 2 JU will ensure that, in line with Annex 1 to the H2020 Audit Strategy, the audit effort is sufficient to allow for adequate coverage and the calculation of a representative error rate on FCH 2 JU expenditure.
- Participation by the financial officers in the *ex-post* audits as observers to further improve the system of *ex-ante* controls.

The FCH 2 JU has a clear control strategy which is multi-annual in nature and combines *ex-ante* and *ex-post* controls while taking cost-efficiency into consideration. Since this strategy has proved its effectiveness from an assurance point of view, the FCH 2 JU is fully committed to continuing its work along the same control principles.

5.4. OVERALL CONCLUSIONS

The purpose of this section is to provide an overall conclusion on the declaration of assurance as a whole (Section 6).

It is important to note that only material weaknesses/risks lead to any reservation concerning the assurances in Section 6. The concept of 'materiality' provides the ED 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 on materiality criteria in Annex 9).

Based on the information provided in the sections above, the following conclusions can be drawn:

- Concerning the FCH 2 JU's policy activities, no qualification is required. Likewise, there is no reservation on the procedures relating to the selection of contractors and beneficiaries for FCH 2 JU projects and their underlying financial operations (legal and financial commitments). This is also the case for JU's payments relating to administrative expenditure and procurement, as well as 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 5.3, no reservation is necessary in this area either.

In conclusion, the 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 the necessary improvements noted by the auditors (i.e. the IAS and ECA) are being implemented. Therefore, the ED, in his capacity as authorising officer, has signed the declaration of assurance presented in Section 6.

06
DECLARATION OF ASSURANCE

I, the undersigned, Bart Biebuyck

Executive Director of the FCH 2 JU

In my capacity as authorising officer

Declare that the information contained in this report gives a true and fair view[243].

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 control and audit manager, the observations of the IAS, and the lessons learnt from the Court of Auditors' reports for the 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.

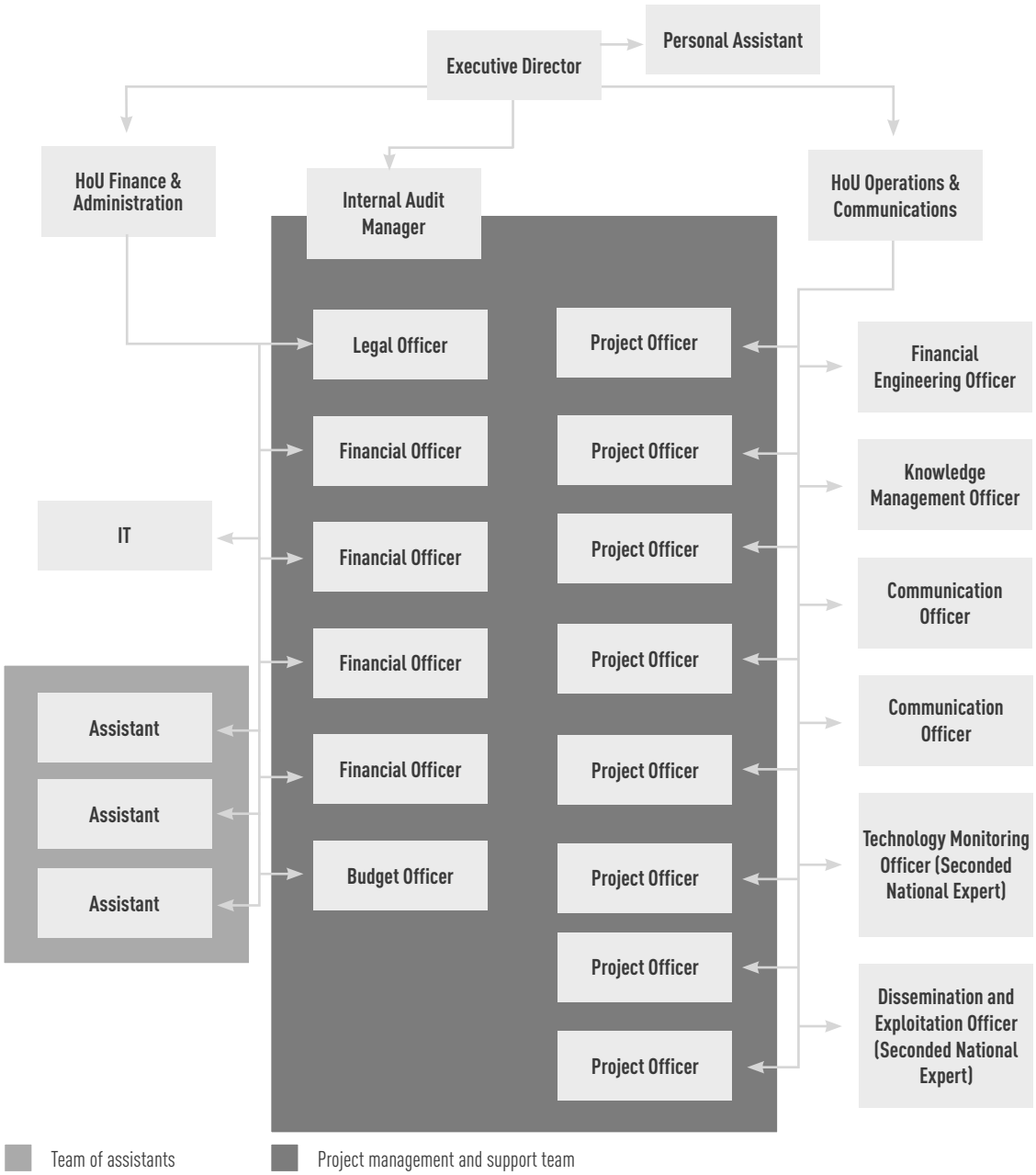
Place ..... date: 25 February 2021

Bart Biebuyck

243 True and fair in this context means a reliable, complete and correct view of the state of affairs in the Joint Undertaking.

07
ANNEXES

ANNEX 1
Organisation chart



ANNEX 2
Staff establishment plan

The JU team of statutory staff consists of 27 members (24 temporary agents and 3 contract agents). In addition, staff resources include two seconded national experts (SNE).

The 2019-2020 Staff establishment plan is shown below.

GRADE	2019 BUDGET	2019 FILLED	2020 BUDGET	2020 FILLED
AD 16	-	-		
AD 15	-	-		
AD 14	1	1	1	1
AD 13	-	-		
AD 12	-	-		
AD 11	2	2	2	2
AD 10	-	-		
AD 9	2	2	4	4
AD 8	6	6	4	4
AD 7	-		1	1
AD 6	4	4	3	3
AD 5	-	-		
Total AD[244]	**15**	**15**	**15**	**15**
AST 11	-	-		
AST 10	-	-		
AST 9	-	-	1	1
AST 8	2	2	1	1
AST 7	1	1	1	1
AST 6	1	1	1	1
AST 5	1	1	1	1
AST 4	4	4	4	4
Total AST[245]	**9**	**9**	**9**	**9**
Function Group IV	1	1	1	1
Function Group III	1	1	1	1
Function Group II	1	1	1	1
Total contract agents	**3**	**3**	**3**	**3**
Total Seconded National Experts	**2**	**1**	**2**	**2**

244 AD stands for administrator.

245 AST stands for assistant.

ANNEX 3
Publications from projects

Publications related to H2020 projects. Information extracted from CORDA for the years 2019 and after. For previous years, please refer to our past Annual Activity Report publications.

Project Acronym	CR Publ Type	CR Publ Title	CR Publ DOI	CR Publ ISSN	CR Publ Authors	CR Publ Journal Title	CR Publ Journal Nbr	CR Publ Publisher	CR Publ Published Place	CR Publ Published Year	CR Publ Relevant Pages	CR Publ Is Joint Public/ Private ?	CR Publ In O-A ?	CR Link To Publication
AD ASTRA	PEER_ REVIEWED_ ARTICLE	Degradation of Ni-YSZ Electrodes in Solid Oxide Cells: Impact of Polarization and Initial Microstructure on the Ni Evolution	10.1149/2.1261915jes	00134651	F. Monaco, M. Hubert, J. Vulliet, J. P. Ouweltjes, D. Montinaro, P. Cloetens, P. Piccardo, F. Lefebvre-Joud, J. Laurencin	Journal of The Electrochemical Society	166/15	Electrochemical Society, Inc.	United States	2019	F1229-F1242	Yes	Yes - Green OA	
AD ASTRA	PEER_ REVIEWED_ ARTICLE	Evolution of the Morphology Near Triple-Phase Boundaries in Ni–Yttria Stabilized Zirconia Electrodes Upon Cathodic Polarization	10.1115/1.4046478	23816872	A. Nakajo, G. Rinaldi, P. Caliandro, G. Jeanmonod, L. Navratilova, M. Cantoni, J. Van herle	Journal of Electrochemical Energy Conversion and Storage	17/4	ASME	on line	2020		No	Yes - Green OA	
AD ASTRA	PEER_ REVIEWED_ ARTICLE	Stochastic Geometrical and Microstructural Modeling for Solid Oxide Cell Electrodes	10.1149/09101.2031ecst	19385862	Hamza Moussaoui, Jérôme Laurencin, Maxime Hubert, Rakesh Sharma, Peter Cloetens, Gérard Delette, Yann Gavet, Johan Debayle	ECS Transactions	91/1	Electrochemical Society, Inc.	United States	2019	2031-2043	Yes	No	
AutoRE	PEER_ REVIEWED_ ARTICLE	Combined heat, cooling, and power systems based on half effect absorption chillers and polymer electrolyte membrane fuel cells	10.1016/j.apenergy.2018.10.109	03062619	Gabriele Loreti, Andrea L. Facci, Ilaria Baffo, Stefano Ubertini	Applied Energy	235	Pergamon Press Ltd.	United Kingdom	2019	747-760	No	Yes - Green OA	
AutoRE	PEER_ REVIEWED_ ARTICLE	Formation of hydrogen bubbles in Pd-Ag membranes during H2 permeation	10.1016/j.ijhydene.2019.02.001	03603199	T.A. Peters, P.A. Carvalho, M. Stange, R. Bredesen	International Journal of Hydrogen Energy		Pergamon Press Ltd.	United Kingdom	2019		No	Yes - Green OA	https://www.researchgate.net/publication/331466578_Formation_of_hydrogen_bubbles_in_Pd-Ag_membranes_during_H2_permeation
AutoRE	PEER_ REVIEWED_ ARTICLE	Numerical modeling of an automotive derivative polymer electrolyte membrane fuel cell cogeneration system with selective membranes	10.1016/j.ijhydene.2018.07.166	03603199	Gabriele Loreti, Andrea Luigi Facci, Thijs Peters, Stefano Ubertini	International Journal of Hydrogen Energy	44/9	Pergamon Press Ltd.	United Kingdom	2019	4508-4523	No	Yes - Green OA	http://dspace.unitus.it/handle/2067/3121
AutoRE	PEER_ REVIEWED_ ARTICLE	Pd-Based Membranes: Overview and Perspectives	10.3390/membranes9020025	20770375	Thijs Peters, Alessio Caravella	Membranes	9/2	Molecular Diversity Preservation International	Switzerland	2019	25	No	Yes - Green OA	
BIG HIT	ARTICLE	Life cycle cost analysis: A case study of hydrogen energy application on the Orkney Islands	10.1016/j.ijhydene.2018.08.015	03603199	Guangling Zhao, Eva Ravn Nielsen, Enrique Troncoso, Kris Hyde, Jesús Simón Romeo, Michael Diderich	International Journal of Hydrogen Energy	44/19	Pergamon Press Ltd.	United Kingdom	2019	9517-9528	No	Yes - Green OA	
BIONICO	PEER_ REVIEWED_ ARTICLE	Life Cycle Assessment and Economic Analysis of an Innovative Biogas Membrane Reformer for Hydrogen Production	10.3390/pr7020086	22279717	Gioele Di Marcoberardino, Xun Liao, Arnaud Dauriat, Marco Binotti, Giampaolo Manzolini	Processes	7/2	MDPI - Processes	Basel, Switzerland	2019	86	No	Yes - Gold OA	
BIONICO	PEER_ REVIEWED_ ARTICLE	Long-Term Stability of Thin-Film Pd-Based Supported Membranes	10.3390/pr7020106	22279717	Niek Nooijer, Alba Arratibel Plazaola, Jon Meléndez Rey, Ekain Fernandez, David Pacheco Tanaka, Martin Sint Annaland, Fausto Gallucci	Processes	7/2	MDPI - Processes	Basel, Switzerland	2019	106	No	Yes - Gold OA	
BIONICO	PEER_ REVIEWED_ ARTICLE	Techno-Economic Assessment in a Fluidized Bed Membrane Reactor for Small-Scale H2 Production: Effect of Membrane Support Thickness	10.3390/membranes9090116	20770375	Di Marcoberardino, Knijff, Binotti, Gallucci, Manzolini	Membranes	9/9	Molecular Diversity Preservation International	Switzerland	2019	116	No	Yes - Gold OA	
Cell3Ditor	PEER_ REVIEWED_ ARTICLE	Gd0.2Ce0.8O1.9/Y0.16Zr0.84O1.92 nano-composite thin films for low temperature ionic conductivity	10.1016/j.jpcs.2019.04.019	00223697	Giovanni Perin, Christophe Gadea, Massimo Rosa, Simone Sanna, Yu Xu, Ragnar Kiebach, Antonella Glisenti, Vincenzo Esposito	Journal of Physics and Chemistry of Solids		Pergamon Press Ltd.	United Kingdom	2019		No	Yes - Green OA	
Cell3Ditor	PEER_ REVIEWED_ ARTICLE	Impact of cation redox chemistry on continuous hydrothermal synthesis of 2D-Ni(Co/Fe) hydroxides	10.1039/c9re00334g	20589883	Massimo Rosa, Debora Marani, Giovanni Perin, Søren Bredmose Simonsen, Philipp Zielke, Antonella Glisenti, Ragnar Kiebach, Andreas Lesch, Vincenzo Esposito	Reaction Chemistry & Engineering		Royal Society of Chemistry	UK	2019		No	Yes - Green OA	
CH2P	PEER_ REVIEWED_ ARTICLE	A Cogeneration System Based on Solid Oxide and Proton Exchange Membrane Fuel Cells With Hybrid Storage for Off-Grid Applications	10.3389/fenrg.2018.00139	2296598X	Francesco Baldi, Ligang Wang, Mar Pérez-Fortes, François Maréchal	Frontiers in Energy Research	6	Frontiers in Energy Research	University of Arizona, United States	2019	1-18	No	Yes - Green OA	https://doi.org/10.3389/fenrg.2018.00139
CH2P	PEER_ REVIEWED_ ARTICLE	Characterization of local morphology and availability of triple-phase boundaries in solid oxide cell electrodes	10.1016/j.actamat.2019.07.027	13596454	G. Rinaldi, A. Nakajo, P. Burdet, M. Cantoni, W.K.S. Chiu, J. Van herle	Acta Materialia	178	Elsevier BV	Netherlands	2019	194-206	No	Yes - Gold OA	https://doi.org/10.1016/j.actamat.2019.07.027
CH2P	PEER_ REVIEWED_ ARTICLE	Design of a Pilot SOFC System for the Combined Production of Hydrogen and Electricity under Refueling Station Requirements	10.1002/fuce.201800200	16156846	M. Pérez-Fortes, A. Mian, S. Srikanth, L. Wang, S. Diethelm, E. Varkaraki, I. Mirabelli, R. Makkus, R. Schoon, F. Maréchal, J. Van herle	Fuel Cells	4	John Wiley & Sons Ltd.	United Kingdom	2019	389-407	No	Yes - Gold OA	https://doi.org/10.1002/fuce.201800200
CH2P	PEER_ REVIEWED_ ARTICLE	Evolution of the Morphology Near Triple-Phase Boundaries in Ni–Yttria Stabilized Zirconia Electrodes Upon Cathodic Polarization	10.1115/1.4046478	23816872	A. Nakajo, G. Rinaldi, P. Caliandro, G. Jeanmonod, L. Navratilova, M. Cantoni, J. Van herle	Journal of Electrochemical Energy Conversion and Storage	17/4	ASME	na	2020		No	Yes - Gold OA	https://asmedigitalcollection.asme.org/electrochemical/article/17/4/041102/1074944/Evolution-of-the-Morphology-Near-Triple-Phase
CRESCENDO	PEER_ REVIEWED_ ARTICLE	Accurate Evaluation of Active-Site Density (SD) and Turnover Frequency (TOF) of PGM-Free Metal–Nitrogen-Doped Carbon (MNC) Electrocatalysts using CO Cryo Adsorption	https://pubs.acs.org/doi/10.1021/acscatal.9b00588	21555435	Fang Luo, Chang Hyuck Choi, Mathias J.M. Primbs, Wen Ju, Shuang Li, Nathaniel D. Leonard, Arne Thomas, Frédéric Jaouen, Peter Strasser	ACS Catalysis	9/6	American Chemical Society	United States	2019	4841-4852	No	Yes - Green OA	
DEMOSOFC	PEER_ REVIEWED_ ARTICLE	Efficiency analysis of 50 kWe SOFC systems fueled with biogas from waste water	10.1016/j.powera.2020.100009	2666-2485	Jari Kiviaho; Marta Gandiglio; Tuomas Hakala; Hendrik Langnickel; Massimo Santarelli; Marco Acri; Markus Rautanen	Journal of Power Sources Advances	1	Elsevier, Journal of Power Sources Advances	Volume 2, April 2020, 100009	2020		Yes	Yes - Gold OA	Efficiency analysis of 50 kWe SOFC systems fueled with biogas from waste water
DEMOSOFC	PEER_ REVIEWED_ ARTICLE	Life Cycle Assessment of a Biogas-Fed Solid Oxide Fuel Cell (SOFC) Integrated in a Wastewater Treatment Plant	10.3390/en12091611	19961073	Marta Gandiglio, Fabrizio De Sario, Andrea Lanzini, Silvia Bobba, Massimo Santarelli, Gian Andrea Blengini	Energies	12/9	Multidisciplinary Digital Publishing Institute (MDPI)	Switzerland	2019	1611	No	Yes - Gold OA	https://www.mdpi.com/1996-1073/12/9/1611
DEMOSOFC	PEER_ REVIEWED_ ARTICLE	Results from an industrial size biogas-fed SOFC plant (the DEMOSOFC project)	10.1016/j.ijhydene.2019.08.022	03603199	Marta Gandiglio, Andrea Lanzini, Massimo Santarelli, Marco Acri, Tuomas Hakala, Markus Rautanen	International Journal of Hydrogen Energy	45/8	Pergamon Press Ltd.	United Kingdom	2020	5449-5464	Yes	Yes - Gold OA	https://demosofc.wordpress.com/download-3/publications/
DEMOSOFC	PEER_ REVIEWED_ ARTICLE	Study of H2S Removal Capability from Simulated Biogas by Using Waste-Derived Adsorbent Materials	10.3390/pr8091030	22279717	Hua Lun Zhu, Davide Papurello, Marta Gandiglio, Andrea Lanzini, Isil Akpinar, Paul R. Shearing, George Manos, Dan J.L. Brett, Ye Shui Zhang	Processes	8/9	MDPI	MDPI	2020	1030	No	Yes - Green OA	
DIGIMAN	CONFERENCE_ PROCEEDING	Automatic PLC Code Generation Based on Virtual Engineering Model	10.1109/ic-phys.2019.8780213	978-1-5386-8500-6	Mohammad Jbair, Bilal Ahmad, Mus'ab H. Ahmad, Daniel Vera, Robert Harrison, Tony Ridler	2019 IEEE International Conference on Industrial Cyber Physical Systems (ICPS)		IEEE	USA	2019	675-680	No	Yes - Green OA	
DIGIMAN	BOOK_CHAPTER	Uncertainty in Measurement			Carlo Ferri	Intelligent System and Computing		Intechopen	London, UK	2019		No	Yes - Gold OA	https://www.intechopen.com/online-first/uncertainty-in-measurement

Project Acronym	CR Publ Type	CR Publ Title	CR Publ DOI	CR Publ ISSN	CR Publ Authors	CR Publ Journal Title	CR Publ Journal Nbr	CR Publ Publisher	CR Publ Published Place	CR Publ Published Year	CR Publ Relevant Pages	CR Publ Is Joint Public/ Private ?	CR Publ In O-A ?	CR Link To Publication
ECo	OTHER	Electricity from renewable sources must be stored efficiently			A. Hagen	www.openaccessgovernment.org	quarterly editions	openaccessgovernment	https://www.openaccessgovernment.org/electricity-from-renewable-sources/59533/	2019	digital publication	No	Yes - Gold OA	https://www.openaccessgovernment.org/electricity-from-renewable-sources/59533/
ECo	PEER_REVIEWED_ARTICLE	Microstructural correlations for specific surface area and triple phase boundary length for composite electrodes of solid oxide cells	10.1016/j.jpowsour.2018.11.095	03787753	H. Moussaoui, R.K. Sharma, J. Debayle, Y. Gavet, G. Delette, J. Laurencin	Journal of Power Sources	412	Elsevier BV	Netherlands	2019	736-748	No	Yes - Gold OA	
ECo	PEER_REVIEWED_ARTICLE	Power-to-fuels via solid-oxide electrolyzer: Operating window and techno-economics	10.1016/j.rser.2019.04.071	13640321	Ligang Wang, Ming Chen, Rainer Küngas, Tzu-En Lin, Stefan Diethelm, François Maréchal, Jan Van herle	Renewable and Sustainable Energy Reviews	110	Elsevier BV	Netherlands	2019	174-187	Yes	Yes - Gold OA	
ECo	PEER_REVIEWED_ARTICLE	Power-to-methane via co-electrolysis of H2O and CO2: The effects of pressurized operation and internal methanation	doi: 10.1016/j.apenergy.2019.05.098	03062619	Ligang Wang, Megha Rao, Stefan Diethelm, Tzu-En Lin, Hanfei Zhang, Anke Hagen, François Maréchal, Jan Van herle	Applied Energy	250	Pergamon Press Ltd.	United Kingdom	2019	1432-1445	Yes	Yes - Gold OA	
ECo	PEER_REVIEWED_ARTICLE	Trade-off designs of power-to-methane systems via solid-oxide electrolyzer and the application to biogas upgrading	doi: 10.1016/j.apenergy.2019.04.055	03062619	Guillaume Jeanmonod, Ligang Wang, Stefan Diethelm, François Maréchal, Jan Van herle	Applied Energy	247	Pergamon Press Ltd.	United Kingdom	2019	572-581	Yes	Yes - Gold OA	
ELYntegration	PEER_REVIEWED_ARTICLE	A Powder Metallurgy Route to Produce Raney-Nickel Electrodes for Alkaline Water Electrolysis	10.1149/2.0851904jes	00134651	Christian Immanuel Bernäcker, Thomas Rauscher, Tilo Büttner, Bernd Kieback, Lars Röntzsch	Journal of The Electrochemical Society	166/6	Electrochemical Society, Inc.	United States	2019	F357-F363	No	Yes - Gold OA	http://jes.ecsdl.org/content/166/6/F357.abstract
ELYntegration	PEER_REVIEWED_ARTICLE	Techno-economic modelling of water electrolysers in the range of several MW to provide grid services while generating hydrogen for different applications: a case study in Spain applied to mobility with FCEVs		0360-3199	Guillermo Matute, José María Yusta, Luis Carlos Correas	International Journal of Hydrogen Energy		Pergamon Press Ltd.	United Kingdom	2019		Yes	Yes - Gold OA	
Fit-4-AMandA	PEER_REVIEWED_ARTICLE	A comprehensive comparison of state-of-the-art manufacturing methods for fuel cell bipolar plates including anticipated future industry trends	10.1016/j.jmapro.2020.10.041	15266125	S. Porstmann, T. Wannemacher, W.-G. Drossel	Journal of Manufacturing Processes	60	Elsevier BV	Netherlands	2020	366-383	Yes	Yes - Gold OA	
Fit-4-AMandA	CONFERENCE_PROCEEDING	Analysis of manufacturing processes for metallic and composite bipolar plates.			Sebastian Porstmann, Allan C. Petersen and Thomas Wannemacher.			Fuel Cell Conference FC³	Chemnitz	2019		No	Yes - Green OA	
Fit-4-AMandA	ARTICLE	Fit-4-AMandA – Stack robot delivered;		2367-3931	"Sebastian Porstmann, Fraunhofer-Institut für Werkzeugmaschinen und Umformtechnik IWU, Chemnitz Dr. Martin Biák, Technische Universität Chemnitz"	H2-international		H2-international e-journal	online	2019		No	Yes - Green OA	https://www.h2-international.com/2019/12/16/fit-4-amanda-stack-robot-delivered/
Fit-4-AMandA	PEER_REVIEWED_ARTICLE	Overcoming the Challenges for a Mass Manufacturing Machine for the Assembly of PEMFC Stacks	10.3390/machines7040066	20751702	Porstmann, Wannemacher, Richter	Machines	7/4	MDPI	Germany	2019	66	Yes	Yes - Green OA	https://www.mdpi.com/2075-1702/7/4/66/review_report
GAIA	PEER_REVIEWED_ARTICLE	Current challenges related to the deployment of shape-controlled Pt alloy oxygen reduction reaction nanocatalysts into low Pt-loaded cathode layers of proton exchange membrane fuel cells	10.1016/j.coelec.2019.10.011	24519103	Lujin Pan, Sebastian Ott, Fabio Dionigi, Peter Strasser	Current Opinion in Electrochemistry	18	Elsevier	Amsterdam	2019	61-71	No	Yes - Green OA	https://doi.org/10.1016/j.coelec.2019.10.011
GAMER	PEER_REVIEWED_ARTICLE	Mixed proton and electron conducting double perovskite anodes for stable and efficient tubular proton ceramic electrolysers	10.1038/s41563-019-0388-2	14761122	Einar Vøllestad, Ragnar Strandbakke, Mateusz Tarach, David Catalán-Martínez, Marie-Laure Fontaine, Dustin Beeaff, Daniel R. Clark, Jose M. Serra, Truls Norby	Nature Materials	18/7	Nature Publishing Group	United Kingdom	2019	752-759	Yes	Yes - Gold OA	https://www.nature.com/articles/s41563-019-0388-2
Giantleap	CONFERENCE_PROCEEDING	Control and prognostics for flexible hybrid battery-hydrogen buses	10.5281/zenodo.2631210		Federico Zenith	Hannover Messe, Hydrogen & Fuel Cells Technical Forum		Hannover Messe	Hannover, Germany	2019		Yes	Yes - Gold OA	
Giantleap	CONFERENCE_PROCEEDING	Diagnostics, Prognostics and Control of Low-Temperature PEM Fuel Cells	10.5281/zenodo.2563594		Federico Zenith	Fundamentals and Development of Fuel Cells 2019		FDFC2019	Nantes, France	2019		No	Yes - Gold OA	
Giantleap	PEER_REVIEWED_ARTICLE	Electrochemical low-frequency impedance spectroscopy algorithm for diagnostics of PEM fuel cell degradation	10.1016/j.ijhydene.2019.04.004	03603199	Ivar J. Halvorsen, Ivan Pivac, Dario Bezmalinović, Frano Barbir, Federico Zenith	International Journal of Hydrogen Energy		Pergamon Press Ltd.	United Kingdom	2019		No	Yes - Gold OA	
Giantleap	CONFERENCE_PROCEEDING	Electrochemical Low-Frequency Impedance Spectroscopy for Diagnostics of Fuel Cells	10.5281/zenodo.3490376		Federico Zenith, Ivar J. Halvorsen, Ivan Pivac, Dario Bezmalinović, Frano Barbir	Vehicle Power Propulsion Conference		IEEE	Hanoi, Vietnam	2019		No	Yes - Gold OA	
Giantleap	CONFERENCE_PROCEEDING	Fuel cell performance prediction using an Auto-Regressive Moving-Average Model	10.5281/zenodo.1467942		A. H. Detti, N. Yousfi Steiner, L. Bouillaut, A. B. Same, S. Jemei	Vehicle Power Propulsion Conference		IEEE	Hanoi, Vietnam	2019		No	Yes - Gold OA	
Giantleap	CONFERENCE_PROCEEDING	Increasing Reliability of Fuel-Cell Buses: The Giantleap Project	10.5281/zenodo.2631200		Federico Zenith	Hydrogen Days		HyTEP	Prague, Czechia	2019		Yes	Yes - Gold OA	
Giantleap	CONFERENCE_PROCEEDING	Relay feedback excitation for identification of Fuel Cell performance parameters	10.5281/zenodo.3552727		Ivar J. Halvorsen, Federico Zenith	Nordic Process Control Workshop		DTU	Copenhagen, Denmark	2019		No	Yes - Gold OA	
GrInHy	PEER_REVIEWED_ARTICLE	Electrolyte-Supported Fuel Cell: Co-Sintering Effects of Layer Deposition on Biaxial Strength	10.3390/ma12203086	19961944	Alessia Masini, Thomas Strohbach, Filip Šiška, Zdeněk Chlup, Ivo Dlouhý	Materials	12/2	MDPI Open Access Publishing	Switzerland	2019	306	Yes	Yes - Gold OA	
GrInHy	PEER_REVIEWED_ARTICLE	Shear Performance at Room and High Temperatures of Glass–Ceramic Sealants for Solid Oxide Electrolysis Cell Technology	10.3390/ma12202298	19961944	Hassan Javed, Antonio Sabato, Ivo Dlouhy, Martina Halasova, Enrico Bernardo, Milena Salvo, Kai Herbrig, Christian Walter, Federico Smeacetto	Materials	12/2	MDPI Open Access Publishing	Switzerland	2019	298	No	Yes - Gold OA	
H2Ports	CONFERENCE_PROCEEDING	Experiencia con maquinaria portuaria basada en hidrógeno y pilas de combustible			Raúl Cascajo (Port Authority of Valencia)	Movilidad y logística sostenibles en áreas portuarias		Bilbao Port Authority	Bilbao (Spain)	2019		No	No	
H2Ports	CONFERENCE_PROCEEDING	Fuel Cell Development in Larger Ships			Kristina Flache Juelsgaard (Business Development Director at BALLARD POWER SYSTEMS EUROPE)	Developing Hydrogen Ports and Maritime Policy in the North Sea Region		European Policy Solutions	Edinburgh (UK)	2019		No	No	
H2Ports	CONFERENCE_PROCEEDING	H2Ports - Implementing Fuel Cells and Hydrogen Technologies in Ports			V. Cigolotti1, P. Di Giorgio2, A. Pianese2, M. Minutillo2, E. Jannelli 1. ENEA - Italian National Agency for New Technologies, Energy and Sustainable Economic Development (Italy) 2. Department of Engineering, University of Naples "Parthenope", Naples (Italy)	Fuel Cell Seminar & Energy Exposition		FCHEA (US)	LONG BEACH, CALIFORNIA (US)	2019		No	No	
H2Ports	CONFERENCE_PROCEEDING	H2PORTS Desarrollo de hidrogenera en el puerto marítimo de Valencia.			Beatriz Nieto, Cristina Ballester, Carlos Fúnez, Gema Alcalde y Carlos Merino (Centro Nacional del Hidrógeno - CNH2).	1er Congreso Iberoamericano de Ingeniería Química (CIBIQ).		1er Congreso Iberoamericano de Ingeniería Química	Santander (Spain)	2019		No	No	
H2Ports	CONFERENCE_PROCEEDING	H2PORTS. Hydrogen efueling system development in the port of Valencia.			Cristina Ballester (Open Innovation Unit – Centro Nacional del Hidrógeno – CNH2)	European Fuel Cells Conference 2019		ATENA, ENEA, Universita degli studi di Napoli "Parthenope" and Universita degli studi de Perugia	Naples (Italy)	2019		No	No	
H2Ports	CONFERENCE_PROCEEDING	The H2PORTS project. Implementing Fuel Cells and Hydrogen Technologies in Ports.			Carlos Fúnez (Head of the Open Innovation Unit at the Centro Nacional de Hidrógeno – CNH2)	Polish Conference on Hydrogen Energy and Technology 2019		Cluster of Hydrogen and Clean Coal Energy Technologies and Regional Pomeranian Chamber of Commerce	Gdynia (Poland)	2019		No	No	
H2Ports	CONFERENCE_PROCEEDING	The H2PORTS project. Implementing Fuel Cells and Hydrogen Technologies in Ports.			José A. Giménez (Head of Port Logistics at Fundación Valenciaport)	Hydrogen & Fuel Cells Energy Summit		Hydrogen Europe	Madrid (Spain)	2019		No	No	
Haeolus	CONFERENCE_PROCEEDING	A Feature-Based Prognostics Strategy for PEM Fuel Cell Operated under Dynamic Conditions	10.1109/phm-besancon49106.2020.00026	978-1-7281-5675-0	Meiling Yue, Zhongliang Li, Robin Roche, Samir Jemei, Noureddine Zerhouni	2020 Prognostics and Health Management Conference (PHM-Besançon)		IEEE	Besançon	2020	122-127	No	Yes - Green OA	https://ieeexplore.ieee.org/document/9115522

Project Acronym	CR Publ Type	CR Publ Title	CR Publ DOI	CR Publ ISSN	CR Publ Authors	CR Publ Journal Title	CR Publ Journal Nbr	CR Publ Publisher	CR Publ Published Place	CR Publ Published Year	CR Publ Relevant Pages	CR Publ Is Joint Public/ Private ?	CR Publ In O-A ?	CR Link To Publication
Haeolus	CONFERENCE_ PROCEEDING	Framtidig bruk av hydrogen	10.5281/zenodo.3675350		Federico Zenith	Hydrogensone Arktis		Troms & Finnmark County Council	Vadsø	2020		No	Yes - Gold OA	
Haeolus	CONFERENCE_ PROCEEDING	HAEOLUS: Proposing a new-generation electrolyser integrated within astate-of-the-art wind farm in a remote area with access to a weak power grid	10.5281/zenodo.3241265		Roche, Robin	Journées du GdR SEEDS-JCGE		CNRS	Oléron, France	2019		No	Yes - Gold OA	
Haeolus	CONFERENCE_ PROCEEDING	Hydrogen energy storage and grid services in microgrids	10.5281/zenodo.3267293		Federico Zenith	Microgrids Summer School		FCLAB	Belfort, France	2019		No	Yes - Gold OA	
Haeolus	CONFERENCE_ PROCEEDING	Hydrogen i Finnmark - Haeolus-pros-jektet & C.	10.5281/zenodo.3465528		Federico Zenith			SINTEF	Ålesund, Norway	2019		No	Yes - Gold OA	
Haeolus	CONFERENCE_ PROCEEDING	Hydrogen som energibærer - Norges nøkkelrolle i et internasjonalt perspektiv	10.5281/zenodo.2605540		Steffen Møller-Holst	Hydrogen i Vinden		SINTEF	Vadsø, Norway	2019		No	Yes - Gold OA	
Haeolus	CONFERENCE_ PROCEEDING	Kickstarting an Arctic Hydrogen Valley: The Haeolus project	10.5281/zenodo.4316974		Federico Zenith	Next Generation Electrolysers Conference		Next Generation Electrolysers Conference	Online	2020		No	Yes - Gold OA	
Haeolus	CONFERENCE_ PROCEEDING	Konkrete muligheter for anvendelser av hydrogen i Varangerregionen	10.5281/zenodo.2605260		Federico Zenith	Hydrogen i Vinden		SINTEF	Vadsø, Norway	2019		No	Yes - Gold OA	
Haeolus	CONFERENCE_ PROCEEDING	La oportunidad de la hibridación entre los sistemas eólicos y los de hidrógeno Almacenamiento y servicios a la red	10.5281/zenodo.4288932		Maider Santos-Mugica	International Summit on the Operational Analysis of Wind Farms		International Summit on the Operational Analysis of Wind Farms	Online (Madrid)	2020		No	Yes - Gold OA	
Haeolus	PEER_ REVIEWED_ ARTICLE	Mixed Logic Dynamic Models for MPC Control of Wind Farm Hydrogen-Based Storage Systems	10.3390/inventions4040057	24115134	Muhammad Faisal Shehzad, Muhammad Bakr Abdelghany, Davide Liuzza, Valerio Mariani, Luigi Glielmo	Inventions	4/4	MDPI	Benevento, Italy	2019	57	No	Yes - Gold OA	https://doi.org/10.3390/inventions4040057
Haeolus	CONFERENCE_ PROCEEDING	Modeling and Optimal Control of a Hydrogen Storage System for Wind Farm Output Power Smoothing	10.5281/zenodo.4420338		Muhammad Bakr Abdelghany, M. F Shehzad, Davide Liuzza, Valerio Mariani, Luigi Glielmo	59th IEEE Conference on Decision and Control		59th IEEE Conference on Decision and Control	Jeju Island, South Korea	2020		No	Yes - Gold OA	
Haeolus	CONFERENCE_ PROCEEDING	Modeling of a Hydrogen Storage Wind Plant for Model Predictive Control Management Strategies	10.23919/ ecc.2019.8795937	978-3-907144-00-8	Muhammad Faisal Shehzad, Muhammad Bakr Abdelghany, Davide Liuzza, Luigi Glielmo	2019 18th European Control Conference (ECC)		IEEE	Naples, Italy	2019	1896-1901	No	Yes - Gold OA	
Haeolus	CONFERENCE_ PROCEEDING	Potential impact and economic potential for integrated wind farm - electrolyser energy system	10.5281/zenodo.3669909		Vibeke S. Nørstebø, Miguel Muñoz Ortiz, Gerardo A. Perez-Valdes	30th European Conference on Operational Research (EURO2019)		UCD	Dublin, Ireland	2019		No	Yes - Gold OA	
Haeolus	CONFERENCE_ PROCEEDING	Predictive maintenance for wind-hydrogen plant using diagnostics and prognostics of PEM electrolysers	10.5281/zenodo.4507353		Robin Roche	European Control Conference 2019		IEEE	Naples, Italy	2019		No	Yes - Gold OA	
Haeolus	CONFERENCE_ PROCEEDING	Visjoner for hydrogen og vind i Finnmark	10.5281/zenodo.2607649		Christian Bue	Hydrogen i Vinden		Varanger Kraft	Vadsø, Norway	2019		No	Yes - Gold OA	
HEALTH-CODE	PEER_ REVIEWED_ ARTICLE	Fault Characterization of a Proton Exchange Membrane Fuel Cell Stack	10.3390/en12010152	19961073	Samuel Simon Araya, Fan Zhou, Simon Lennart Sahlin, Sobi Thomas, Christian Jeppesen, Søren Knudsen Kær	Energies	12/1	Multidisciplinary Digital Publishing Institute (MDPI)	Switzerland	2019	152	No	Yes - Green OA	
HEALTH-CODE	PEER_ REVIEWED_ ARTICLE	Generalized scaling-up approach based on Buckingham theorem for Polymer Electrolyte Membrane Fuel Cells impedance simulation	10.1016/j. egypro.2019.01.360	18766102	Pierpaolo Polverino, Giovanni Bove, Marco Sorrentino, Cesare Pianese	Energy Procedia	158	Elsevier	UK	2019	1514-1520	No	Yes - Green OA	
HEATSTACK	PEER_ REVIEWED_ ARTICLE	The effect of aluminium addition on the high-temperature oxidation behaviour and Cr evaporation of aluminised and alumina-forming alloys for SOFC cathode air pre-heaters	10.1016/j. corsci.2020.108612	0010938X	Kun Zhang, Ahmad El-Kharouf, Jong-Eun Hong, Robert Steinberger-Wilckens	Corrosion Science	169	Pergamon Press Ltd.	United Kingdom	2020	108612	No	Yes - Green OA	
HEATSTACK	PEER_ REVIEWED_ ARTICLE	The Effect of Pre-Heat Treatment of AluChrom 318 on the Corrosion Behaviour and Cr Evaporation in SOFC Cathode Air Pre-Heater	10.1149/09101.2253ecst	19385862	Kun Zhang, Ahmad El-kharouf, Robert Steinberger-Wilckens	ECS Transactions	91/1	Electrochemical Society, Inc.	United States	2019	2253-2260	No	Yes - Green OA	
HyCARE	OTHER	In-situ neutron diffraction during reversible deuterium loading in under-stoichiometric and Mn,Cu-substituted Ti(Fe,Mn,Cu)0.9 alloys	10.5286/isis.e.rb1920559		Principal Investigator: Dr Erika Dematteis Experimenter: Professor Bjorn Hauback Local Contact: Dr Ivan da Silva Gonzalez Experimenter: Dr Stefano Deledda Experimenter: Dr Fermin Cuevas Experimenter: Dr MICHEL LATROCHE Experimenter: Dr Giovanni Capurso Experimenter: Miss JUSSARA BARALE	ISIS Neutron and Muon Source Data Journal		STFC ISIS Neutron and Muon Source	UK	2020		No	Yes - Green OA	https://data.isis.stfc.ac.uk/doi/ STUDY/108681923/
HyCARE	OTHER	In-situ neutron diffraction during reversible deuterium loading in under-stoichiometric and Mn,Cu-substituted Ti(Fe,Mn,Cu)0.9 alloys	10.5286/isis.e.rb1920559		Principal Investigator: Dr Erika Dematteis Experimenter: Professor Bjorn Hauback Local Contact: Dr Ivan da Silva Gonzalez Experimenter: Dr Stefano Deledda Experimenter: Dr Fermin Cuevas Experimenter: Dr MICHEL LATROCHE Experimenter: Dr Giovanni Capurso Experimenter: Miss JUSSARA BARALE	ISIS Neutron and Muon Source Data Journal		STFC ISIS Neutron and Muon Source	UK	2020		No	Yes - Green OA	https://data.isis.stfc.ac.uk/doi/ STUDY/108681923/
HyCARE	OTHER	In-situ neutron diffraction during reversible deuterium loading in under-stoichiometric and Mn,Cu-substituted Ti(Fe,Mn,Cu)0.9 alloys	10.5286/isis.e.rb1920559		Principal Investigator: Dr Erika Dematteis Experimenter: Professor Bjorn Hauback Local Contact: Dr Ivan da Silva Gonzalez Experimenter: Dr Stefano Deledda Experimenter: Dr Fermin Cuevas Experimenter: Dr MICHEL LATROCHE Experimenter: Dr Giovanni Capurso Experimenter: Miss JUSSARA BARALE	ISIS Neutron and Muon Source Data Journal		STFC ISIS Neutron and Muon Source	UK	2020		No	Yes - Green OA	https://data.isis.stfc.ac.uk/doi/ STUDY/108681923/
HyCARE	OTHER	In-situ neutron diffraction during reversible deuterium loading in under-stoichiometric and Mn,Cu-substituted Ti(Fe,Mn,Cu)0.9 alloys	10.5286/isis.e.rb1920559		Principal Investigator: Dr Erika Dematteis Experimenter: Professor Bjorn Hauback Local Contact: Dr Ivan da Silva Gonzalez Experimenter: Dr Stefano Deledda Experimenter: Dr Fermin Cuevas Experimenter: Dr MICHEL LATROCHE Experimenter: Dr Giovanni Capurso Experimenter: Miss JUSSARA BARALE	ISIS Neutron and Muon Source Data Journal		STFC ISIS Neutron and Muon Source	UK	2020		No	Yes - Green OA	https://data.isis.stfc.ac.uk/doi/ STUDY/108681923/
HyCARE	OTHER	In-situ neutron diffraction during reversible deuterium loading in under-stoichiometric and Mn-substituted Ti(Fe,Mn)0.9 alloys	10.5291/ill-data.5-22-771		CUEVAS Fermin (ORCID, ResearcherId), DELEDDA Stefano, Erika Michela Dematteis (ORCID, ResearcherId), HAUBACK Bjorn C., Michel Latroche (ORCID, ResearcherId), LAVERSENNE Laetitia ZHANG Junxian	Institut Laue-Langevin (ILL)		Institut Laue-Langevin	France	2020		No	Yes - Green OA	https://doi.ill.fr/10.5291/ILL-DATA.5-22-771
HyCARE	OTHER	In-situ neutron diffraction during reversible deuterium loading in under-stoichiometric and Mn-substituted Ti(Fe,Mn)0.9 alloys	10.5291/ill-data.5-22-771		CUEVAS Fermin (ORCID, ResearcherId), DELEDDA Stefano, Erika Michela Dematteis (ORCID, ResearcherId), HAUBACK Bjorn C., Michel Latroche (ORCID, ResearcherId), LAVERSENNE Laetitia ZHANG Junxian	Institut Laue-Langevin (ILL)		Institut Laue-Langevin	France	2020		No	Yes - Green OA	https://doi.ill.fr/10.5291/ILL-DATA.5-22-771
HyCARE	OTHER	In-situ neutron diffraction during reversible deuterium loading in under-stoichiometric and Mn-substituted Ti(Fe,Mn)0.9 alloys	10.5291/ill-data.5-22-771		CUEVAS Fermin (ORCID, ResearcherId), DELEDDA Stefano, Erika Michela Dematteis (ORCID, ResearcherId), HAUBACK Bjorn C. Michel Latroche (ORCID, ResearcherId), LAVERSENNE Laetitia ZHANG Junxian	Institut Laue-Langevin (ILL)		Institut Laue-Langevin	France	2020		No	Yes - Green OA	https://doi.ill.fr/10.5291/ILL-DATA.5-22-771
HyCARE	OTHER	In-situ neutron diffraction during reversible deuterium loading in under-stoichiometric and Mn-substituted Ti(Fe,Mn)0.9 alloys	10.5291/ill-data.5-22-771		CUEVAS Fermin (ORCID, ResearcherId), DELEDDA Stefano, Erika Michela Dematteis (ORCID, ResearcherId), HAUBACK Bjorn C., Michel Latroche (ORCID, ResearcherId), LAVERSENNE Laetitia ZHANG Junxian	Institut Laue-Langevin (ILL)		Institut Laue-Langevin	France	2020		No	Yes - Green OA	https://doi.ill.fr/10.5291/ILL-DATA.5-22-771

Project Acronym	CR Publ Type	CR Publ Title	CR Publ DOI	CR Publ ISSN	CR Publ Authors	CR Publ Journal Title	CR Publ Journal Nbr	CR Publ Publisher	CR Publ Published Place	CR Publ Published Year	CR Publ Relevant Pages	CR Publ Is Joint Public/ Private ?	CR Publ In O-A ?	CR Link To Publication
HyCARE	PEER_ REVIEWED_ ARTICLE	Metal Hydrides and Related Materials. Energy Carriers for Novel Hydrogen and Electrochemical Storage	10.1021/acs.jpcc.0c01806	19327447	A. El Kharbachi, E. M. Dematteis, K. Shinzato, S. C. Stevenson, L. J. Bannenberg, M. Heere, C. Zlotea, P. Á. Szilágyi, J.-P. Bonnet, W. Grochala, D. H. Gregory, T. Ichikawa, M. Baricco, B. C. Hauback	The Journal of Physical Chemistry C	124/14	American Chemical Society	United States	2020	7599-7607	No	Yes - Green OA	https://pubs.acs.org/doi/abs/10.1021/acs.jpcc.0c01806
HyCARE	PEER_ REVIEWED_ ARTICLE	Metal Hydrides and Related Materials. Energy Carriers for Novel Hydrogen and Electrochemical Storage	10.1021/acs.jpcc.0c01806	19327447	A. El Kharbachi, E. M. Dematteis, K. Shinzato, S. C. Stevenson, L. J. Bannenberg, M. Heere, C. Zlotea, P. Á. Szilágyi, J.-P. Bonnet, W. Grochala, D. H. Gregory, T. Ichikawa, M. Baricco, B. C. Hauback	The Journal of Physical Chemistry C	124/14	American Chemical Society	United States	2020	7599-7607	No	Yes - Green OA	https://pubs.acs.org/doi/abs/10.1021/acs.jpcc.0c01806
HyCARE	PEER_ REVIEWED_ ARTICLE	Metal Hydrides and Related Materials. Energy Carriers for Novel Hydrogen and Electrochemical Storage	10.1021/acs.jpcc.0c01806	19327447	A. El Kharbachi, E. M. Dematteis, K. Shinzato, S. C. Stevenson, L. J. Bannenberg, M. Heere, C. Zlotea, P. Á. Szilágyi, J.-P. Bonnet, W. Grochala, D. H. Gregory, T. Ichikawa, M. Baricco, B. C. Hauback	The Journal of Physical Chemistry C	124/14	American Chemical Society	United States	2020	7599-7607	No	Yes - Green OA	https://pubs.acs.org/doi/abs/10.1021/acs.jpcc.0c01806
HyCARE	PEER_ REVIEWED_ ARTICLE	Metal Hydrides and Related Materials. Energy Carriers for Novel Hydrogen and Electrochemical Storage	10.1021/acs.jpcc.0c01806	19327447	A. El Kharbachi, E. M. Dematteis, K. Shinzato, S. C. Stevenson, L. J. Bannenberg, M. Heere, C. Zlotea, P. Á. Szilágyi, J.-P. Bonnet, W. Grochala, D. H. Gregory, T. Ichikawa, M. Baricco, B. C. Hauback	The Journal of Physical Chemistry C	124/14	American Chemical Society	United States	2020	7599-7607	No	Yes - Green OA	https://pubs.acs.org/doi/abs/10.1021/acs.jpcc.0c01806
HYDRAITE	PEER_ REVIEWED_ ARTICLE	Assessment of hydrogen quality dispensed for hydrogen refuelling stations in Europe	10.1016/j.ijhydene.2020.11.163	03603199	Thor Anders Aarhaug, Ole Kjos, Thomas Bacquart, Vladimir Valter, Thomas Optenhostert	International Journal of Hydrogen Energy		Pergamon Press Ltd.	United Kingdom	2020		No	Yes - Gold OA	
HYDRAITE	PEER_REVIEWED_ ARTICLE	Determination of fuel utilisation and recirculated gas composition in dead-ended PEMFC systems	10.1016/j.ijhydene.2020.04.252	03603199	Pauli Koski, Jaana Viitakangas, Jari Ihonen	International Journal of Hydrogen Energy	45/43	Pergamon Press Ltd.	United Kingdom	2020	23201-23226	No	Yes - Gold OA	
HYDRAITE	PEER_ REVIEWED_ ARTICLE	Operando characterisation of the impact of carbon monoxide on PEMFC performance using isotopic labelling and gas analysis	10.1016/j.powera.2020.100036	26662485	Hans Becker, Thomas Bacquart, Mark Perkins, Niamh Moore, Jari Ihonen, Gareth Hinds, Graham Smith	Journal of Power Sources Advances	6	Elsevier Ltd.	Amsterdam, Netherlands	2020	100036	No	Yes - Gold OA	https://www.sciencedirect.com/science/article/pii/S2666248520300366
HYDRO-SOL-beyond	PEER_ REVIEWED_ ARTICLE	Parametric investigation of a volumetric solar receiver-reactor	10.1016/j.solener.2020.04.045	0038092X	A. Lidor, T. Fend, M. Roeb, C. Sattler	Solar Energy	204	Pergamon Press Ltd.	United Kingdom	2020	256-269	No	Yes - Green OA	https://doi.org/10.1016/j.solener.2020.04.045
HyGrid	PEER_ REVIEWED_ ARTICLE	Comparison between carbon molecular sieve and Pd-Ag membranes in H2-CH4 separation at high pressure	10.1016/j.ijhydene.2020.07.191	03603199	Maria Nordio, Jon Melendez, Martin van Sint Annaland, D. Alfredo Pacheco Tanaka, Margot Llosa Tanco, Fausto Gallucci	International Journal of Hydrogen Energy	45/53	Pergamon Press Ltd.	United Kingdom	2020	28876-28892	No	Yes - Gold OA	
HyGrid	PEER_REVIEWED_ ARTICLE	Hydrogen permeation studies of composite supported alumina-carbon molecular sieves membranes: Separation of diluted hydrogen from mixtures with methane	10.1016/j.ijhydene.2020.05.088	03603199	Margot A. Llosa Tanco, Jose A. Medrano, Valentina Cechetto, Fausto Gallucci, David A. Pacheco Tanaka	International Journal of Hydrogen Energy		Pergamon Press Ltd.	United Kingdom	2020		No	Yes - Gold OA	
HyGrid	PEER_ REVIEWED_ ARTICLE	Techno-economic evaluation on a hybrid technology for low hydrogen concentration separation and purification from natural gas grid	10.1016/j.ijhydene.2020.05.009	03603199	Maria Nordio, Solomon Assefa Wassie, Martin Van Sint Annaland, D. Alfredo Pacheco Tanaka, José Luis Viviente Sole, Fausto Gallucci	International Journal of Hydrogen Energy		Pergamon Press Ltd.	United Kingdom	2020		No	Yes - Gold OA	
HyGrid	PEER_ REVIEWED_ ARTICLE	Water Adsorption Effect on Carbon Molecular Sieve Membranes in H2-CH4 Mixture at High Pressure	10.3390/en13143577	19961073	Maria L. V. Nordio, José A. Medrano, Martin van Sint Annaland, David Alfredo Pacheco Tanaka, Margot Llosa Tanco, Fausto Gallucci	Energies	13/14	Multidisciplinary Digital Publishing Institute (MDPI)	Switzerland	2020	3577	No	Yes - Gold OA	
HySEA	PEER_ REVIEWED_ ARTICLE	A simple model for calculating peak pressure in vented explosions of hydrogen and hydrocarbons	10.1016/j.ijhydene.2019.02.213	03603199	Anubhav Sinha, Jennifer X. Wen	International Journal of Hydrogen Energy		Pergamon Press Ltd.	United Kingdom	2019		No	Yes - Gold OA	https://doi.org/10.1016/j.ijhydene.2019.02.213
HySEA	PEER_ REVIEWED_ ARTICLE	Blind-prediction: Estimating the consequences of vented hydrogen deflagrations for homogeneous mixtures in 20-foot ISO containers	10.1016/j.ijhydene.2018.06.191	03603199	T. Skjold, H. Hisken, S. Lakshmipathy, G. Atanga, M. Carcassi, M. Schiavetti, J.R. Stewart, A. Newton, J.R. Hoyes, I.C. Tolias, A.G. Venetsanos, O.R. Hansen, J. Geng, A. Huser, S. Helland, R. Jambut, K. Ren, A. Kotchourko, T. Jordan, J. Daubech, G. Lecocq, A.G. Hanssen, C. Kumar, L. Krumenacker, S. Jallais, D. Miller, C.R. Bauwens	International Journal of Hydrogen Energy	44/17	Pergamon Press Ltd.	United Kingdom	2019	8997-9008	Yes	Yes - Green OA	
HySEA	PEER_ REVIEWED_ ARTICLE	Blind-prediction: Estimating the consequences of vented hydrogen deflagrations for inhomogeneous mixtures in 20-foot ISO containers	10.1016/j.jlp.2019.06.013	09504230	Trygve Skjold, Helene Hisken, Laurence Bernard, Lorenzo Mauri, Gordon Atanga, Sunil Lakshmipathy, Melodia Lucas Pérez, Marco Carcassi, Martino Schiavetti, Vendra Chandra Madhav Rao, Anubhav Sinha, Jennifer X. Wen, Ilias C. Tolias, Stella G. Giannissi, Alexandros G. Venetsanos, James R. Stewart, Olav Roald Hansen, Chenthil Kumar, Laurent Krumenacker, Florian Laviron, Romain Jambut, Asmund Huser	Journal of Loss Prevention in the Process Industries		Elsevier BV	Netherlands	2019		Yes	Yes - Gold OA	https://doi.org/10.1016/j.jlp.2019.06.013
HySEA	PEER_REVIEWED_ ARTICLE	Consequence models for vented hydrogen deflagrations: CFD vs. engineering models	10.1016/j.ijhydene.2018.08.079	03603199	S. Lakshmipathy, T. Skjold, H. Hisken, G. Atanga	International Journal of Hydrogen Energy	44/17	Pergamon Press Ltd.	United Kingdom	2019	8699-8710	No	Yes - Green OA	
HySEA	PEER_ REVIEWED_ ARTICLE	Fluid structure interactions modelling in vented lean deflagrations	10.1016/j.jlp.2019.06.004	09504230	Vendra C. Madhav Rao, Jennifer X. Wen	Journal of Loss Prevention in the Process Industries		Elsevier BV	Netherlands	2019		No	Yes - Green OA	
HySEA	CONFERENCE_ PROCEEDING	Modelling approach for vented lean deflagrations in non-rigid enclosures	10.18720/spbpu/2/k19-81	978-5-7422-6496-5	Rao, V.C.M and Wen, J.X.	Proceedings Ninth International Seminar on Fire and Explosion Hazards (ISFEH9), 21-24 April 2019	Vol. 1	St. Petersburg Polytechnic University Press	St. Petersburg, Russia	2019	393-402	No	Yes - Green OA	http://doi.org/10.18720/SPBPU/2/k19-81
HySEA	PEER_ REVIEWED_ ARTICLE	Modular phenomenological model for vented explosions and its validation with experimental and computational results	10.1016/j.jlp.2019.05.017	09504230	Anubhav Sinha, Vendra C. Madhav Rao, Jennifer X. Wen	Journal of Loss Prevention in the Process Industries	61	Elsevier BV	Netherlands	2019	8-23	No	Yes - Green OA	
HySEA	CONFERENCE_ PROCEEDING	Numerical investigation of venting through roof for an ISO containers			Rao, V.C.M and Wen, J.X.	Proceedings Twenty-Seventh International Colloquium on the Dynamics of Explosions and Reactive Systems (27 ICDERS)		INSTITUTE FOR DYNAMICS OF EXPLOSIONS AND REACTIVE SYSTEMS	Beijing, China	2019	6 pp	No	Yes - Green OA	
HySEA	PEER_ REVIEWED_ ARTICLE	Numerical modelling of vented lean hydrogen deflagations in an ISO container	10.1016/j.ijhydene.2018.11.093	03603199	C. Madhav Rao Vendra, Jennifer X. Wen	International Journal of Hydrogen Energy	44/17	Pergamon Press Ltd.	United Kingdom	2019	8767-8779	No	Yes - Green OA	
HySEA	PEER_ REVIEWED_ ARTICLE	Performance evaluation of empirical models for vented lean hydrogen explosions	10.1016/j.ijhydene.2018.09.101	03603199	Anubhav Sinha, Vendra C. Madhav Rao, Jennifer X. Wen	International Journal of Hydrogen Energy	44/17	Pergamon Press Ltd.	United Kingdom	2019	8711-8726	No	Yes - Green OA	http://doi.org/10.5281/zenodo.1137672
HySEA	CONFERENCE_ PROCEEDING	Simulating vented hydrogen deflagrations: improved modelling in the CFD tool FLACS-Hydrogen			Lucas, M., Hisken, H. and Skjold, T.	Proceedings Eighth International Conference on Hydrogen Safety (ICHS 2019)		ICHS 2019	Adelaide, Australia	2019		Yes	Yes - Green OA	
HySEA	PEER_ REVIEWED_ ARTICLE	Small scale experiments and Fe model validation of structural response during hydrogen vented deflagrations	10.1016/j.ijhydene.2018.05.052	03603199	T. Pini, A.Grønsund Hanssen, M. Schiavetti, M. Carcassi	International Journal of Hydrogen Energy	44/17	Pergamon Press Ltd.	United Kingdom	2019	9063-9070	Yes	Yes - Green OA	

Project Acronym	CR Publ Type	CR Publ Title	CR Publ DOI	CR Publ ISSN	CR Publ Authors	CR Publ Journal Title	CR Publ Journal Nbr	CR Publ Publisher	CR Publ Published Place	CR Publ Published Year	CR Publ Relevant Pages	CR Publ Is Joint Public/ Private ?	CR Publ In O-A ?	CR Link To Publication
HySEA	PEER_ REVIEWED_ ARTICLE	Structural response for vented hydrogen deflagrations: Coupling CFD and FE tools	10.1016/j.ijhydene.2018.08.085	03603199	G. Atanga, S. Lakshmipathy, T. Skjold, H. Hisken, A.G. Hanssen	International Journal of Hydrogen Energy	44/17	Pergamon Press Ltd.	United Kingdom	2019	8893-8903	No	Yes - Green OA	https://doi.org/10.5281/zenodo.1165356
HySEA	CONFERENCE_ PROCEEDING	Structural response of 20-foot shipping containers during vented hydrogen deflagrations			Skjold, T., Hisken, H., Bernard, L. and Hanssen A.G.	Proceedings Twenty-Seventh International Colloquium on the Dynamics of Explosions and Reactive Systems (27 ICDERS)		INSTITUTE FOR DYNAMICS OF EXPLOSIONS AND REACTIVE SYSTEMS	Beijing, China	2019		No	Yes - Green OA	
HySEA	PEER_ REVIEWED_ ARTICLE	The effect of venting process on the progress of a vented deflagration	10.1016/j.ijhydene.2018.05.007	03603199	M. Schiavetti, T. Pini, M. Carcassi	International Journal of Hydrogen Energy	44/17	Pergamon Press Ltd.	United Kingdom	2019	9080-9088	No	Yes - Green OA	
HySEA	PEER_ REVIEWED_ ARTICLE	Vented hydrogen deflagrations in containers: Effect of congestion for homogeneous and inhomogeneous mixtures	10.1016/j.ijhydene.2018.10.010	03603199	T. Skjold, H. Hisken, S. Lakshmipathy, G. Atanga, L. Bernard, M. van Wingerden, K.L. Olsen, M.N. Holme, N.M. Turøy, M. Mykleby, K. van Wingerden	International Journal of Hydrogen Energy	44/17	Pergamon Press Ltd.	United Kingdom	2019	8819-8832	No	Yes - Gold OA	https://doi.org/10.1016/j.ijhydene.2018.10.010
HySEA	CONFERENCE_ PROCEEDING	Vented hydrogen deflagrations in weak enclosures: experimental results and implications for industrial practice			Skjold, T.	Chemical Engineering Transactions	Vol. 75	Italian Association of Chemical Engineering	Milano, Italy	2019		No	Yes - Gold OA	
HySTOC	PEER_ REVIEWED_ ARTICLE	Effect of Toluene on PEMFC Performance	10.1002/fuce.201900075	16156846	J. Viitakangas, S. Auvinen, M. Costantino, S. Viik, J. Ihonen	Fuel Cells	20/3	John Wiley & Sons Ltd.	United Kingdom	2020	245-252	No	Yes - Gold OA	
HyTunnel-CS	PEER_ REVIEWED_ ARTICLE	Dynamics of blast wave and fireball after hydrogen tank rupture in a fire in the open atmosphere		03603199	Molkov V.V., Cirrone D.M.C., Shentsov V.V., Dery W., Kim W., Makarov D.V.	International Journal of Hydrogen Energy (Accepted for publication)		Pergamon Press Ltd.	United Kingdom	2020		No	Yes - Green OA	
HyTunnel-CS	PEER_ REVIEWED_ ARTICLE	Numerical analysis of hydrogen release, dispersion and combustion in a tunnel with fuel cell vehicles using all-speed CFD code GASFLOW-MPI	10.1016/j.ijhydene.2020.09.063	03603199	Yabing Li, Jianjun Xiao, Han Zhang, Wolfgang Breitung, Jack Travis, Mike Kuznetsov, Thomas Jordan	International Journal of Hydrogen Energy		Pergamon Press Ltd.	United Kingdom	2020		No	Yes - Green OA	
HyTunnel-CS	PEER_ REVIEWED_ ARTICLE	Pressure peaking phenomena: Unignited hydrogen releases in confined spaces – Large-scale experiments	10.1016/j.ijhydene.2020.08.221	03603199	Agnieszka Weronika Lach, André Vagner Gaathaug, Knut Vaagsaether	International Journal of Hydrogen Energy		Pergamon Press Ltd.	United Kingdom	2020		No	Yes - Green OA	
HyTunnel-CS	PEER_ REVIEWED_ ARTICLE	The blast wave decay correlation for hydrogen tank rupture in a tunnel fire	10.1016/j.ijhydene.2020.08.062	03603199	V. Molkov, W. Dery	International Journal of Hydrogen Energy	45/55	Pergamon Press Ltd.	United Kingdom	2020	31289-31302	No	Yes - Green OA	
INLINE	CONFERENCE_ PROCEEDING	Automatic Intrinsics and Extrinsics Projector Calibration with Embedded Light Sensors	10.3217/978-3-85125-663-5-80	978-3-85125-663-5	Thomas Pönitz, Christoph Heindl, Andreas Pichler, Martin Kampel	Proceedings of the ARW & OAGM Workshop 2019	yearly	Verlag der Technischen Universität Graz	https://graz.pure.elsevier.com/en/publications/proceedings-of-the-arw-amp-oagm-workshop-2019	2019	193-194	Yes	Yes - Green OA	http://openlib.tugraz.at/download.php?id=5d09dba10ebbd&location=browse
INLINE	CONFERENCE_ PROCEEDING	Autonomous planning tool for changeable assembly systems			Tom Staehr, Nicole Stricker, Gisela Lanza	Procedia CIRP		KIT WBK	Ischia, Italy	2019		No	Yes - Green OA	
INNO-SOFC	PEER_ REVIEWED_ ARTICLE	Elcogen – Next Generation Solid Oxide Cell and Stack Technology	10.1149/09101.0091ecst	19385862	Matti Noponen, Pauli Torri, Jukka Göös, Jouni Puranen, Henri Kaar, Sergii Pylypko, Marek Roostar, Enn Õunpuu	ECS Transactions	91/1	Electrochemical Society, Inc.	United States	2019	91-97	No	Yes - Green OA	10.1149/09101.0091ecst
INSIGHT	PEER_ REVIEWED_ ARTICLE	Characterization of local morphology and availability of triple-phase boundaries in solid oxide cell electrodes	10.1016/j.actamat.2019.07.027	13596454	G. Rinaldi, A. Nakajo, P. Burdet, M. Cantoni, W.K.S. Chiu, J. Van herle	Acta Materialia	178	Elsevier BV	Netherlands	2019	194-206	No	Yes - Green OA	
INSIGHT	PEER_ REVIEWED_ ARTICLE	Degradation of Ni-YSZ Electrodes in Solid Oxide Cells: Impact of Polarization and Initial Microstructure on the Ni Evolution	10.1149/2.1261915jes	00134651	F. Monaco, M. Hubert, J. Vulliet, J. P. Ouweltjes, D. Montinaro, P. Cloetens, P. Piccardo, F. Lefebvre-Joud, J. Laurencin	Journal of The Electrochemical Society	166/15	Electrochemical Society, Inc.	United States	2019	F1229-F1242	No	Yes - Green OA	
INSIGHT	PEER_REVIEWED_ ARTICLE	Effects of Polarization on the Microstructural Changes at the YSZ/Ni-YSZ Interface	10.1149/09101.0641ecst	19385862	Giorgio Rinaldi, Arata Nakajo, Priscilla Caliandro, Lucie Navratilova, Jan Van herle	ECS Transactions	91/1	Electrochemical Society, Inc.	United States	2019	641-652	No	Yes - Green OA	
INSIGHT	PEER_ REVIEWED_ ARTICLE	Identification of the coupling functions between the process and the degradation dynamics by means of the variational Bayesian inference: an application to the solid-oxide fuel cells	10.1098/rsta.2019.0086	1364503X	Boštjan Dolenc, Bani Jurč, Pavle Boškoski	Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences	377/2160	Royal Society of London	United Kingdom	2019	20190086	No	Yes - Green OA	
INSIGHT	PEER_ REVIEWED_ ARTICLE	Interdiffusion between gadolinia doped ceria and yttria stabilized zirconia in solid oxide fuel cells: Experimental investigation and kinetic modeling	10.1016/j.jpowsour.2019.227152	03787753	Huixia Xu, Kaiming Cheng, Ming Chen, Lijun Zhang, Karen Brodersen, Yong Du	Journal of Power Sources	441	Elsevier BV	Netherlands	2019	227152	No	Yes - Green OA	
INSIGHT	PEER_ REVIEWED_ ARTICLE	Microstructural correlations for specific surface area and triple phase boundary length for composite electrodes of solid oxide cells	10.1016/j.jpowsour.2018.11.095	03787753	H. Moussaoui, R.K. Sharma, J. Debayle, Y. Gavet, G. Delette, J. Laurencin	Journal of Power Sources	412	Elsevier BV	Netherlands	2019	736-748	No	Yes - Green OA	
INSIGHT	PEER_REVIEWED_ ARTICLE	Model-assisted identification of solid oxide cell elementary processes by electrochemical impedance spectroscopy measurements	10.1016/j.jpowsour.2019.226838	03787753	P. Caliandro, A. Nakajo, S. Diethelm, J. Van herle	Journal of Power Sources	436	Elsevier BV	Netherlands	2019	226838	No	Yes - Green OA	
INSPIRE	PEER_ REVIEWED_ ARTICLE	Controlling Near-Surface Ni Composition in Octahedral PtNi(Mo) Nanoparticles by Mo Doping for a Highly Active Oxygen Reduction Reaction Catalyst	10.1021/acs.nanolett.9b02116	15306984	F. Dionigi, C. Cesar Weber, M. Primbs, M. Gocyla, A. Martinez Bonastre, C. Spöri, H. Schmies, E. Hornberger, S. Kühl, J. Dmoc, M. Heggen, J. Sharman, R. Edward Dunin-Borkowski, P. Strasser	Nano Letters	19/10	American Chemical Society	United States	2019	6876-6885	Yes	Yes - Gold OA	
INSPIRE	PEER_REVIEWED_ ARTICLE	Electrodeposition of Platinum Catalyst from Ionic Liquids	10.1149/09208.0533ecst	19385862	Jonathan Diederich, Sladjana Martens, Ludwig Asen, Oliver Schneider	ECS Transactions	92/8	Electrochemical Society, Inc.	United States	2019	533-546	No	Yes - Gold OA	
INSPIRE	PEER_ REVIEWED_ ARTICLE	Impact of Carbon Support Corrosion on Performance Losses in Polymer Electrolyte Membrane Fuel Cells	10.1149/2.0611913jes	00134651	Friedemann Hegge, Jonathan Sharman, Riko Moroni, Simon Thiele, Roland Zengerle, Matthias Breitwieser, Severin Vierrath	Journal of The Electrochemical Society	166/13	Electrochemical Society, Inc.	United States	2019	F956-F962	Yes	Yes - Gold OA	
INSPIRE	PEER_ REVIEWED_ ARTICLE	"Preparation of Ni@Pt core@shell conformal nanofibre oxygen reduction electrocatalysts via microwave-assisted galvanic displacement"	10.1039/c9cy01514k	20444753	Giorgio Ercolano, Filippo Farina, Lorenzo Stievano, Deborah J. Jones, Jacques Rozière, Sara Cavaliere	Catalysis Science & Technology		Royal Society of Chemistry	United Kingdom	2019	6920 - 6928	No	Yes - Green OA	https://dx.doi.org/10.1039/c9cy01514k
INSPIRE	PEER_ REVIEWED_ ARTICLE	Revealing the nature of active sites in electrocatalysis	10.1039/c9sc02654a	20416520	Batyr Garlyyev, Johannes Fichtner, Oriol Piqué, Oliver Schneider, Aliaksandr S. Bandarenka, Federico Calle-Vallejo	Chemical Science	10/35	Royal Society of Chemistry	United Kingdom	2019	8060-8075	No	Yes - Gold OA	
LOWCOST-IC	CONFERENCE_ PROCEEDING	Enhancing the Robustness of Brittle Solid Oxide Cell Stack Components	10.1149/09101.2201ecst	19385862	Henrik Lund Frandsen, Ilaria Ritucci, Peyman Khajavi, Belma Talic, Ragnar Kiebach, Peter Vang Hendriksen	ECS Transactions	91/1	Electrochemical Society, Inc.	United States	2019	2201-2211	No	Yes - Green OA	https://orbit.dtu.dk/en/publications/enhancing-the-robustness-of-brittle-solid-oxide-cell-stack-compon
LOWCOST-IC	CONFERENCE_ PROCEEDING	Improved Robustness and Low Area Specific Resistance with Novel Contact Layers for the Solid Oxide Cell Air Electrode	10.1149/09101.2225ecst	19385862	Belma Talic, Ilaria Ritucci, Ragnar Kiebach, Peter Vang Hendriksen, Henrik Lund Frandsen	ECS Transactions	91/1	Electrochemical Society, Inc.	United States	2019	2225-2232	No	Yes - Green OA	https://orbit.dtu.dk/en/publications/improved-robustness-and-low-area-specific-resistance-with-novel-c
LOWCOST-IC	PEER_ REVIEWED_ ARTICLE	Long-term (4 year) degradation behavior of coated stainless steel 441 used for solid oxide fuel cell interconnect applications	10.1016/j.jpowsour.2019.227480	03787753	Claudia Goebel, Robert Berger, Carlos Bernuy-Lopez, Jörgen Westlinder, Jan-Erik Svensson, Jan Froitzheim	Journal of Power Sources	449	Elsevier BV	Netherlands	2020	227480	Yes	Yes - Gold OA	

Project Acronym	CR Publ Type	CR Publ Title	CR Publ DOI	CR Publ ISSN	CR Publ Authors	CR Publ Journal Title	CR Publ Journal Nbr	CR Publ Publisher	CR Publ Published Place	CR Publ Published Year	CR Publ Relevant Pages	CR Publ Is Joint Public/ Private ?	CR Publ In O-A ?	CR Link To Publication
LOWCOST-IC	ARTICLE	The Influence of Different Factors on the Dual Atmosphere Effect Observed for AISI 441 Interconnects Used in Solid Oxide Fuel Cells	10.1149/09101.2261ecst	19385862	Claudia Goebel, Caterina Bo, Jan-Erik Svensson, Jan Froitzheim	ECS Transactions	91/1	Electrochemical Society, Inc.	United States	2019	2261-2266	No	Yes - Green OA	https://research.chalmers.se/publication/513169
MAMA-MEA	PEER_ REVIEWED_ ARTICLE	Review of Catalyst-deposition Techniques for PEMFC Electrodes	10.18280/ti-ijes.630109	00401846	Paolo Santangelo, Maria Cannio, Marcello Romagnoli	TECNICA ITALIA-NA-Italian Journal of Engineering Science	63/1	Tecnica Italiana	Italy	2019	65-72	No	Yes - Green OA	http://www.iieta.org/journals/ti-ijes/paper/10.18280/ti-ijes.630109
MEMPHYS	PEER_ REVIEWED_ ARTICLE	"Data file for paper: C Jackson, LFJM Raymakers, MJJ Mulder, ARJ Kucernak ""Poison Mitigation Strategies for the use of Impure Hydrogen in Electrochemical Hydrogen Pumps and Fuel Cells"", J Power Sources 2020"	10.5281/zenodo.3908487	0378-7753	Colleen Jackson, Anthony Kucernak, L Raymakers, M Mulder	Journal of Power Sources	1	Elsevier BV	Netherlands	2020	not yet published	No	Yes - Green OA	
MEMPHYS	PEER_ REVIEWED_ ARTICLE	An Engineering Toolbox for the Evaluation of Metallic Flow Field Plates	10.3390/chemengineering3040085	23057084	Uwe Reimer, Dieter Froning, Gert Nelissen, Leonard F. J. M. Raymakers, Shidong Zhang, Steven B. Beale, Werner Lehnert	ChemEngineering	3/4	MDPI AG	Basel, Switzerland	2019	85	No	Yes - Gold OA	
MEMPHYS	PEER_ REVIEWED_ ARTICLE	Assessing electrocatalyst hydrogen activity and CO tolerance: Comparison of performance obtained using the high mass transport 'floating electrode' technique and in electrochemical hydrogen pumps	10.1016/j.apcatb.2020.118734	09263373	C. Jackson, L.F.J.M. Raymakers, M.J.J. Mulder, A.R.J. Kucernak	Applied Catalysis B: Environmental	268	Elsevier BV	Netherlands	2020	118734	No	Yes - Green OA	
MEMPHYS	PEER_ REVIEWED_ ARTICLE	Fault detection of fuel cell systems based on statistical assessment of impedance data	10.1016/j.enconman.2019.05.004	01968904	Martin Stepančič, Bani Jurčič Pavle Boškoski	Energy Conversion and Management	195	Pergamon Press Ltd.	United Kingdom	2019	76-85	No	Yes - Green OA	
MEMPHYS	PEER_REVIEWED_ ARTICLE	Membrane based purification of hydrogen system (MEMPHYS)	10.1016/j.ijhydene.2019.01.108	03603199	Linda Schorer, Sven Schmitz, Alexandra Weber	International Journal of Hydrogen Energy	44/25	Pergamon Press Ltd.	United Kingdom	2019	12708-12714	No	Yes - Gold OA	
NEPTUNE	PEER_REVIEWED_ ARTICLE	Analysis of performance degradation during steady-state and load-thermal cycles of proton exchange membrane water electrolysis cells	10.1016/j.jpowsour.2020.228390	03787753	Stefania Siracusano, Stefano Trocino, Nicola Briguglio, Fabiola Pantò, Antonino S. Aricò	Journal of Power Sources	468	Elsevier BV	Netherlands	2020	228390	No	Yes - Green OA	
NEPTUNE	PEER_ REVIEWED_ ARTICLE	Chemically stabilised extruded and recast short side chain Aquivion® proton exchange membranes for high current density operation in water electrolysis	10.1016/j.memsci.2019.02.021	03767388	Stefania Siracusano, Claudio Oldani, Maria Assunta Navarra, Stefano Tonella, Lucia Mazzapioda, Nicola Briguglio, Antonino S. Aricò	Journal of Membrane Science	578	Elsevier BV	Netherlands	2019	136-148	Yes	Yes - Gold OA	https://www.sciencedirect.com/science/article/pii/S0376738819301347?via%3Dihub
NEPTUNE	PEER_ REVIEWED_ ARTICLE	Durability of a recombination catalyst-based membrane-electrode assembly for electrolysis operation at high current density	10.1016/j.apenergy.2020.115809	03062619	Fabiola Pantò, Stefania Siracusano, Nicola Briguglio, Antonino Salvatore Aricò	Applied Energy	279	Pergamon Press Ltd.	United Kingdom	2020	115809	No	Yes - Green OA	
NEPTUNE	PEER_ REVIEWED _ARTICLE	Enhanced performance of a PtCo recombination catalyst for reducing the H2 concentration in the O2 stream of a PEM electrolysis cell in the presence of a thin membrane and a high differential pressure	10.1016/j.electacta.2020.136153	00134686	N. Briguglio, F. Pantò, S. Siracusano, A.S. Aricò	Electrochimica Acta	344	Pergamon Press Ltd.	United Kingdom	2020	136153	No	Yes - Green OA	
NEPTUNE	PEER_ REVIEWED_ ARTICLE	Flammability reduction in a pressurised water electrolyser based on a thin polymer electrolyte membrane through a Pt-alloy catalytic approach	10.1016/j.apcatb.2018.12.079	09263373	Nicola Briguglio, Stefania Siracusano, Giuseppe Bonura, David Sebastián, Antonino S. Aricò	Applied Catalysis B: Environmental	246	Elsevier BV	Netherlands	2019	254-265	Yes	Yes - Gold OA	https://www.sciencedirect.com/science/article/pii/S0926337318312323?via%3Dihub
NET-Tools	CONFERENCE_ PROCEEDING	Modelling of Hydrogen Tank Fuelling		978-5-7422-6498-9	Dadashzadeh M., Makarov D., Molkov V.	PROCEEDINGS OF THE NINTH INTERNATIONAL SEMINAR on FIRE AND EXPLOSION HAZARDS		Saint Petersburg Peter the Great St. Petersburg Polytechnic University 2019	Saint Petersburg	2019	1396	No	Yes - Green OA	http://elib.spbstu.ru/dl/2/k19-97.pdf/download/k19-97.pdf
NET-Tools	OTHER	Modelling of Hydrogen Tank Fuelling			Dadashzadeh M., Makarov D., Molkov V.	PRESENTATION AT NINTH INTERNATIONAL SEMINAR ON FIRE AND EXPLOSION HAZARDS		Saint Petersburg Peter the Great St. Petersburg Polytechnic University 2019	Saint Petersburg	2019		No	Yes - Green OA	
NET-Tools	CONFERENCE_ PROCEEDING	Near Field Thermal Dose of Cryogenic Hydrogen Jet Fires		978-5-7422-6498-9	Cirrone D., Makarov D., Molkov V.	PROCEEDINGS OF THE NINTH INTERNATIONAL SEMINAR on FIRE AND EXPLOSION HAZARDS		Saint Petersburg Peter the Great St. Petersburg Polytechnic University 2019	Saint Petersburg	2019	1361	No	Yes - Green OA	http://elib.spbstu.ru/dl/2/k19-97.pdf/download/k19-97.pdf
NET-Tools	OTHER	Near Field Thermal Dose of Cryogenic Hydrogen Jet Fires			Cirrone D., Makarov D., Molkov V.	PRESENTATION AT NINTH INTERNATIONAL SEMINAR ON FIRE AND EXPLOSION HAZARDS		Saint Petersburg Peter the Great St. Petersburg Polytechnic University 2019	Saint Petersburg	2019		No	Yes - Green OA	
NET-Tools	CONFERENCE_ PROCEEDING	Scientific Principles of e-Laboratory of Hydrogen Safety		978-5-7422-6498-9	Shentsov V., Makarov D., Molkov V.	PROCEEDINGS OF THE NINTH INTERNATIONAL SEMINAR on FIRE AND EXPLOSION HAZARDS		Saint Petersburg Peter the Great St. Petersburg Polytechnic University 2019	Saint Petersburg	2019	1306	No	Yes - Green OA	http://elib.spbstu.ru/dl/2/k19-97.pdf/download/k19-97.pdf
NET-Tools	OTHER	Scientific Principles of e-Laboratory of Hydrogen Safety			Shentsov V., Makarov D., Molkov V.	PRESENTATION AT NINTH INTERNATIONAL SEMINAR ON FIRE AND EXPLOSION HAZARDS		Saint Petersburg Peter the Great St. Petersburg Polytechnic University	Saint Petersburg	2019		No	Yes - Green OA	
NET-Tools	PEER_ REVIEWED_ ARTICLE	Similitude analysis and critical conditions for spontaneous ignition of hydrogen release into the atmosphere through a tube	10.1016/j.fuel.2019.02.064	0016-2361	Liang Gonga, Qiangling Duana, Jinhua Suna, Vladimir Molkov	Fuel - The Science and Technology of Fuel and Energy	245	Elsevier BV	Netherlands	2019	413-419	No	Yes - Green OA	https://www.sciencedirect.com/science/article/pii/S0016236119302674
NET-Tools	CONFERENCE_ PROCEEDING	Stand-Alone Hemisphere-Tank Rupture in Tunnel Fire: Effect of Hydrogen Inventory on Blast Wave Strength in Far Field	10.18720/spbpu/2/k19-45		Shentsov V., Makarov D., Dery W	PROCEEDINGS OF THE NINTH INTERNATIONAL SEMINAR on FIRE AND EXPLOSION HAZARDS		Saint Petersburg Peter the Great St. Petersburg Polytechnic University 2019	Saint Petersburg	2019	1315	No	Yes - Green OA	http://elib.spbstu.ru/dl/2/k19-97.pdf/download/k19-97.pdf
NET-Tools	OTHER	Stand-Alone Hemisphere-Tank Rupture in Tunnel Fire: Effect of Hydrogen Inventory on Blast Wave Strength in Far Field			Shentsov V., Makarov D., Dery W	PRESENTATION AT NINTH INTERNATIONAL SEMINAR ON FIRE AND EXPLOSION HAZARDS		Saint Petersburg Peter the Great St. Petersburg Polytechnic University 2019	Saint Petersburg	2019		No	Yes - Green OA	
NewSOC	PEER_ REVIEWED_ ARTICLE	"The promoting effect of Fe on Ni/GDC for the Solid Oxide H_2O electrolysis"	https://onlinelibrary.wiley.com/doi/10.1002/er.5837	0363907X	Charalampos Neofytidis, Evangelia Ioannidou, Maria Kollia, Stylianos G. Neophytides, Dimitrios K. Niakolas	International Journal of Energy Research		John Wiley & Sons Inc.	United States	2020		No	Yes - Gold OA	https://onlinelibrary.wiley.com/doi/10.1002/er.5837
PACE	PEER_ REVIEWED_ ARTICLE	Status on Demonstration of Fuel Cell Based Micro-CHP Units in Europe	10.1002/fuce.201800189	16156846	E. R. Nielsen, C. B. Prag, T. M. Bachmann, F. Carricelli, E. Boyd, I. Walker, L. Ruf, A. Stephens	Fuel Cells	Volume 19	John Wiley & Sons Ltd.	United Kingdom	2019	340-345	Yes	Yes - Gold OA	https://onlinelibrary.wiley.com/doi/epdf/10.1002/fuce.201800189
PECSYS	PEER_ REVIEWED_ ARTICLE	A Bias-Free, Stand-Alone, and Scalable Photovoltaic–Electrochemical Device for Solar Hydrogen Production	10.1002/adsu.202000070	23667486	Minoh Lee, Bugra Turan, Jan-Philipp Becker, Katharina Welter, Benjamin Klingebiel, Elmar Neumann, Yoo Jung Sohn, Tsvetelina Merdzhanova, Thomas Kirchartz, Friedhelm Finger, Uwe Rau, Stefan Haas	Advanced Sustainable Systems	4/8	Wiley	USA	2020	2000070	No	Yes - Green OA	
PECSYS	PEER_ REVIEWED_ ARTICLE	Applicability of a New Sulfonated Pentablock Copolymer Membrane and Modified Gas Diffusion Layers for Low-Cost Water Splitting Processes	10.3390/en12112064	19961073	S. Filice, G. Urzì, R. G. Milazzo, S. M. S. Privitera, S. A. Lombardo, G. Compagnini, S. Scalese	Energies	12/11	Multidisciplinary Digital Publishing Institute (MDPI)	Switzerland	2019	2064	No	Yes - Green OA	https://doi.org/10.3390/en12112064
PECSYS	PEER_ REVIEWED_ ARTICLE	"Bifunctional CoFeVO x Catalyst for Solar Water Splitting by using Multijunction and Heterojunction Silicon Solar Cells"	10.1002/admt.202000592	2365709X	Minoh Lee, Xinyu Ding, Swarnendu Banerjee, Florian Krause, Vladimir Smirnov, Oleksandr Astakhov, Tsvetelina Merdzhanova, Benjamin Klingebiel, Thomas Kirchartz, Friedhelm Finger, Uwe Rau, Stefan Haas	Advanced Materials Technologies	5/12	Wiley-VCH GmbH	Weinheim	2020	2000592	No	Yes - Green OA	https://doi.org/10.1002/admt.202000592
PECSYS	PEER_ REVIEWED_ ARTICLE	Characteristics of a New Polymer Electrolyte Electrolysis Technique with Only Cathodic Media Supply Coupled to a Photovoltaic Panel	10.3390/en12214150	1996-1073	M. Müller, W. Zwaygardt, E. Rauls, M. Hehemann, S. Haas, L. Stolt, H. Janßen and M. Carmo	Energies	12/21	Multidisciplinary Digital Publishing Institute (MDPI)	Switzerland	2019	4150	No	Yes - Green OA	https://doi.org/10.3390/en12214150
PECSYS	PEER_ REVIEWED_ ARTICLE	Effect of Morphology and Mechanical Stability of Nanometric Platinum Layer on Nickel Foam for Hydrogen Evolution Reaction	10.3390/en12163116	19961073	Rachela G. Milazzo, Stefania M. S. Privitera, Silvia Scalese, Salvatore A. Lombardo	Energies	12/16	Multidisciplinary Digital Publishing Institute (MDPI)	Switzerland	2019	3116	No	Yes - Green OA	

Project Acronym	CR Publ Type	CR Publ Title	CR Publ DOI	CR Publ ISSN	CR Publ Authors	CR Publ Journal Title	CR Publ Journal Nbr	CR Publ Publisher	CR Publ Published Place	CR Publ Published Year	CR Publ Relevant Pages	CR Publ Is Joint Public/ Private ?	CR Publ In O-A ?	CR Link To Publication
PECSYS	PEER_ REVIEWED_ ARTICLE	Effect of the ambient conditions on the operation of a large-area integrated photovoltaic-electrolyser	doi: 10.1039/d0se00921k	23984902	Erno Kemppainen, Stefan Aschbrenner, Fuxi Bao, Aline Luxa, Christian Schary, Radu Bors, Stefan Janke, Iris Dorbandt, Bernd Stannowski, Rutger Schlatmann, Sonya Calnan	Sustainable Energy & Fuels	4/9	Royal Society of Chemistry	London	2020	4831-4847	No	Yes - Green OA	
PECSYS	PEER_ REVIEWED_ ARTICLE	Highly efficient solar hydrogen production through the use of bifacial photovoltaics and membrane electrolysis	10.1016/j.jpows-our.2020.228619	03787753	S.M.S. Privitera, M. Muller, W. Zwaygardt, M. Carmo, R.G. Milazzo, P. Zani, M. Leonardi, F. Maita, A. Canino, M. Foti, F. Bizzarri, C. Gerardi, S.A. Lombardo	Journal of Power Sources	473	Elsevier BV	Netherlands	2020	228619	No	Yes - Green OA	https://doi.org/10.1016/j.jpows-our.2020.228619
PECSYS	PEER_ REVIEWED_ ARTICLE	Impedance Spectroscopy Modeling of Nickel–Molybdenum Alloys on Porous and Flat Substrates for Applications in Water Splitting	doi: 10.1021/acs.jpcc.9b02714	19327447	Iknur Bayrak Pehlivan, Miguel A. Arvizu, Zhen Qiu, Gunnar A. Niklasson, Tomas Edvinsson	The Journal of Physical Chemistry C	123/39	American Chemical Society	United States	2019	23890-23897	No	Yes - Green OA	
PECSYS	PEER_ REVIEWED_ ARTICLE	Impedance spectroscopy of water splitting reactions on nanostructured metal-based catalysts	doi:10.1088/1757-899x/503/1/012005	1757899X	G A Niklasson, Z Qiu, I Bayrak Pehlivan, T Edvinsson	IOP Conference Series: Materials Science and Engineering	503	IOP Publishing Ltd.	United Kingdom	2019	012005	No	Yes - Green OA	https://iopscience.iop.org/article/10.1088/1757-899X/503/1/012005/meta
PECSYS	PEER_ REVIEWED_ ARTICLE	"Ni foam electrode solution impregnated with Ni-Fe X (OH) Y catalysts for efficient oxygen evolution reaction in alkaline electrolyzers"	10.1039/d0ra03856c	20462069	Dipanjan Sengupta, Stefania M. S. Privitera, Rachela Gabriella Milazzo, Corrado Bongiorno, Silvia Scalese, Salvatore Lombardo	RSC Advances	10/43	Royal Society of Chemistry	United Kingdom	2020	25426-25434	No	Yes - Green OA	https://doi.org/10.1039/D0RA03856C
PECSYS	PEER_ REVIEWED_ ARTICLE	Optimum Band Gap Energy of ((Ag),Cu)(In,Ga)Se2 Materials for Combination with NiMo–NiO Catalysts for Thermally Integrated Solar-Driven Water Splitting Applications	10.3390/en12214064	19961073	Bayrak Pehlivan, Edoff, Stolt, Edvinsson	Energies	12/21	Multidisciplinary Digital Publishing Institute (MDPI)	Switzerland	2019	4064	No	Yes - Green OA	
PECSYS	PEER_ REVIEWED_ ARTICLE	Prospects for Hermetic Sealing of Scaled-Up Photoelectrochemical Hydrogen Generators for Reliable and Risk Free Operation	10.3390/en12214176	19961073	Sonya Calnan, Stefan Aschbrenner, Fuxi Bao, Erno Kemppainen, Iris Dorbandt, Rutger Schlatmann	Energies	12/21	Multidisciplinary Digital Publishing Institute (MDPI)	Switzerland	2019	4176	No	Yes - Green OA	https://doi.org/10.3390/en12214176
PECSYS	PEER_ REVIEWED_ ARTICLE	The climatic response of thermally integrated photovoltaic-electrolysis water splitting using Si and CIGS combined with acidic and alkaline electrolysis	10.1039/d0se01207f	23984902	I Bayrak Pehlivan, U. Malm, P. Neretnieks, A. Glüsen, M. Müller, K. Welter, S. Haas, S. Calnan, A. Canino, R. G. Milazzo, S. M. S. Privitera, S. A. Lombardo, L. Stolt, M. Edoff, T. Edvinsson	Sustainable Energy & Fuels	4/12	Royal Society of Chemistry	UK	2020	6011-6022	No	Yes - Green OA	https://doi.org/10.1039/D0SE01207F
PECSYS	PEER_ REVIEWED_ ARTICLE	Ultralow loading electroless deposition of IrOx on nickel foam for efficient and stable water oxidation catalysis	10.1016/j.ijhydene.2020.07.049	03603199	Rachela G. Milazzo, Stefania M.S. Privitera, Silvia Scalese, Francesca Monforte, Corrado Bongiorno, Guglielmo G. Condorelli, Salvatore A. Lombardo	International Journal of Hydrogen Energy	45/51	Pergamon Press Ltd.	United Kingdom	2020	26583-26594	No	Yes - Green OA	https://doi.org/10.1016/j.ijhydene.2020.07.049
PEGASUS	PEER_ REVIEWED_ ARTICLE	Local impact of load cycling on degradation in polymer electrolyte fuel cells	10.1016/j.apenergy.2019.114210	03062619	D. García-Sánchez, T. Morawietz, P. Gama da Rocha, R. Hiesgen, P. Gazdzicki, K.A. Friedrich	Applied Energy	259	Pergamon Press Ltd.	United Kingdom	2020	114210	Yes	Yes - Gold OA	https://www.sciencedirect.com/science/article/pii/S0306261919318975?via%3Dihub
PEGASUS	PEER_ REVIEWED_ ARTICLE	Steady-State Electrocatalytic Activity Evaluation with the Redox Competition Mode of Scanning Electrochemical Microscopy: A Gold Probe and a Boron-Doped Diamond Substrate	10.1002/celc.202001088	21960216	Olivier Henrotte, Alice Boudet, Ndrina Limani, Philippe Bergonzo, Bacem Zribi, Emmanuel Scorsone, Bruno Jousselme, Renaud Cornut	ChemElectroChem	7/22	Chemistry Europe	chemistry-europe.onlinelibrary.wiley.com	2020	4633-4640	No	No	https://chemistry-europe.onlinelibrary.wiley.com/doi/10.1002/celc.202001088
PRESLHY	CONFERENCE_ PROCEEDING	CFD Validation against large scale liquefied helium release			Venetsanos A.G., Giannissi S., Proust C.	8th International Conference on Hydrogen Safety		HySafe	Adelaide, Australia	2019		Yes	Yes - Green OA	
PRESLHY	CONFERENCE_ PROCEEDING	Choked two-phase flow with account of discharge line effect			Venetsanos A.G.	8th International Conference on Hydrogen Safety		HySafe	Adelaide, Australia	2019		No	Yes - Green OA	
PRESLHY	CONFERENCE_ PROCEEDING	Cryogenic hydrogen jets: calculation of hazard distances.			Cirrone D., Makarov D., Molkov V.	8th International Conference on Hydrogen Safety, 24th-26th September 2019		na	Adelaide, Australia	2019		Yes	Yes - Green OA	
PRESLHY	CONFERENCE_ PROCEEDING	Near field thermal dose of cryogenic hydrogen jet fires			Cirrone, D., Makarov D., Molkov V.	International Seminar on Fire and Explosion Hazards	21th-26th April 2019	na	Saint Petersburg, Russia	2019	1361-1367	Yes	No	https://isfeh9.org/
PRESLHY	CONFERENCE_ PROCEEDING	Numerical predictions of cryogenic hydrogen vertical jets			Giannissi S.G., Venetsanos A.G. and Hecht E.S.	8th International Conference on Hydrogen Safety		HySafe	Adelaide, Australia	2019		Yes	Yes - Green OA	
PRESLHY	CONFERENCE_ PROCEEDING	Status of the pre-normative research project PRESLHY for the safe use of LH2			Jordan T., Bernard L., Jallais S., Venetsanos A., Coldrick S., Cirrone D.	8th International Conference on Hydrogen Safety		HySafe	Adelaide, Australia	2019		Yes	Yes - Green OA	www.ichs2019.com
PRESLHY	PEER_ REVIEWED_ ARTICLE	Thermal radiation from cryogenic hydrogen jet fires		0360-3199	D. Cirrone, D. Makarov, V. Molkov	International Journal of Hydrogen Energy	Volume 44, Issue 17, 2 April 2019	Pergamon Press Ltd.	United Kingdom	2019	Pages 8874-8885	No	Yes - Green OA	https://www.sciencedirect.com/science/article/pii/S036031991832651X
PRETZEL	PEER_ REVIEWED_ ARTICLE	A modular design approach for PEM electrolyser systems with homogeneous operation conditions and highly efficient heat management	10.1016/j.ijhydene.2019.03.185	03603199	F.J. Wirkert, J. Roth, S. Jagalski, P. Neuhaus, U. Rost, M. Brodmann	International Journal of Hydrogen Energy		Pergamon Press Ltd.	United Kingdom	2019		Yes	Yes - Gold OA	https://www.sciencedirect.com/science/article/pii/S0360319919312145
qSOFC	PEER_ REVIEWED_ ARTICLE	Elcogen – Next Generation Solid Oxide Cell and Stack Technology	10.1149/09101.0091ecst	19385862	Matti Noponen, Pauli Torri, Jukka Göös, Jouni Puranen, Henri Kaar, Sergii Pylypko, Marek Roostar, Enn Õunpuu	ECS Transactions	91/1	Electrochemical Society, Inc.	United States	2019	91-97	No	Yes - Green OA	https://zenodo.org/record/3828905#.X11Dcj_iuUt
qSOFC	PEER_REVIEWED_ ARTICLE	Method to Measure Area Specific Resistance and Chromium Migration Simultaneously from Solid Oxide Fuel Cell Interconnect Materials	10.1002/fuce.201800169	16156846	J. Tallgren, O. Himanen, M. Bianco, J. Mikkola, O. Thomann, M. Rautanen, J. Kiviaho, J. Van herle	Fuel Cells	19/5	John Wiley & Sons Ltd.	United Kingdom	2019	570-577	Yes	Yes - Gold OA	
QualyGridS	CONFERENCE_ PROCEEDING	A Review of the European Grids Services Markets Suitable for Distributed Loads	10.5281/zenodo.3759171		Tanaka Mandy Mbavarira, Christoph Imboden	16. Symposium Energieinnovation 2020 TU Graz		TU Graz	Graz	2020		No	Yes - Gold OA	
QualyGridS	CONFERENCE_ PROCEEDING	Application of qualifying testing protocols in alkaline electrolysers			L. Abadía, T. Villuendas, V. Gil	HYPOTHESIS XV HYdrogen POwer THeoretical and Engineering Solutions International Symposium e-Book of Abstracts	3-5 June 2020	Niels Luchters, Rhiyaad Mohamed, Giuseppe Spazzafumo (editors)	on-line	2020		No	No	
QualyGridS	CONFERENCE_ PROCEEDING	Cualificación de electrolizadores alcalinos para su participación en servicios de red: Validación experimental de protocolos		AE-2019-19011772	L. Abadía, T. Villuendas, V.Gil	Communication Book IV Iberoamerican Congress on Hydrogen and Fuel Cells 2019		Spanish Fuel Cell Association (APPICE)	https://appice.es/libro-iberconappice-2019/	2019	199-204	No	Yes - Gold OA	https://appice.es/Congresos/Comunicaciones-Orales-Iberconappice2019.pdf

Project Acronym	CR Publ Type	CR Publ Title	CR Publ DOI	CR Publ ISSN	CR Publ Authors	CR Publ Journal Title	CR Publ Journal Nbr	CR Publ Publisher	CR Publ Published Place	CR Publ Published Year	CR Publ Relevant Pages	CR Publ Is Joint Public/ Private ?	CR Publ In O-A ?	CR Link To Publication
QualyGridS	CONFERENCE_ PROCEEDING	Offering water electrolysers' flexibility to European grid service markets	10.5281/zenodo.3355399		Klemenz, V., Mbavarira, T. M. & Imboden, C.	(2019) Proc. of 3rd Grid Service Markets Symposium		Imboden, C., Nucci, C. A., Hatziargyriou, N., Friedrich, K. A., C., Bosnjak, D., Kudela, T., Svendstrup-Bjerre, A., Ziegler, S., Schwark, B.	Lucerne, Switzerland	2019		No	Yes - Gold OA	
QualyGridS	MONOGRA-PHIC_BOOK	Proceedings of 3rd Grid Service Markets Symposium 2019		978-3-905592-22-1	Imboden, C. et. al. (Eds.)	Proceedings of 3rd Grid Service Markets Symposium 2019		HSLU	Lucerne	2020		No	Yes - Green OA	http://doi.org/10.5281/zenodo.3355399
QualyGridS	CONFERENCE_ PROCEEDING	Qualifying tests and economic analysis of electrolyzers for grid services			"R. Reissner, J. Bürkle, S. Crevon, V. Seguin, V. Klemenz, T. M. Mbavarira, C. Imboden"	HYPOTHESIS XV HYdrogen POwer THeo-retical and Engineering Solutions International Symposium, e-Book of Abstracts		Niels Luchters, Rhiyaad Mohamed, Giuseppe Spazzafumo (editors)	on-line	2020		No	No	
QualyGridS	OTHER	Qualifying Tests of Electrolysers for Grid Services - System Behaviour and Scalability		978-3-905592-24-5	Reissner R., Bürkle, J. Lettenmeier, P. Gago, A. Friedrich, K. A.	Proceedings of the EFCF 2019 Low-Temperature Fuel Cells, Electrolysers & H2 Processing, Fundamentals and Engineering Design, 03.-05. Juli 2019, Luzern, Schweiz		European Fuel Cell Forum	Lucerne, Switzerland	2019		No	No	
QualyGridS	CONFERENCE_ PROCEEDING	Unified and Standardized qualifying tests of electrolysers for grid services			Reissner, R., DLR; You, Shi, DTU; Bourasseau, C., CEA; Marcuello, P., IHT; Lacroix, V., CEA; Lavaille, G., CEA; Greenhalgh, D.; ITM; Abadia, L. FHA; Imboden, Chr., HSLU; Bornstein, M. NEL	(2019). Proceedings of GSM 2019		Imboden, Christoph (Hrsg.), Bosnjak, Davor (Hrsg.), Friedrich, K. Andreas (Hrsg.), Hatziargyriou, Nikos (Hrsg.), Kudela, Thomas (Hrsg.), Nucci, Carlo Alberto (Hrsg.), ... Spirig, Michael (Hrsg.)	Lucerne, Switzerland	2019		No	Yes - Gold OA	
REFLEX	ARTICLE	Optimization of Solid Oxide Cells and Stacks for Reversible Operation	doi: 10.1149/09101.2517ecst	19385862	Alexandra Ploner, Anne Hauch, Sergii Pylypko, Stéphane Di Iorio, Géraud Cubizolles, Julie Mougin	ECS Transactions	91/1	Electrochemical Society, Inc.	United States	2019	2517-2526	No	No	
REFLEX	CONFERENCE_ PROCEEDING	Test and characterization of reversible solid oxide cells and stacks for innovative renewable energy storage			Anne Hauch, Alexandra Ploner, Sergii Pylypko, Julie Mougin, Geraud Cubizolles	14th European SOFC&SOE Forum 20-23 October 2020		14th European SOFC&SOE Forum 20-23 October 2020	Lucerne, Switzerland	2020	B0903	No	No	https://orbit.dtu.dk/en/publications/test-and-characterization-of-reversible-solid-oxide-cells-and-sta
REMOTE	PEER_ REVIEWED_ ARTICLE	Flexible and Scalable Energy Management of Islanded Renewable Energy Sources Storage Systems	10.3303/cet1976103	22839216	Kafetzis Alexandros, Ziogou Chrysovalantou, Panopoulos Kyriakos D., Papadopoulou Simira, Seferlis Panos, Voutetakis Spyros	Chemical Engineering Transactions	Vol 76	AIDIC	Italy	2019	613-618	No	Yes - Gold OA	
REMOTE	CONFERENCE_ PROCEEDING	H2-based energy storage systems in remote areas: the REMOTE project		978-989-54499-8-3	Marocco Paolo, Ferrero Domenico, Gandiglio Marta, Lanzini Andrea, Santarelli Massimo	Conference Proceedings of the 4th Energy for Sustainability International Confe-rence - Designing a Sustainable Future	1	Itecons - Instituto de Investigação e Desenvolvimento Tecnológico para a Construção, Energia, Ambiente e Susten-tabilidade	Online	2020		No	Yes - Gold OA	
SElySOs	PEER_ REVIEWED_ ARTICLE	A continuum model for yttria-stabilized zirconia incorporating triple phase boundary, lattice structure and immobile oxide ions	10.1007/s10008-019-04356-9	14328488	Petr Vágner, Clemens Guhlke, Vojtěch Miloš, Rüdiger Müller, Jürgen Fuhrmann	Journal of Solid State Electrochemistry		Springer Verlag	Germany	2019		No	Yes - Gold OA	https://link.springer.com/article/10.1007/s10008-019-04356-9
SElySOs	PEER_ REVIEWED_ ARTICLE	Affecting the H2O electrolysis process in SOECs through modification of NiO/GDC: experimental case of Au-Mo-Ni synergy	10.1016/j.jcat.2019.04.002	00219517	Ch. Neofytidis, E. Ioannidou, L. Sygellou, M. Kollia, D.K. Niakolas	Journal of Catalysis	373	Academic Press	United States	2019	260-275	No	Yes - Gold OA	https://www.sciencedirect.com/science/article/pii/S0021951719301551
SElySOs	PEER_ REVIEWED_ ARTICLE	Experimental Clarification of the RWGS Reaction Effect in H_2O/CO_2 SOEC Co-Electrolysis Conditions	10.3390/catal9020151	20734344	Evangelia Ioannidou, Stylianos Neophytides, Dimitrios Niakolas	Catalysts	9/2	Multidisciplinary Digital Publishing Institute (MDPI)	Switzerland	2019	151	No	Yes - Gold OA	
SElySOs	PEER_ REVIEWED_ ARTICLE	High Performance LSC Infiltrated LSCF Oxygen Electrode for High Temperature Steam Electrolysis Application	10.1149/2.0741902jes	00134651	V. Vibhu, S. Yildiz, I. C. Vinke, R.-A. Eichel, J.-M. Bassat, L. G. J. de Haart	Journal of The Electro-chemical Society	166/2	Electrochemical Society, Inc.	United States	2019	F102-F108	No	Yes - Green OA	http://jes.ecsdl.org/content/166/2/F102.abstract
SElySOs	PEER_ REVIEWED_ ARTICLE	La2Ni1-Co O4+δ (x = 0.0, 0.1 and 0.2) based efficient oxygen electrode materials for solid oxide electrolysis cells	10.1016/j.jpows-our.2019.227292	03787753	V. Vibhu, I.C. Vinke, R.-A. Eichel, J.-M. Bassat, L.G.J. de Haart	Journal of Power Sources	444	Elsevier BV	Netherlands	2019	227292	No	Yes - Gold OA	
SElySOs	PEER_ REVIEWED_ ARTICLE	Thermodynamic analysis of high temperature steam and carbon dioxide systems in solid oxide cells	10.1039/c9se00030e	23984902	Petr Vágner, Roman Kodým, Karel Bouzek	Sustainable Energy & Fuels	3/8	Royal Society of Chemistry	N/A	2019	2076-2086	No	Yes - Gold OA	10.1039/c9se00030e
SOSLeM	THESIS_ DISSERTATION	Analysis of High Temperature Degradation of Alloys in Solid Oxide Fuel Cell	10.5075/epfl-thesis-9086		Bianco Manuel, Van Herle Jan, Diethelm Stefan			EPFL	Lausanne	2019		No	No	https://infoscience.epfl.ch/record/263901?ln=en
SOSLeM	PEER_ REVIEWED_ ARTICLE	Ex-situ experimental benchmarking of solid oxide fuel cell metal interconnects	10.1016/j.jpows-our.2019.226900	03787753	Manuel Bianco, Johan Tallgren, Jong-Eun Hong, Shicai Yang, Olli Himanen, Jyrki Mikkola, Jan Van herle, Robert Steinberger-Wilckens	Journal of Power Sources	437	Elsevier BV	Netherlands	2019	226900	Yes	Yes - Gold OA	https://www.sciencedirect.com/science/article/pii/S0378775319308936
SOSLeM	PEER_ REVIEWED_ ARTICLE	Model-assisted identification of solid oxide cell elementary processes by electrochemical impedance spectroscopy measurements	10.1016/j.jpows-our.2019.226838	03787753	P. Caliandro, A. Nakajo, S. Diethelm, J. Van herle	Journal of Power Sources	436	Elsevier BV	Netherlands	2019	226838	Yes	Yes - Gold OA	https://www.sciencedirect.com/science/article/pii/S0378775319308316
TAHYA	PEER_ REVIEWED_ ARTICLE	Monte-Carlo-analysis of minimum load cycle requirements for composite cylinders for hydrogen	10.1016/j.ijhyde-ne.2018.09.185	03603199	G.W. Mair, B. Becker, B. Wang, S. Gesell	International Journal of Hydrogen Energy	44/17	Pergamon Press Ltd.	United Kingdom	2019	8833-8841	No	No	
TeacHy	CONFERENCE_ PROCEEDING	Teaching FCH Technologies in a Masters' Course across Europe			Robert Steinberger-Wilckens, Aravind Purushothaman Vellayani, Massimo Santarelli, Yegor Brodnikovskyi, Lars N. Cleeman, Karel Bouzek, Jan Van herle, Jean-Luc Delplancke, Ioan Iordache, Florence Druart, Vladimir Molkov, Olaf Jedicke	Proceedings of the 14th European SOFC & SOE Forum 2020	14th / 30 June – 3 July 2020 / bi-annual	EFCF	Lucerne	2020		No	Yes - Green OA	

Project Acronym	CR Publ Type	CR Publ Title	CR Publ DOI	CR Publ ISSN	CR Publ Authors	CR Publ Journal Title	CR Publ Journal Nbr	CR Publ Publisher	CR Publ Published Place	CR Publ Published Year	CR Publ Relevant Pages	CR Publ Is Joint Public/ Private ?	CR Publ In O-A ?	CR Link To Publication
WASTE2GRIDS	PEER_ REVIEWED_ ARTICLE	Balancing wind-power fluctuation via onsite storage under uncertainty: Power-to-hy-drogen-to-power versus lithium battery	10.1016/j. rser.2019.109465	13640321	Yumeng Zhang, Ligang Wang, Ningling Wang, Liqiang Duan, Yi Zong, Shi You, François Maréchal, Jan Van herle, Yongping Yang	Renewable and Sustainable Energy Reviews	116	Elsevier BV	Netherlands	2019	109465	Yes	Yes - Gold OA	https://www.sciencedirect.com/science/article/pii/S1364032119306732
WASTE2GRIDS	PEER_ REVIEWED_ ARTICLE	Balancing wind-power fluctuation via onsite storage under uncertainty: Power-to-hy-drogen-to-power versus lithium battery	10.1016/j. rser.2019.109465	13640321	Yumeng Zhang, Ligang Wang, Ningling Wang, Liqiang Duan, Yi Zong, Shi You, François Maréchal, Jan Van herle, Yongping Yang	Renewable and Sustainable Energy Reviews	116	Elsevier BV	Netherlands	2019	109465	Yes	Yes - Gold OA	https://www.sciencedirect.com/science/article/pii/S1364032119306732
WASTE2GRIDS	PEER_ REVIEWED_ ARTICLE	Balancing wind-power fluctuation via onsite storage under uncertainty: Power-to-hy-drogen-to-power versus lithium battery	10.1016/j. rser.2019.109465	13640321	Yumeng Zhang, Ligang Wang, Ningling Wang, Liqiang Duan, Yi Zong, Shi You, François Maréchal, Jan Van herle, Yongping Yang	Renewable and Sustainable Energy Reviews	116	Elsevier BV	Netherlands	2019	109465	Yes	Yes - Gold OA	https://www.sciencedirect.com/science/article/pii/S1364032119306732
WASTE2GRIDS	CONFERENCE_ PROCEEDING	Converting wastes efficiently and flexibly for grid- balancing services and sector coupling			Ligang Wang, Yumeng Zhang, Chengzhou Li, Mar Pérez-Fortes, Yi Zong, Vincenzo Motola, Alessandro Agostini, Stefan Diethelm, Olivier Bucheli, Jan Van herle	European GRID SERVICE MARKET Symposium	19-20 Oct. 2020	European GRID SERVICE MARKET Symposium	Conference proceeding	2020		No	No	
WASTE2GRIDS	CONFERENCE_ PROCEEDING	Converting wastes efficiently and flexibly for grid- balancing services and sector coupling			Ligang Wang, Yumeng Zhang, Chengzhou Li, Mar Pérez-Fortes, Yi Zong, Vincenzo Motola, Alessandro Agostini, Stefan Diethelm, Olivier Bucheli, Jan Van herle	European GRID SERVICE MARKET Symposium	19-20 Oct. 2020	European GRID SERVICE MARKET Symposium	Conference proceeding	2020		No	No	
WASTE2GRIDS	CONFERENCE_ PROCEEDING	Converting wastes efficiently and flexibly for grid- balancing services and sector coupling			Ligang Wang, Yumeng Zhang, Chengzhou Li, Mar Pérez-Fortes, Yi Zong, Vincenzo Motola, Alessandro Agostini, Stefan Diethelm, Olivier Bucheli, Jan Van herle	European GRID SERVICE MARKET Symposium	19-20 Oct. 2020	European GRID SERVICE MARKET Symposium	Conference proceeding	2020		No	No	
WASTE2GRIDS	CONFERENCE_ PROCEEDING	Data-driven flexibility requirements for current and future scenarios with high penetration of renewables			Karen Pardos Olsen, Yi Zong, Shi You, Henrik Bindner, Matti Koivisto, Juan Gea-Bermúdez	International Conference on Applied Energy 2019	Aug 12-15, 2019, Västerås, Sweden	none	none	2019		No	No	
WASTE2GRIDS	CONFERENCE_ PROCEEDING	Data-driven flexibility requirements for current and future scenarios with high penetration of renewables			Karen Pardos Olsen, Yi Zong, Shi You, Henrik Bindner, Matti Koivisto, Juan Gea-Bermúdez	International Conference on Applied Energy 2019	Aug 12-15, 2019, Västerås, Sweden	none	none	2019		No	No	

ANNEX 4
Patents from projects.

A. Information extracted from CORDA for H2020

Project number	Project acronym	Patent application title	Patent appl. name	Patent appl. date	Patent awarded
671473	D2Service	Heat Exchanger and Method for Manufacturing a Heat Exchanger Core with Manifold	Bosal Emission Control Systems Nv	19/04/2018	Yes
671403	INNO-SOFC	Protection arrangement and method of solid oxide cells	Elcogen Oy	14/03/2018	NO
671403	INNO-SOFC	Sealing Arrangement and Method of Solid Oxide Cell Stacks	Elcogen Oy	17/07/2014	Yes
700101	Giantleap	Inrichting voor het koppelen van een trekkend voertuig met een te trekken voertuig	VDL Enabling Transport Solutions BV	06/02/2018	Yes
700667	SOSLeM	Method for Determining an Operating State of an Electrochemical System	AVL List GmbH	07/12/2018	Yes
700667	SOSLeM	Recursive, Time-Series-Based Method for Determining the State of an Electrochemical Reactor	AVL List GmbH	27/11/2018	Yes

B. Additional information to CORDA, coming directly from the projects (for H2020)

Project number	Project acronym	Patent application title	Patent appl. name	Patent appl. date	Patent awarded
621181	FERRET	Advanced double skin membranes for membrane reactors	TUE Tecnalia	2017	YES
700355	HyGrid	Carbon molecular sieve membrane and its use in separation processes	TUE Tecnalia	2019	YES
700355	HyGrid	Method for low hydrogen content separation from a natural gas mixture	TUE Tecnalia	12/2018	YES
779644	TAHYA	Composite Pressure Vessel with Reinforced Inner Liner and Process for the Production Thereof	Optimum CPV	26/06/2019	YES
779644	TAHYA	Composite Pressure Vessel with Boss Connector	Optimum CPV	26/06/2019	YES
779644	TAHYA	Tank Liner Having Two Cylindrical Sections	Optimum CPV	26/06/2019	YES
700266	Cell3Ditor	Method and device for Manufacturing of Ceramic or Metallic Pieces by Additive Manufacturing	3DCERAM	20/06/2018	NO
700266	Cell3Ditor	Method and device for manufacturing at least one piece of at least ceramic and/or metallic material by additive manufacturing	3DCERAM	20/06/2018	NO
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	20/06/2018	NO
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	3DCERAM	20/06/2018	NO
826204	DOLPHIN	Procédé de fabrication d'un guide d'écoulement pour réacteur électrochimique	CEA	2019	YES

ANNEX 5
Scoreboard of Horizon 2020 common KPIs[245]

	H2020 KPI number	Key Performance Indicator	Type of data required	Results H2020 up to 31 December 2020 (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	80
	13	SME - Growth and job creation in participating SMEs	Turnover of company, number of employees	Turnover of SMEs at most recent reporting: EUR 996.3 mil. No. of employees in SMEs at most recent reporting: 9 679
SOCIETAL CHALLENGES	14	Publications in peer-reviewed high-impact journals	Publications from relevant funded projects (DOI: digital object identifiers); journal impact benchmark (ranking) data to be collected by commercially available bibliometric databases	289 publications in peer-reviewed high-impact journals
	15	Patent applications and patents awarded in the area of the JTI	Patent application number	5 patent applications and 12 patents awarded
	16	Number of prototypes testing activities and clinical trials	Reports on prototypes, and testing activities, clinical trials	No. of prototypes: 178 No. of testing activities: 272 No. of clinical trials: 0
	17	Number of joint public-private publications in projects	Properly flagged publications data (DOI) from relevant funded projects	80 joint public-private publications
	18[247]	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	No of projects with: New products: N/A[248] New processes: 30 New methods: 18
EVALUATION	N/A	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 of % of information letters sent to applicants within target Average TTI in calendar days Maximum TTI in calendar dayst	133 information letters with an average of 107 days (100 % within target)
	N/A	Redress after evaluations	Number of redresses requested	13

246 Based on Annex II to Council Decision 2013/743/EU.

247 This indicator is not legally compulsory but covers several additional specific indicators requested for more societal challenges by the services in charge.

248 Not available.

	H2020 KPI number	Key Performance Indicator	Type of data required	Results H2020 up to 31 December 2020 (Calls 2014-2020)
GRANTS	N/A	Time to Grant (TTG) measured (average) from call deadline to signature of grants	Number and % of grants signed within target Average TTG in calendar days Maximum TTG in calendar days	131 GAs signed (82 % within target) Average TTG: 240 days Maximum TTG: 589 days
	N/A	Time to Sign (TTS) grant agreements from the date of informing successful applicants (information letters)	Number and % of grants signed within target Average TTS in calendar days Maximum TTS in calendar days	131 GAs signed Average TTS: 130 days Maximum TTS: 463 days
PAYMENTS	N/A	Time to Pay (TTP) (% made on time) -pre-financing - interim payment -final payment	Average number of days for pre-financing, interim payments and final payments Average number of days for administrative payments	Average number of days for pre-financing: 6 (93 % on time) Average number of days for interim payments: 66 (100 % on time) Average number of days for final payments: 698 (100 % on time) Average number of days for administrative payments in 2020: 16
HR	Vacancy rate (%)	% of posts filled	100 %	100 %
JU EFFICIENCY	N/A	Budget implementation/execution: 1. % commitment appropriation (CA) to total budget 2. % payment appropriation (PA) to total budget	% of CA and PA	In 2020 CA: 94 % PA: 95 %
	N/A	Administrative budget: Number and % of total of late payments	Number of delayed payments % of delayed payments (of the total)	In 2020 10 late payments 1.8 % late payments (of the total)

ANNEX 6
Indicators for monitoring cross-cutting issues[248]

NUMBER	DEFINITION/RESPONDING TO QUESTION	TYPE OF DATA REQUIRED	AAR 2020 (CALLS 2014-2020)[249]
2.1	Total number of participations by 27 Member States + the UK	Nationality of H2020 applicants and beneficiaries (number)	EU-27: Applications 3 198; Grant participations 1 280 + UK: Applicants 1 330; Grant participants 658
2.2	Total amount of EU financial contribution by 27 Member States + the UK (EUR million)	Nationality of H2020 beneficiaries and corresponding EU financial contribution	In EUR million per country (total EUR 577.9 million): AT 24.07, BE 24.25, BG 0.39, CY 0.17, CZ 1.46, DE 148.46, DK 26.85, EE 0.61, EL 6.13 ES 36.35, FI 18.84, FR 93.07, HR 0.72, HU 0.02, IE 0.28, IT 52.7, LT 0.13, LU 1.64 LV 0.66, MT 0.03, NL 47.36, PL 1.07, PT 2.27, RO 0.26, SE 9.96, SI 3.35, UK 76.81
N/A	Total number of participations by Associated Countries	Nationality of H2020 applicants and beneficiaries (number)	Associated Countries Applications 328; Grants participations 143 Applicants 223; Grant participants 75
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 47.85 million): CH 12.41, IL 0.24, IS 1.07, NO 34.08, UA 0.06
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: 330 (23 %); Grant participants: 157 EUR (21 %); Funding: 186.0 mil. (30 %)
6.1	Percentage of women participants in H2020 projects	Gender of participants in H2020 projects	According to continuous reporting: 25.3 %

249 Based on Annex III to Council Decision 2013/743/EU; source: CORDA, unless specified otherwise.

250 The figures include 131 projects.

NUMBER	DEFINITION/RESPONDING TO QUESTION	TYPE OF DATA REQUIRED	AAR 2020 (CALLS 2014-2020)[249]
6.2	Percentage of women project coordinators in H2020	Gender of MSC fellows, ERC principal investigators and scientific coordinators in other H2020 activities	36/131 (27.5 %)
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 %) on 31/12/2020 SRG: 9/42 (21.4 %) on 31/12/2020 Evaluators: 30/83 (36.14 %) on 31/12/2020
7.1	Share of third-country participants in H2020	Nationality of H2020 beneficiaries	Grants: 8 participations, 8 participants from third countries with EU funding: EUR 1.11 million
7.2	Percentage of EU financial contribution attributed to third-country participants	Nationality of H2020 beneficiaries and corresponding EU financial contribution	0.18 %
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	No: 37/131 (28.2%) Funding: EUR 372 732 793.62/ EUR 632 885 427.4 (58.89 %)
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	1.9 %
N/A	Scale of impact of projects (high technology readiness level - TRL)	Number of projects addressing TRL between (2-3, 4-6, 5-7)	Based on TRL specified in the topic (project start) TRL: 2, 3, 4, 5, 6, 7, 8, unspecified # projects: 13, 29, 28, 15, 11, 10, 1, 24
11.1	Percentage of H2020 beneficiaries from the private-for-profit sector	Number of and % of the total H2020 beneficiaries classified by type of activity and legal status	Participations: 864 / 1464 (59 %) Participants: 493/ 747 (66 %)
11.2	Share of EU financial contribution going to private-for-profit entities (Enabling and industrial tech and Part III of Horizon 2020)	H2020 beneficiaries classified by type of activity; corresponding EU contribution	EUR 438.3 mil / EUR 626.9 mil (69.9 %)
12.1	EU financial contribution for public-private partnerships (PPP) (Art. 187)	EU contribution to PPP (Art. 187)	Cumulative EU contribution to administrative and operational budget for the period 2014-2020: CA: 654 713 409 PA: 503 097 874
12.2	PPPs leverage: total amount of funds leveraged through Art. 187 initiatives, including additional activities, divided by the EU contribution	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)	2.34 (see section 1.1, Formula B)

NUMBER	DEFINITION/RESPONDING TO QUESTION	TYPE OF DATA REQUIRED	AAR 2020 (CALLS 2014-2020)[249]
13.3	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)]	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	Activities as reported by the projects during FCH 2 JU data collection exercise for 2020: **Dissemination activities (69 projects): 402** Participations in conferences/events (presentations, posters, etc.): 245 Scientific publications: 76 Press releases, interviews, etc.: 27 Education activities (summer schools, etc.): 20 Clustering activities (workshops, etc.): 13 Scientific cooperation activities (joint events, research nights, etc.): 8 Presentations at policy working groups: 7 Training activities: 6 **PRD 2020 (76 projects)** Websites: 74 Twitter accounts: 31 LinkedIn accounts: 28
14.2	Proposal evaluators by country	Nationality of proposal evaluators (at pool level)	AT 3, BE 1, CA 2, CZ 1, DE 6, EL 10, ES 15, FR 5, HU 3, IE 2, IN 1, IT 13, NL 1, PL 4, PT 4, RO 4, RU 1, SE 1, UK 4, US 2
14.3	Proposal evaluators by organisations' type of activity	Type of activity of evaluators' organisations	Type of activity: No of expert participations (%) Higher or secondary education establishment: 22 (26 %) Private-for-profit organisation: 27 (32 %) Public organisation: 2 (2 %) Research organisation: 23 (28 %) Other: 9 (11 %)
N/A	Participation of RTO[3]s and universities in PPPs (Art. 187 initiatives)	Number of RTOs participating in funded projects and % of the total	297 / 1464 (20.2 %)
		Number of universities participating in funded projects and % of the total	198 / 1477 (13.5 %)
		% of budget allocated to RTOs and to universities	RTO: EUR 97.1 million (15.5 %) HES: EUR 46.6 million (7.4 %)
N/A	The aim is to ensure that research projects funded are efficiently compliant with provisions on ethics	% of proposals not granted because of non-compliance with ethical rules/proposals invited to grant (target 0 %); time to ethics clearance (target 45 days)	N/A
N/A	Error rate	% of common representative error; % residual error	H2020: Representative: 2.16 % Residual: 1.34 %
N/A	Implementation of *ex-post* audit results	Number of cases implemented; in total EUR million; of cases implemented/total cases	H2020: # closed participations: 65 Percentage of implementation: 84 %

ANNEX 7
Scoreboard of KPIs specific to FCH 2 JU

NO	KEY PERFORMANCE INDICATOR	RESULTS
1	Share of the funding allocated to the following research activities: • renewable energy • end-user energy efficiency • smart grids • storage	Renewable energy: EUR 96.2 million (15 %)[250] End-user energy efficiency: EUR 121.4 million (20 %) Smart grids: EUR 38 million (6 %) Storage: EUR 69.5 million (11 %)
2	Demonstrator projects hosted in Member States and regions benefiting from EU Structural and Investment Funds	The FCH 2 JU has also collaborated with national programmes for the blending of funds. For instance, the FCH 2 JU project HySHIP on a 3MW FC-powered ferry is benefiting from circa EUR 20 million in funding from ENOVA (Norwegian Innovation Fund) in addition to the EUR 8 million support from the FCH 2 JU.

251 Projects addressing topics related to renewable energy integration (KPI 1) and storage (KPI 4) are interrelated, in many cases covering both aspects. Complementarily, a common KPI of 26 % can be reported for KPIs 1 and 4.

ANNEX 8

Draft annual accounts

		EUR '000
	31.12.2020	31.12.2019
NON-CURRENT ASSETS		
Intangible assets	25	45
Property, plant and equipment	112	104
Pre-financing	115 524	98 464
	115 661	**98 613**
CURRENT ASSETS		
Pre-financing	47 690	51 455
Exchange receivables and non-exchange recoverables	7 028	22 784
	54 718	**74 239**
TOTAL ASSETS	**170 379**	**172 852**
CURRENT LIABILITIES		
Payables and other liabilities	(52 599)	(69 543)
Accrued charges and deferred income	(37 582)	(41 036)
	(90 181)	**(110 578)**
TOTAL LIABILITIES	**(90 181)**	**(110 578)**
NET ASSETS		
Contribution from members	1 403 608	1 300 886
Accumulated deficit	(1 238 612)	(1 099 785)
Economic result for the year	(84 798)	(138 828)
NET ASSETS	**80 198**	**62 274**

STATEMENT OF FINANCIAL PERFORMANCE		*EUR '000*
	2020	2019
REVENUE		
Revenue from non-exchange transactions		
Recovery of expenses	3 444	1 534
Other	0	0
Total	**3 444**	**1 534**
Revenue from exchange transactions		
Financial income	6	15
Other exchange revenue	44	10
Total	**50**	**24**
	3 494	**1 558**
EXPENSES		
Operating costs	(83 343)	(135 418)
Staff costs	(3 086)	(3 001)
Finance costs	0	0
Other expenses	(1 863)	(1 967)
	(88 292)	**(140 386)**
ECONOMIC RESULT FOR THE YEAR	**(84 798)**	**(138 828)**

ANNEX 9
Materiality criteria

The '**materiality**' concept provides the ED 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.

Whereas the FCH 2 JU control strategy is multi-annual in nature (i.e. the effectiveness of the 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 ED 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 JU's control system has to be assessed, not only for the year of reference but, more importantly, with a multi-annual aspect.

The **control objective** for FCH 2 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 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 ED 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 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 FCH 2 JU detected by *ex-post* audits measured with respect to the amounts accepted after *ex-ante* controls.

According to the FCH 2 JU *ex-post* audit strategy approved by the GB, 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 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:

$$RepER\% = \frac{(RepER\% * (P\text{-}A) - (RepERsys\% * E)}{P}$$

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.

ANNEX 10
List of acronyms

AAR	Annual Activity Report
AHA	Ad-hoc assistance
ARES	Advanced REcord System (EC Document Management IT system)
AST	Accelerated stress test
AWP	Annual Work Plan
BCP	Business continuity plan
BEV	Battery electric vehicle
BOP	Balance of plants
BPD	Business plan development
CAPEX	Capital expenditure
CAS	Common Audit Service
CCS	Carbon capture and storage
CERT-EU	Computer Emergency Response Team for the EU institutions
CFS	Certificate of financial statements
(m)CHP	(micro)combined heat and power
CIC	Common Implementation Centre
COSO	Committee of Sponsoring Organizations of the Treadway Commission
CPMR	Conference of Peripheral Maritime Regions
CRaS	Common representative sample
CSA	Coordination and support actions
CSC	Common Support Centre
D&E	Dissemination and exploitation
DG	Directorate-General
DIGIT	Directorate-General for Informatics
DPIA	Data Protection Impact Assessment
EC	European Commission
ECA	European Court of Auditors
ECHA	European Clean Hydrogen Alliance
ED	Executive Director
EHSP	European Hydrogen Safety Panel
EHV-S3P	European Hydrogen Valleys Partnership
EHW	European Hydrogen Week
EMM	European Media Monitor
ESS	Exploitation strategy seminars
ESSF	European Sustainable Shipping Forum

EU	European Union
EUDPR	EU Data Protection Regulation
EUSEW	European Sustainable Week
FAIR	Fraud and Irregularity Committee
FCB	Fuel cell bus
FCEV	Fuel cell electric vehicle
FCH	Fuel cells and hydrogen
FCH 2 JU	Fuel Cells and Hydrogen 2 Joint Undertaking
FCHO	Fuel Cells and Hydrogen Observatory
FP7	European Union's Seventh Framework Programme
GA	Grant agreement
GAP	Grant agreement preparation
GB	Governing Board
GDPR	General Data Protection Regulation
GHG	Greenhouse gas
GO	Guarantee of Origin
H2020	Horizon 2020
HELLEN	Hydrogen Events and Lessons LEarNed database
HHV	High heating value
HIAD	Hydrogen Incidents and Accidents Database (European Hydrogen Safety Reference Database)
HRP	Horizon Results Platform
HRS	Hydrogen refuelling station
HTE	High-temperature electrolysis
IA	Innovation action
IaaS	Infrastructure-as-a-Service
IAS	Internal Audit Service
ICF	Internal Control Framework
IKAA	In-kind contributions in additional activities
IKOP	In-kind contributions in operational activities
IPCEI	Important Projects of Common European Interest
IPHE	International Partnership for Hydrogen into the Economy
IPI	Innovation Potential Index
ISPT	Institute for Sustainable Process Technology
IT	Information technology
JRC	Joint Research Centre
JTI	Joint Technology Initiative
KER	Key exploitable results
KPI	Key performance indicator
kW(e)	kilowatt (electric)
kWh	Kilowatt hour
LCA	Life cycle assessment

LHV	Lower heating value
LOHC	Liquid organic hydrogen carrier
MAIP	Multi-Annual Implementation Plan
MAWP	Multi-Annual Work Programme
MEA	Membrane electrode assembly
MHV	Material handling vehicles
MUS	Monetary Unit Sampling
MW(e)	Megawatt (electric)
MWh	Megawatt hour
MWth	Megawatt thermal
NECP	National Energy and Climate Plans
NOx	Nitrogen oxides
OEM	Original equipment manufacturer
OLAF	European Anti-Fraud Office
PCE	Proton ceramic electrolyser
PDA	Project development assistance
PEM(FC)	Proton exchange membrane (fuel cell)
PGM	Platinum group metals
PM	Particulate matter
PNR	Pre-normative research
PO	Programme Office
(I)PPP	(Institutionalised) public-private partnership
PRD	Programme Review Days
PV	Photovoltaic
QES	Qualified electronic signature
RCS SC	Regulations, Codes and Standards Strategy Coordination
RED II	Renewable Energy Directive
RIA	Research and innovation actions
RTD/R&I	Research, technological development and demonstration / research and innovation
SC	Scientific Committee of the Fuel Cells and Hydrogen Joint Undertaking
SET-Plan	European Strategic Energy Technology Plan
SLA	Service Level Agreement
SME	Small and medium-sized enterprise
SNE	Seconded national expert
SOE	Solid oxide electrolysis
SOFC	Solid oxide fuel cell
SOx	Sulphur oxides
SRG	States Representatives Group
SSERR	Support Services for Exploitation of Research Results
SWD	Staff Working Document
SYSPER	SYStème de gestion du PERsonnel

TCO	Total cost of ownership
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
TTS	Time To Sign
µ-CHP	Combined heat and power for residential applications
VOC	Volatile organic compounds

Contact us
FUEL CELLS AND HYDROGEN JOINT UNDERTAKING
Avenue de la Toison d'Or 56-60, B-1060 Brussels
Find us on google map
Tel.: +32 2 221 81 28 - Fax: +32 2 221 81 26 - Email: fch-ju@fch.europa.eu